Lecture Abstracts

Room 117

09:00 h – Opening Lecture

Current technological and non-technological trends in cardiovascular fields

Prof. Valentin Fuster, MD, PhD
Physician-in-Chief, The Mount Sinai Medical Center, Director, Mount Sinai Heart, New York, USA

Dr. Fuster’s presentation will cover the three main trends that are occurring in today’s cardiovascular field: the new technology, specifically the emergence of imaging, genetics, and tissue regeneration; the integration of the heart and the brain in health and disease; and the shift from treating disease to promoting health.

State of the art at the arterial level

Bioimaging is a thriving research field for cardiovascular (CV) prediction and clinical management. Several bioimaging techniques and blood biomarkers have been recently shown to substantially improve prediction of CV disease when compared to classical score equations. Our group, integrated by leading experts in clinical and population aspects of CV disease, has already developed novel bioimaging tools (www.hrpinitiative.com) and has performed a preliminary testing of a panel of blood biomarkers for CV events prediction. Developments in technology from 1990 to the present, include the latest innovation, 3-D ultrasounds, can be used to identify plaques in various areas of the body. Because subclinical disease is a “silent disease” many people don’t know they have it. Technology is crucial in identifying the disease in at-risk individuals. Fortunately, the new technology is four times more predictive than conventional risk factor profiling used today. Furthermore, we can risk saying that in less than five years, a 3-D ultrasound will cost a mere $ 50, making these crucial tests economical enough for use in developing countries.

State of the art at the myocardial level

The new nano-bioimaging techniques for arterial disease have been applied to the myocardium. As a result, an extraordinary window of opportunities is evolving as a potential for the future prediction of cardiac decompensation in pressure and volume overload, as well as in predicting sudden death. In the late 1990s, the possibility that discoveries in genetics and genomics could have a positive impact on the diagnosis, treatment, and prevention of cardiovascular diseases seemed to be just a distant promise. Today, a little more than a decade later, the promise is beginning to take shape. Dr. Fuster’s work is based on the basic mechanisms of cardiac diseases and identification of high-risk groups and genomic predictors so that they can be part of the daily clinical care of patients. Unique biorepositories combined with cardiovascular areas of excellence make possible crucial genetic studies. Dr. Fuster’s team has developed the world’s first potential gene therapy for heart failure. The next research projects, already underway, focus on using novel gene therapy vectors to target diastolic heart failure, ventricular arrhythmias, pulmonary hypertension and myocardial infarctions.

State of the art at the brain level

Another issue that will be cover will be the new findings in identifying risk factors for Alzheimer’s disease along with those for cardiovascular disease. The goal should be preventing brain’s degeneration before it starts
by identifying and treating at-risk individuals before symptoms become manifest.

But medicine is not all based on technology; Dr. Fuster will share some successful studies suggesting the efficacy of health promotion programmes aimed at three different age groups (children, adults, and older adults). In one study, a “polypill” developed for adults over age 70, who are at risk of heart attack and stroke, was found to be effective and the pill has so far been approved for use in three countries.

As a summary, Dr. Fuster will insist on reaching a balance between technology and the human aspect of medicine. We can’t go to one extreme or to the other.

10:30 h – P1
Do “new technologies” mean better outcomes?
Chairs: Didier Payen, France; Juan Manuel Campos, Spain

P1-1
Security concepts: From the aeronautic technology to the operating room:
Does new technologies help anaesthesiologists to manage critical situations?

Carsten Wächter
Cpt. Aeronautic expert, Idstein, Germany

Why do mistakes slip into our work, even though we’re trained properly? Why do people act amiss? Why do we allow ourselves to be misled or distracted even though we know it better? Only since approximately three generations, we move faster than the naturally fastest creatures on earth. Within this short time span, we have developed technical systems with unprecedented complexity. This results in having to handle a multitude of competing information in parallel – within reduced time!

The human brain, however, hasn’t changed much in its basic functioning and performance since the early days of human history. We simply haven’t given evolution enough time to prepare us for flying aeroplanes, operating complex machinery or conducting micro-invasive surgery.

The airline industry, as well as other high risks organizations, classifies errors in three categories: Human, Technical and Organizational. Its meaning for the medical industry: top qualified people take care of a best possible treatment of patients. Technical: the technical equipment of an operation room is “state of the art” and steadily improved. Organizational: adoption of work processes, quality management and a continuously improvement of processes lead to an endogenous organizational leaning process.

Focussing on the human factor, which competencies are needed? Technical Know How, Procedural knowledge and Interpersonal competencies. The latter combines clear communication under time pressure, structured decision making behaviour in a dynamic environment, situative adapted leadership in critical situations, open error culture, professional coping of stress.

Flying an aircraft and working in an operation room are characterized by high dynamic, complex and time-critical work processes.

Questions to be asked are: How do people act in critical situations? How do they make decisions under stress? How do people communicate and how do they lead under time pressure?

Medical doctors and pilots have one thing in common: they have to manage extreme and often time-critical situations.

Extreme situations, for example the emergency landing on the Hudson River shows that pilots have to be able act fast, rationally and structured.

Which concepts are provided by the airline industry to prepare human beings for situations, which are dangerous and might be even life-endangering for themselves?
On the basis of concrete examples Cpt. Carsten Wächter shows training methods, which are commonly used in pilot trainings.

Together with the participants he will draw parallels between humans flying an aircraft and humans working in an operating room. He will focus on the question of how medical doctors and their whole team manage to retain control in critical situations during surgery.

P1-2
When the numbers are wrong – Pitfalls and challenges in monitoring!

Erik Jensen
Biomedical-Engineer, UPC, Barcelona, Spain

Modern anaesthesia monitors display a wide range of numbers representing the patient state.

The first expectation is that the numbers shown on the screen are real time but this is rarely the case. In particular more advanced measurements where processing is needed can have a considerable delay, for example the EEG indices of depth of hypnosis used during general anaesthesia. In order to reach the final number, a window of data is needed for the processing, for example 30 s. Additional processing time is often needed and what is important is that smoothing of the index is applied as well, adding further to the total delay.

Another issue is noise also termed artifacts. Artifacts occur more frequently in signals which are very small as compared with the background activity. An example is Evoked Potentials which are in the range of microvolts whereas the EEG and electrical noise from 50 Hz or external devices can reach levels of millivolts, hence the delay may vary depending on the amount of artifacts present.

The evoked potentials are extracted by averaging which further adds to the delay of the signal. It means that what is presented is a “smeared” mean of all the events summarized to create the image on the screen.

Wrong numbers can lead to medication errors. On a low level, a medication error may not cause a problem for a patient, but high level errors can result in severe complications, including death, for the patient. Concern about medication errors has led a number of national governments and medical device manufacturers to work on methods and devices which are designed to reduce the incidence of such errors.

Medication errors may occur with infusion pumps which are not infusing correctly into the vein of the patient. This is why monitoring the drug effect is important. If the drug effect is monitored then a warning can be given in case the measured effect does not correspond to the desired effect.

Probabilities

Some monitors are based on probabilities, this means that they predict the state of the patient with a certain probability, rather than predicting the real state of the patient. Coming back to the example of the depth of hypnosis monitor, each number is related to a probability as shown in the figure below:

![Probability of response](image)

This figure shows that an index of 60 gives 20% probability of response and 80% of no response. This means that there is a grey zone where the numbers should not be trusted blindly, rather they serve as a guideline of the patient state. The ideal monitor should have no delay and present the information in real time.

When raw data are presented, they may appear chaotic without any obvious deter-
ministic system behind. Look at the curve above, it appears highly chaotic (it is).

But behind it is a simple equation, the logistic equation.

\[ \chi_{n+1} = 3.5 \times \chi_n \times (1 - \chi_n) \]

This is an example of how the first impression of data can be misleading. What looks like random data finally ends up as being highly ordered.

The above figure is the Lorenz attractor, in chaos mathematics this was originally used to model weather systems but has later been applied to predict physiological parameters such as blood pressure and variation in RR-intervals.

**P1-3**

**Does technology make us risk averse or risk aware?**

*John Kneeshaw FRCA, FESC*

Papworth Hospital, Cambridge, UK

The environment in which we conduct our everyday business of cardiac anaesthesia has become increasingly complex and increasingly dominated by technology. The conventional wisdom is that the application of these various technologies (for example near patient testing, BIS, NIRS, TEE etc) has made the experience safer for the patient and easier for us. We are told that we have increased safety by ameliorating much of the risk of harm that our patients suffered 10 or 20 years ago. But is this true, or are we so busy dealing with the sleeping machines and the false alarm sounds that they generate that we haven’t got time to even consider if there may be a better way?

I have a habit of questioning that which everybody takes on trust. The question that often troubles me is has the adoption of various risk reduction techniques created a new series of risks that were never thought of? Are we, and our patients, the victims of unintended consequences?

I want to discuss what we mean by risk and how we perceive it, and to illustrate the discussion with some examples from the wider world as well as the world of cardiac surgery and anaesthesia. Some questions I would like to think about are: Do surgeons and anaesthetists have the same perception of risk? And can we use our understanding
of risk to work out which components of our
daily work make a difference to patents and
which we might concentrate on rather less?

In order to address some of these issues
I would like to look at several sources. Risk
and probability are scientific terms, but they
are frequently used to manipulate us to pro-
duce fear. In particular fear that if we do not
undertake some task, or employ some piece
of equipment, very bad things might hap-
pen. Examples are the sale of burglar alarms,
depth of anaesthesia monitoring, the millen-
nium bug, and even the use of TEE. What is
almost never investigated is the risk of un-
foreseen outcomes from the actions. I rec-
ommend that all doctors should read a book
called, Risk: The Science and Politics of Fear
by Dan Gardner. Gardner starts by explain-
ing why the 9/11 attack on the United States
caused the number of people killed on roads
around the world to increase, and goes on
to explain how the perception of risk can be
used to create fear, and that fear is one of the
best marketing tools for politics, medicine
and business.

A current European example of an un-
foreseen outcome as a consequence of a
medical scare campaign is the outbreak of
measles in young teenagers that is spread-
ing through a part of the UK. This current
outbreak is a direct outcome of media scare
publicity given to a paper published in Lan-
cet in 1998, which linked the triple Mumps,
Measles, Rubella vaccine with autism. The
paper was found to be fraudulent and was
later discredited, but such was the level of
publicity devoted to it that thousands of chil-
dren were not immunised. The consequenc-
es have taken 15 years to emerge.

In anaesthesia, we are aware that BIS is
controversial with both pro and anti cam-
paigns getting equal air time, but what about
TEE where the case in favour is accepted as
a universal truth with a level of evidence that
is no better than BIS. Is this because TEE con-
fers other benefits on its users and promot-
ers, and adds an air of exclusivity to our spe-
ciality that others cannot claim? The danger
of the technologies that claim our time and
attention in cardiac anaesthesia is that they
may divert us away from the key tasks in an-
aesthesia. Rather like sending text messages
while driving a car, there are a limited num-
ber of things an anaesthetic brain can cope
with before a disaster or a near miss occurs.

I will also examine some of the more un-
usual work of Professor Steven Levitt of Chi-
cago and his observations on such things as
the causes of the reduction of the crime rate
in US cities to see if we can relate it to the
reasons for improving outcomes in cardiac
surgery and anaesthesia.

What we will find is that we believe
things if they seem scientifically plausible, if
they are reinforced by anecdote, if there are
horrible potential outcomes if we don’t be-
lieve, and if the cost of remedies or preven-
tion is high. Sadly the original belief may still
me totalement wrong, but the damage is done.
Or to put it another way – it is very easy to
scare people, but much more difficult to uns-
care them.

I will also try to look at what things make
cardiac anaesthetists perform better and ask
if there are things that an organisation can
do to optimise the actions of surgeons and
anaesthetists.

The take home message is not complicat-
ed. Do not believe everything you are told.
Think about it for yourself and then make
your own evidence based decisions about
how you treat your patients.

References
1. Risk: The Science and Politics of Fear. Dan
2. Freakonomics: A Rogue Economist Ex-
plores the Hidden Side of Everything. Ste-
Harper Collins.
3. Wakefield AJ, Murch SH, Anthony A, Lin-
nell, Casson DM, Malik M, et al. Ileal lym-
phoid nodular hyperplasia, non-specific
colitis, and pervasive developmental dis-
351: 637-641. Please note this paper was
fraudulent and later discredited.
P1-4
Wireless anaesthetic data management

Dr. Andy Pybus
St. George Private Hospital, Sydney NSW, Australia

Recent advances in wireless technology have greatly simplified the process of remotely displaying anaesthetic data on portable computing devices such as ‘UltraBooks’, ‘Tablets’ and ‘Smart Phones’. Network-based data transmission and local broadcasting using wireless-enabled serial port devices attached to patient monitors have both been used to supply the physiological signals to these computer systems.

Modern portable devices are now so powerful that, once the signals have been acquired, they can be quite simply collated, displayed, analysed and stored by the receiving system. In this regard, an extensible, open-source data structure which can be used for the ‘Near Real Time’ recording of complete anaesthetic datasets in a compact, computationally-efficient format has also been described. This structure permits the recording of ECG signals at 300 Hz, pressure waveforms at 100 Hz and airway signals at 25 Hz.

Once recorded, complete anaesthetic datasets can be submitted to a (cloud-based) ‘Accessible Repository of Anaesthesia Patient Monitoring Data for Research’, to be used for the creation of a printable anaesthetic record, or provide the data input to a ‘Smart’ anaesthetic alarm system. Furthermore, because the complete dataset is available, individual cases can be the subject of subsequent ‘forensic’ examination during morbidity or mortality review.

The availability of complete datasets also makes it possible for novel data presentation techniques to be developed. In particular, it is possible to notify the anaesthetist of potentially critical conditions using ‘Augmented Reality’ visual displays. These displays can then also be used to automatically provide management strategies for the particular condition within the anaesthetist’s visual field. Some of the technologies mentioned above will be demonstrated during the course of this presentation.

14:30 h – P2
EACTA – SCA International Panel
Chairs: Linda Shore, USA; Manfred Seeberger, Switzerland

P2-1
Cerebral Oximetry: Better monitoring, improved patient outcomes, both or neither?

Hilary P. Grocott, MD, FRCPC, FASE
Professor of Anesthesia and Surgery
University of Manitoba, Cardiac Anesthesia Fellowship Director, I. H. Asper Clinical Research Institute, Winnipeg, Manitoba, Canada

Utilizing some of the same general principles as ubiquitously available and standard of care pulse oximetry, cerebral oximetry is increasingly becoming adopted into cardiovascular (and non-cardiovascular) anaesthetic and critical care practice. Though far from becoming a standard of care itself, the increasingly available information outlining its potential utility in optimizing peri-operative management warrants a careful examination of both its current status and future directions.

Cerebral oximetry had its early beginnings in the 1980s with the work of Jöbsis and colleagues. By using multi-wavelength light sources in the near infrared range, these investigators demonstrated the utility of exploiting the ability of the differential absorption of oxygenated and de-oxygenated haemoglobin of these wavelengths in brain (and possibly other) tissue. Differing from pulse oximetry, that discriminates between
the pulsatile (i.e. arterial) from non-pulsatile (venous) components in order to calculate arterial saturation, tissue oximetry integrates both signals to give a mixed (in an approximately 3:1 ratio of venous to arterial blood) overall tissue oximetric signal. As opposed to pulse oximetry, this provides a signal regardless of the presence of any pulsatility (ideal in low flow conditions, as well as the relatively non-pulsatile situation of CPB) resulting in an overall oxygen saturation signal of all the blood contained within the interrogated tissue. In the case of the brain, the penetration of photons is likely limited to within 15-20 mm of the brain surface. This does significantly limit the spatial resolution of the device by only providing information in the most superficial area of the frontal lobe. By integrating this oximetric data and comparing it to validated direct measurements of jugular venous saturation, these devices (with now at least 4 commercial devices on the market worldwide and 3 available in North America), produce a continuous output of tissue (i.e. brain) oxygen saturation. This saturation information can then be integrated with our understanding of oxygenation delivery and utilization conditions to allow modifications to be made in peri-operative physiologic conditions with the aim of optimizing overall tissue oxygenation, and ideally, corresponding end-organ function and outcome.

However, despite extensive publications (now numbering in the hundreds) highlighting various case reports, observational studies and a few very modestly sized randomized trials, we are far from understanding how this technology can influence neurologic outcome, yet alone overall peri-operative outcomes. A few of these publications are highlighted further on in this text and in the suggested readings at the end of this summary. This list is by no means comprehensive, but it does outline some of the more influential papers in the field.

Despite approval by regulatory authorities, the FDA (and other national regulatory bodies) does not require these devices (as opposed to pharmaceuticals) to be linked to an improvement in patient outcome. These devices need only be shown to validly determine the measurements that they claim to measure. That is, they only need demonstrate that they validly measure actual tissue oxygenation, with no proof required that by measuring this (and/or intervening to modify it) that they can improve outcome. This is the irony of the technology approval pathway (as opposed to pharmaceutical approval). That said, those who intermittently (and many who routinely) utilize these devices repeatedly have developed their own understanding of the potential utility of cerebral oximetry and provide case after case of anecdotal evidence of how these devices have averted certain catastrophe. However, these sorts of endorsements are clearly insufficient to confidently warrant wide-scale adoption of this technology. However, proponents of a more wide spread adoption, point to other technologies that we currently cannot do without (such as pulse oximetry) that have never undergone the same scrutiny for which cerebral oximetry is now being considered. It is clear that pulse oximetry has never been demonstrated in a large randomized double blind controlled clinical trial to improve outcome, yet none of us could advocate not using it. The same type of grandfathering process that led to the current use of pulse oximetry will not be afforded to other technologies and it is now in the hands of clinicians, academics, researchers, and device companies to prove the true worth of these devices.

We have a history in peri-operative medicine and anaesthesia, of failing to properly examine clinical utility of the devices we now integrate into our everyday practice although we as a specialty are not unique since other specialties also lack the timely yet rigorous evaluation of technologies and interventions. No better an example of this is with BIS technology. Despite its wide availability for almost 15 years, we have only recently undertaken the needed large-scale clinical trials to truly evaluate the utility of its initial stated purpose. If we don’t learn from these examples, we will soon be in the same
position with cerebral oximetry. In fact, in many respects we are already there, as commercially available oximetric devices have been available since the mid to late 1990s.

Complicating the issue of technology utility is the apparent differences in the various devices that are now available. Extrapolating information (and utility) derived from one device, is not necessarily applicable to similar, though subtly different devices. Arguing against this device specific evaluation is again the example of the pulse oximeter where none of us could confidently dismiss a saturation signal from one pulse oximeter manufacturer over the other. Clearly there are subtle differences in these pulse oximetry devices (such as how they deal with artifact induced by movement and low flow states), but essentially pulse oximetry is pulse oximetry, despite which manufacturer has his name on it. It is likely too early, however, to say the same for the 4 devices (and likely more to come) that are now on the market. This makes the design of clinical trials somewhat difficult as until equivalency is determined, we are handicapped in designing trials that should probably have uniformity of technology.

As compelling an argument one can make at the present moment for the use of these devices (I personally would not like to do a case without the information that it provides me, though this is clearly an opinion not based on solid scientific grounds), we need hard scientific data to definitely prove this point and outline how best to manage patients. A further handicap is that no technology can improve outcome without being linked to a management strategy. We are still in our relative infancy in understanding how to intervene based on the information that these devices provide for us. Although interventional algorithms (such as the one proposed by Denault et al) have been suggested, they have not yet been subjected to the rigor of corroborative clinical trials.

The rationale for using cerebral oximetry developed from multiple sources, an example of which was data from Croughwell et al based on the relationship between jugular bulb desaturation and clinical outcome. However, the invasiveness of jugular bulb saturation and other logistical difficulties have limited its use, making a non-invasive option that can capture some of the same information highly desirable. Cerebral oximeter devices were first used to focus on brain injury after cardiac surgery. As there had been well described pattern of brain injury in this area since the advent of cardiac surgery, to have a monitor to determine when these injurious events occurred was clearly advantageous. What followed in the literature was a logical time course and pattern with observational and anecdotal case reports of the use of these devices.

One of the first of many observational studies published was by Yao et al who reported an observational trial focusing on the relationship between the degree of cerebral desaturation and functional brain outcome. Specifically, they examined the integral accounting for the amount of time and degree of cerebral desaturation compared to the postoperative mental status examination (MMSE) and other indices of frontal lobe function. What these investigators demonstrated was that the more severe the desaturation the patients experienced, the more impaired their cognitive function was. Numerous case reports continued the discussion of potential overall clinical utility of this device. Because of its fast signal response time, it rapidly became a user friendly (as compared to invasive jugular venous saturation and tedious TCD) monitor of cerebral perfusion, in particular, being excellent at interrogating the symmetry of perfusion across the brain. Without doubt, numerous catastrophic intra-operative events were avoided by the use of this device by the early recognition of perfusion abnormalities in the brain. Both in the adult as well as in the paediatric literature, these types of anecdotal case reports are increasingly prevalent.

However, it has only been relatively recently that randomized controlled data specifically defining the utility of cerebral
oximetry have been published. Murkin et al published a trial of 200 patients in which an interventional strategy was utilized to maintain the cerebral saturation signals within 75% of their baseline reading. This interventional strategy was based upon optimizing both oxygen supply and utilization in the brain. For example, following establishment of the baseline reading (an initial step in utilizing cerebral oximetry), the investigators instituted an interventional algorithm if the patient’s saturation dropped 20% from their baseline. This intervention included ruling out mechanical causes such as cannula malplacement or jugular venous impingement due to head position, and followed with techniques to optimize oxygen supply to the brain. For example, if patients were hypocapnic, PaCO₂ was returned to a normal level. In addition, the mean arterial pressure (MAP) was increased modestly, and as well, there were increases in FiO₂. If these parameters failed to return the saturation to normal, and if there was significant anaemia, the patients were transfused to improve oxygen carrying capacity. If these efforts to improve oxygen delivery failed, additional methods to suppress cerebral oxygen metabolism were used including administration of additional propofol and modest cooling. This management strategy has been further elucidated by Denault and colleagues.

Although the Murkin et al study was not adequately powered to examine neurological outcome (i.e. stroke) the results did demonstrate a trend toward the stroke reduction in patients that were managed with the interventional algorithm. However, what was unique about the study was that not only was there a trend toward an improvement in neurologic outcome, but that there was an improvement in an overall organ outcome as identified by reduction in major organ morbidity. Indeed, this study described that the use of these technologies may have come full circle from only examining brain perfusion (as a means to improve neurologic outcome) to the point of monitoring brain perfusion as an index organ for overall organ function. Interestingly, Murkin et al suggested that the brain simply represents an index organ for overall tissue perfusion. This is partly correct as it is the only major organ that is within reach of the light sources that these devices utilize. However, in some respects its unique protective mechanisms (i.e. autoregulation) make it the last organ to be compromised in a situation of impaired blood flow and oxygenation. It is exactly the opposite of the ‘canary in the coal mine’ in that its oxygenation status is maintained long after other organs (such as those perfused by the splanchnic vasculature) have been compromised. Thus, although it is probably important to maintain its saturation, covert tissue compromise is likely occurring frequently despite our confidence that we are doing all the right things. This probably accounts for the lack of robust correlation to overall outcome.

More recently, Slater et al have also studied the use of cerebral oximetry in cardiac surgery. 265 patients undergoing cardiopulmonary bypass were randomized to either be blinded to cerebral oximetry or unblinded with the aforementioned interventions if cerebral saturations (rSO₂) dropped below 20% of baseline. Neurocognitive testing was performed pre-operatively, prior to hospital discharge, and at 3 months. Although the incidence of neurocognitive dysfunction was not decreased in the treatment group (59% vs. 61%), they did find a correlation between prolonged cerebral desaturation below 50% (i.e. 25% below baseline) and increased risk of neurocognitive decline. An rSO₂ desaturation score was calculated as the length of time each patient’s rSO₂ was below 50%. An rSO₂ score greater than 3,000%-second below 50% was seen in 33% of patients with postoperative cognitive decline compared to 20% of patients with no decline (P = 0.024). When multivariate analyses were performed, there was a trend towards decreased cognitive decline in the intervention group (OR = 0.81, 95% C.I. 0.46-1.43), but this was not statistically significant (P = 0.47). The authors suggest that the failure to see a treatment effect may have been the result of poor
compliance with the protocol when an intraoperative rSO2 desaturation was encountered. Although the study was not powered to study length of hospital stay, they found a significant correlation between prolonged rSO2 desaturation and hospital stay greater than 6 days (OR 2.71, 95% C.I. 1.31-5.60, P = 0.07), which may also add to the data that cerebral oximetry may be a surrogate marker for overall end organ perfusion/oxygenation.

There are probably a limited number of clinical situations where there is a distinctly robust relationship of oximetric data to outcome. One of these is in the use of cerebral oximetry for monitoring the symmetry of brain blood flow during antegrade selective cerebral perfusion (such as during hypothermic circulatory arrest for aortic arch surgery). I would argue that this is the best, most user friendly (certainly compared to transcranial Doppler) and pertinent monitor one can use in this situation. However, due to the limited numbers of these cases, it is unlikely that his will be proven in a large-scale clinical trial. However, it remains an essential monitoring apparatus for these cases.

Although most of the studies reported have been in cardiac surgical patients, Casati et al studied cerebral oximetry in an elderly general surgical population, again demonstrating that improvements in neurologic outcome (i.e. postoperative cognitive dysfunction) could be reduced if this type of monitor was used with a similar type interventional strategy.

So where are we now, and where do we need to go? We have such compelling data that at this point, I contend that it would do our patients a disservice to abandon (due to the lack of definitive supportive data) this technology. Similarly, it would be a great disservice not to do the work to definitely prove its overall utility. Getting there, however, will take a very well defined and progressive approach that needs to answer in a step-wise fashion, a number of smaller, but contributory questions. I believe that despite its wide availability, we are in the relative infancy in the life of cerebral oximetry as a peri-operative monitor.

References

P2-2
Monitoring with Point-of-Care Hemo-
stasis Testing. Does it affect Outcome? 
In which patients?

Linda Shore-Lesserson MD, FASE
President of the Society of Cardiovascu-
ar Anesthesiologists (SCA), Professor of 
Anesthesiology, Director of Cardiothoracic 
Anesthesiology, Northshore-Long Island 
Jewish Medical Center, Montefiore Medical 
Center, New York, USA

Point-of-care (POC) haemostasis testing has 
been known for decades to improve the 
care of patients undergoing complex surgery 
who have excessive bleeding. Testing dates 
back to the 1940’s, when viscoelastic testing 
of whole blood was first introduced, and to 
the 1960’s, when whole blood clotting times 
were utilized for cardiovascular surgery. The 
array and variety of available POC haemo-
stasis tests are enormous. The healthcare 
market is currently saturated with complex 
and expensive instruments whose real value 
and contribution to cost-effective care is un-
known. The following summary will describe 
the POC instruments whose value in reduc-
ing the transfusion of blood products and/or 
in reducing morbidity associated with car-
diac surgery has been demonstrated in the 
literature.

Transfusion Algorithms

Many transfusion algorithms have been 
shown to reduce transfusion requirements 
in cardiac surgical patients. The key to a 
cost-effective algorithm is early diagnosis of 
non-coagulopathy-related bleeding (surgical 
bleeding) and the careful measurement of 
likely defects expected. Major morbidity is 
incurred when patients are transfused mul-
tiple allogeneic blood products and when 
re-operation for surgical bleeding occurs late 
in the course of bleeding. For these reasons, 
the implementation of viscoelastic testing in 
the form of Thromboelastography (TEG®) or 
ROTEM® has been ideal. These instruments 
are acutely able to measure platelet function, 
fibrinogen function, coagulation factor func-
tion, and fibrinolysis, all of which are likely 
culprits contributing to bleeding in cardio-
vascular surgical patients.

The use of POC testing has also proven 
advantageous in directing the therapies with 
pro-coagulant drugs used in certain transfu-
sion practices. TEG has been used to guide 
rVIIa treatment in surgical patients and 
ROTEM is utilized in certain algorithms to 
diagnose the need to treat with prothrom-
bin complex concentrates, after fibrinogen 
has been repleted. Observational data and 
randomized trials demonstrate that point-
of-care directed algorithms reduce transfu-
sion requirements and have thus contributed 
to the Class IA recommendation for blood 
management POC algorithms in the STS/SCA 
Guidelines for Blood Conservation.

Anti-Platelet Therapeutics in Cardiovascu-
lar Patients

Anti-thrombotic therapy for the treatment 
of acute coronary syndromes and interven-
tional cardiology procedures is increasing 
and the development of new drugs contin-
ues. Treatment of patients after implant of 
a drug-eluting stent includes 12 months of 
anti-thrombotic therapy which poses a risk 
for patients who require surgery in that time 
period. Testing of interventional cardiology 
patients who have a drug-eluting stent does 
not prove cost-effective since the drugs used 
have a fairly wide therapeutic index in the 
general non-surgical population. However, 
drug resistance is a problem with clopidogrel 
and patients suspected of reduced respon-
siveness to drug may benefit from drug or ge-
netic testing. Cardiovascular patients who are 
maintained on drugs such as clopidogrel and 
prasugrel, have increased bleeding compli-
cations and morbidity after cardiac surgery. 
Thus surgical patients have a unique need 
for platelet testing. There is evidence that an
increased risk of infection exists in cardiac surgical patients who have taken clopidogrel and aspirin prior to surgery. This may be a result of an increased volume of transfusion, an increase in bleeding itself, or an independent effect. These drugs (thienopyridine agents) act by non-competitive antagonism at one of the platelet ADP receptors, the P2Y12 receptor. The P2Y12 receptor inhibits cyclic AMP production and potentiates platelet aggregation. The duration of anti-platelet activity is the life-span of the platelet because the P2Y12 receptor is permanently altered. The effects of clopidogrel plus aspirin are not just additive, they are synergistic and this may explain why cardiac surgical patients having received this combination of drugs seem to have excessive postoperative bleeding. Ticagrelor, a new anti-thrombotic agent in the cyclo-pentyl-triazolo-pyrimidine class, works as a direct-acting inhibitor of platelet P2Y12 inhibitor. Unlike the thienopyridine agents this drug’s antagonistic effects on the receptor is reversible making it a more attractive alternative for patients who may be at high risk for requiring a surgical procedure. Specific monitoring of the platelet defect induced by these anti-thrombotic drugs would be advantageous for a number of reasons. For therapeutic efficacy, the degree to which patients are protected from thrombotic events is related to the degree of platelet inhibition. Thus platelet function monitoring can be used for titrating drug effect. However, when patients present for surgery after discontinuation of clopidogrel, specific platelet function testing is useful in order to determine the risk of bleeding need for transfusion. A number of point-of-care platelet function assays have been developed that utilize ADP and can assess the degree of platelet inhibition with some degree of accuracy as compared with standard aggregometry. Platelet function tests are listed in the Table.

Many of the POC tests listed in the Table can also be used in transfusion algorithms for treating bleeding patients in the perioperative period. New guidelines were recently published in The Annals of Thoracic Surgery that include POC testing for platelet reactivity as a new recommendation for preoperative patient assessment. These platelet function assays are useful to detect patients who have residual anti-thrombotic therapy on board and those that have CPB-induced bleeding.

The use of POC testing must be employed with careful cost-benefit analyses. Testing must measure those defects most

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Mechanism/Agonist</th>
<th>Clinical Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thromboelastograph®</td>
<td>Viscoelastic/Thrombin (native), ADP, arachidonic acid (AA)</td>
<td>Post-CPB, liver transplant, paediatric, obstetrics, drugs</td>
</tr>
<tr>
<td>ROTEM®</td>
<td>Viscoelastic/Thrombin</td>
<td>Post-CPB?, drug efficacy</td>
</tr>
<tr>
<td>Sonoclot®</td>
<td>Viscoelastic/Thrombin</td>
<td>Post-CPB, liver transplant</td>
</tr>
<tr>
<td>PlateletWorks®</td>
<td>Plt count ratio/ADP, AA, collagen</td>
<td>Post-CPB, drug therapy</td>
</tr>
<tr>
<td>PFA-100®</td>
<td>In vitro bleeding time/ADP, epinephrine</td>
<td>vWD, congenital disorder, aspirin therapy, post-CPB</td>
</tr>
<tr>
<td>VerifyNow®</td>
<td>Agglutination/TRAP, AA, ADP</td>
<td>Drug therapy</td>
</tr>
<tr>
<td>Clot Signature Analyser®</td>
<td>Shear-induced in vitro bleeding time/ Collagen</td>
<td>Post-CPB, drug effects</td>
</tr>
<tr>
<td>Whole blood aggregometry</td>
<td>Electrical impedance/Many</td>
<td>Post-CPB, drug effects</td>
</tr>
<tr>
<td>Multiplate analyser</td>
<td>Electrical impedance/ADP, AA, collagen, ristocetin, TRAP-6</td>
<td>Drug therapy, congenital disorder, post-CPB</td>
</tr>
</tbody>
</table>
likely to occur in certain surgical patients and the testing must result in treatments (or lack of treatment) that result in reduced morbidity, length of stay and cost. The decision in whom to measure and when to measure must be carefully designed by the clinician team in order to optimize outcomes.

References

P2-3
Transcatheter AVR – Does this technology have merit and in whom? An anesthesiologist’s perspective

Jack Shanewise, MD
Professor & Director Division of Cardiothoracic Anesthesiology. Columbia University College of Physicians & Surgeons, New York, USA

Aortic valve replacement (AVR), secondary to calcific aortic stenosis, remains the most common valvular heart surgery with 50,000 procedures performed annually in the US [1, 2]. Although percutaneous valvuloplasty provides temporary relief [3], valvular stenosis and symptoms typically return within 6 months [4], making valvular replacement the only definitive therapy [5, 6]. Aortic stenosis prevalence and age-related co-morbidities will increase as the population ages [7].
Health care providers have been developing novel techniques for addressing symptomatic aortic stenosis, including transcatheter prosthetic valve implantation [8].

Despite the clear benefits of AVR for patients with stenotic valves [9], open AVR surgery in high-risk patients has an associated peri-operative mortality of 4-18%, dependent on patient co-morbidities [10, 11]. Consequently, despite the dismal prognosis of symptomatic aortic stenosis [12], open-heart surgery is often withheld from high-risk patients. A less invasive management for valvular stenosis might benefit this patient population. Cribier first described transcatheter aortic valve replacement (TAVR) following transcatheter valvuloplasty in 2002 [13]. He chose to approach the aortic valve (AV) via femoral venous cannulation, trans-atrial septal puncture, and antegrade deployment through the left ventricular outflow tract by way of the mitral valve. Since then, and more popularly, prosthetic aortic valves have been deployed retrograde, from the aorta, via cannulation of the femoral artery and antegrade, by puncture of the left ventricular (LV) apex via a small left thoracotomy [14]. The Partner Trial is a multicentre, randomized study comparing TAVR to medical management (including balloon valvuloplasty) in patients not considered to be surgical candidates and to conventional AVR in high-risk surgical candidates. Published results showed improved survival with TAVR over medical management [15] and equivalent mid-term survival compared to AVR [16]. Questions have been raised about these studies and the broad application of TAVR in place of conventional AVR [17].

In 2011 the FDA approved TAVR with one device for patients with severe AS who are not surgical candidates, and there are ongoing trials comparing TAVR to conventional AVR in high-risk patients with two devices. Recently an expert consensus document addressing TAVR was published in a collaborative effort by the American Heart Association, American Society of Echocardiography, European Association for Cardio-Thoracic Surgery, Heart Failure Society of America, Mended Hearts, Society of Cardiovascular Anesthesiologists, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance. [18]. It includes an extensive review of the development of TAVR and considerations in evaluating patients for the procedure and the team approach needed to have a successful TAVR programme.

The anaesthetic considerations of TAVR have been reviewed [19]. We have employed haemodynamic monitoring and general anaesthesia with endotracheal intubation on all cases, but some centres have used conscious sedation for transfemoral procedures. Most agree that performing TOE during TAVR is an indication for general anaesthesia and intubation. Most cases require some pressor support and a few positive inotropic agents during the procedure. Double lumen endotracheal tubes for one lung ventilation have not been necessary for the transapical cases. A cardiopulmonary bypass machine and a perfusionist team are on standby in the room for transapical cases. We have been able to extubate most of the transfemoral cases, and more than half of the transapical patients in the cath lab or OR at the end of the procedure. As experience has accumulated, the procedures are taking less time and are having fewer problems.

At my institution all patients receive TOE monitoring during valve implantation. The TOE probe is inserted after endotracheal intubation and removed at the end of the procedure. A comprehensive baseline exam is performed to reconfirm the diagnosis, assess baseline ventricular function, and detect associated valvular lesions such as mitral and tricuspid regurgitation. Measurements of the AV annulus are made from 3D views to assist size selection of the prosthetic valve. The annulus must be between 18-21 or 22-25 mm in diameter, for use of the 23 or 26 mm Edwards’ prosthesis, respectively. To prevent obscuring the fluoroscopic image during positioning and inflation of the valvuloplasty
balloon, the TOE probe is withdrawn to the level of the aortic arch and then re-advanced to assess the results, focusing primarily on the severity of AR. The TOE probe is again withdrawn for positioning and deployment of the prosthesis under fluoroscopic imaging, and then advanced to assess the results. As with any major cardiac intervention, we found TOE to be invaluable while monitoring procedural cardiac function.

The deployed device is examined with TOE in short and long axis views to assess the position of the device within the AV annulus. Deployment too proximal in the left ventricular outflow tract may cause over expansion of the device and central regurgitation. Distal deployment may cause valve emboiliation into the aorta or interference with coronary blood flow. Colour flow Doppler assesses AR. TOE can be particularly helpful in differentiating transvalvular AR from perivalvular AR, an important distinction that remains difficult to make using aortic root contrast injection and fluoroscopy. Perivalvular AR may be treated by re-inflating the deployment balloon within the prosthesis, further expanding the valve within the annulus. Significant transvalvular AR suggests over expansion of the prosthesis, which may require deployment of a second prosthetic valve within the first. TOE is also helpful in detecting potential complications such as aortic dissection, myocardial ischaemia from coronary artery ostial obstruction or emboiliation, and hypovolaemia. The application of TOE during TAVR has recently been reviewed [20] and guidelines have been published [21].

References
7. Boon NA, Bloomfield P. The medical management of valvar heart disease. Heart


Pulmonary Hypertension

There are multiple different classifications of pulmonary hypertension. However, from the Anesthesiologist’s point of view there are two main subgroups: pulmonary hypertension due to left-heart disease and pulmonary hypertension due to end-stage lung disease (ESLD). Although primary pulmonary hypertension may in and of itself be a cause of ESLD, this is a rare condition that has an incidence of only 1-2 per million [1]. Much more commonly, pulmonary hypertension and right ventricular failure is the result of chronic hypoxemia and ESLD. Although much has been written about anesthesia for patients with pulmonary hypertension, most of the literature focuses on patients with underlying cardiac disease [2]. Clinicians are more likely to encounter patients with pulmonary hypertension secondary to lung disease and the anesthetic management is very different from patients with left-heart disease [3].

While estimates vary widely depending on disease severity and the method of measurement, the prevalence of pulmonary hypertension (mean pulmonary artery pressure > 25 mm Hg) in advanced COPD, IPF, and CF ranges from 40-50% [4]. As pulmonary artery pressures rise, evidence of cor pulmonale develops as increased strain causes the right ventricle to hypertrophy and become dysfunctional. In the United States, cor pulmonale accounts for 10-30% of all heart failure admissions, of which 84% are secondary to COPD. The risk of right ventricular ischemia is also increased. The right ventricle is normally perfused throughout the cardiac cycle. However, the increased right ventricular trans-mural and intra-cavitary pressures associated with pulmonary hypertension may restrict perfusion of the right coronary artery during systole, especially if pulmonary artery pressures approach systemic levels. Avoiding hypotension is key to managing these patients.

The impact of pulmonary hypertension on right ventricular dysfunction has several anesthetic implications. The hemodynamic goals are similar to other conditions in which cardiac output is relatively fixed. Care should be taken to avoid physiologic states which will worsen pulmonary hypertension such as hypoxemia, hypercarbia, acidosis, and hypothermia. Conditions which impair right ventricular filling such as tachycardia and arrhythmias may not be well tolerated. Ideally, under anesthesia, right ventricular contractility and systemic vascular resistance is maintained or increased while pulmonary vascular resistance decreases. This would ensure forward flow and minimize the risk of right ventricular ischemia. In practice, these goals can be a challenge to achieve because anesthetics are commonly associated with either i) a decrease in systemic vascular resistance (SVR) and a variable affect on pulmonary vascular resistance (PVR) (e.g. propofol, thiopental, inhalational agents), or ii) minimal effects on systemic and pulmonary
vascular tone (e.g. benzodiazepines, opioids). Ketamine may be an interesting exception. Known for its sympathomimetic effects, ketamine increases cardiac contractility and SVR. However, its effect on PVR is controversial. Though concern is often raised over ketamine's potential to worsen pulmonary hypertension, animal and human clinical studies have suggested that it may decrease PVR [5]. Anecdotally, at the author’s institution, ketamine is commonly and safely used to induce patients with severe pulmonary hypertension. Volatile anesthetics may be detrimental to the hemodynamics in patients with pulmonary hypertension and right heart failure. An animal model has shown that sevoflurane causes the most hypotension and has the most negative effects compared to desflurane or isoflurane [6].

Inotropes such as dobutamine and phosphodiesterase inhibitors (e.g. milrinone) may improve hemodynamics in patients with pulmonary hypertension secondary to cardiac disease. However, they cause systemic vascular tone to decrease and can cause a deterioration in patients with underlying lung disease. To maintain a systemic blood pressure that is greater than the pulmonary pressure, vasopressors such as phenylephrine or nor-epinephrine are commonly used. Of the two, norepinephrine is better suited in pulmonary hypertension because it maintains cardiac index and decreases the ratio of pulmonary artery pressure (PAP) to systemic blood pressure (SBP). In contrast, phenylephrine causes the cardiac index to drop while the PAP:SBP ratio remains the same [7]. Increasingly, vasopressin is also being used to maintain systemic pressures. Based on limited human data, vasopressin appears to significantly increase SBP without affecting PAPs in patients with pulmonary hypertension [8]. In patients with severe pulmonary hypertension, selective pulmonary vasodilators including inhaled nitric oxide and inhaled prostaglandins should be considered. The extreme ends of patient lung volumes can cause compression of the extra-alveolar and alveolar vessels, both of which contribute to an increased PVR. As a result, a ventilation strategy that avoids atelectasis as well as lung hyperinflation should be employed.

Treatment of the failing right ventricle in the context of ESLD involves two steps. First, restoration of the systemic blood pressure with the use of pressors to maintain the coronary perfusion pressure of the right-heart. Second, an inhaled pulmonary vasodilator to decrease pulmonary vascular resistance and to restore cardiac output. Nitric oxide (NO) has been used for this purpose but is not available in many centers. Nebulized, prostanoids can lead to similar improvements in oxygenation and pulmonary pressures as compared to inhaled NO. A crossover study compared inhaled NO to inhaled prostaglandins in patients after lung or heart transplantation. In this acute hemodynamic study, there was no significant difference in hemodynamics or oxygenation between agents [9]. Prostacyclin can be delivered by nebulizer into a ventilator circuit at a starting dose of 50 ng/kg/min and clinical effects should be evident within 10min [10].

Although there have been multiple case report of the use of lumbar epidural analgesia in obstetric patients with pulmonary hypertension [11], there are very few reports of the use of thoracic epidural analgesia in pulmonary hypertension. Animal studies suggest that the hemodynamic response to an increase in right ventricular afterload is very different with thoracic vs. lumbar epidurals. Right ventricular contractility increases as afterload increases in animals with lumbar epidural local anesthetic blockade, similar to the response in animals without neuraxial block. However the cardiac sympathectomy of thoracic epidural blockade abolishes this increase in contractility [12].

References
2. Fischer LG, Van Aken H, Bürkle H. Management of pulmonary hypertension: phys-


17:30 h – P4
Pro/Con Debate Transfusion & Haemostasis

Chairs: David Royston, UK; Pilar Panigua, Spain

P4-1
Fibrinogen: Necessary in cardiovascular surgery? Pro position

Sibylle Kozek
Professor and Chairwoman, Department of Anaesthesia and Intensive Care, Evangelisches Krankenhaus, University of Vienna, Vienna, Austria

1) Fibrinogen is coagulation factor 1 and plays a pivotal role in haemostasis.

2) Fibrinogen levels correlate inversely with postoperative bleeding in cardiovascular surgery (r up to −0.897). Accordingly, fibrinogen is useful in protecting against bleeding.

3) Decreased fibrin polymerization occurs among other pathological mechanisms in the complex peri-operative coagulopathy in cardiovascular surgery. This may result in decreased resistance against fibrinolysis, platelet aggregation, adsorption of factors IIa and Xa with potential clinical correlates of increased fibrinolysis, platelet dysfunction and thrombosis.

4) Fibrinogen is antithrombin 1. Accordingly, fibrinogen is useful in protecting against thromboembolism.

5) Fibrinogen is affected by other confounders which may occur during cardiovascular surgery. Acidosis increases fibrinogen breakdown; hypothermia decreases fibrinogen synthesis. During progressive bleeding fibrinogen levels deteriorate critically before other coagulation factors.

6) Fibrinogen can be substituted by administration of fibrinogen concentrate, fresh
frozen plasma, cryoprecipitate. Differences in efficacy and safety have been outlined at EACTA 2012.

7) Scientific evidence including prospective RCTs show that goal-directed substitution with fibrinogen concentrate according to predefined target values (of fibrinogen function) decrease bleeding, transfusion requirements, re-exploration rates, critical adverse events, thrombosis, costs, lactate levels, postoperative duration of mechanical ventilation, and mortality. Thus, procoagulant therapy with fibrinogen concentrate among other goal-directed interventions according to an algorithm, is useful in improving patient outcome and patient safety.

8) Evidence-based guideline of the European Society of Anaesthesiology (ESA) on the management of severe peri-operative bleeding recommends that fibrinogen concentrate infusion guided by point-of-care viscoelastic coagulation monitoring should be used to reduce peri-operative blood loss in complex cardiovascular surgery (GRADE 1B).

P4-2
Fibrinogen: Necessary in cardiovascular surgery? Con position

Wulf Dietrich MD, PhD
Departments of Anaesthesiology and Transfusion Medicine, Institute for Research in Cardiac Anaesthesia, University of Munich, Munich, Germany

Over recent years there was an explosive utilization of fibrinogen in cardiac surgery. Fibrinogen is used as a universal haemostatic agent in excessive bleeding patients with reduced plasma concentrations of fibrinogen. It is an expensive clotting factor and very high dosages are recommended [1]. From a theoretical standpoint it seems to be biologically appropriate to transfuse fibrinogen and to strengthen the last step of the coagulation cascade in order to accomplish the formation of fibrin clots [2]. At the end of large and invasive operations there is always a sharp drop in fibrinogen plasma concentration. However, fibrinogen is an acute phase protein, which is replenished very fast. In cardiac surgery very high fibrinogen concentrations can be observed just a couple of hours after operation. Supra-normal concentrations exceeding normal concentrations by far can be seen on the first postoperative day and later on in cardiac surgical patients [3].

Fibrinogen is a risk factor for cardiovascular disease and cardiovascular events [4]. High fibrinogen concentrations may trigger adverse thrombotic events. Cardiac surgical patients are at increased risk of postoperative thromboembolic complications during and especially after operation and demonstrate a prothrombotic milieu postoperatively [5]. But little is known about the association of high fibrinogen levels and postoperative adverse events in cardiac surgery.

The evidence of the clinical effectiveness of fibrinogen substitution is poor in contrast to the widespread use in cardiovascular and orthopaedic anaesthesia [6]. Only a few studies with low quality [7] demonstrated effectiveness of high dosages fibrinogen in bleeding patients. Even less information is available about the postoperative course of fibrinogen plasma concentrations. The study most often referred to in regard to postoperative plasma levels and safety was a pilot study in just 20 patients (10 placebo and 10 fibrinogen) [8]. Another pilot study investigated fibrinogen substitution in AVR [9]. These two underpowered pilot studies support the clinical efficacy of pre-emptive use of fibrinogen concentrate; but the results are inconclusive. Larger studies are of retrospective design with only indirect evidence of the effectiveness of fibrinogen substitution [10]. The extremely high dosing was not justified in controlled trials [9]. Thus, dosing remains still an open issue [11]. The question is still open as to what is the appropriate level of fibrinogen to trigger treatment, and what is the optimal dose of fibrinogen? [12].
Convincing safety studies are lacking [6]. Therefore, prospective and controlled larger studies investigating not only the impact on blood loss and transfusion requirement but also on safety and outcome are urgently needed before the widespread use of fibrinogen in cardiac surgery is justified.

The recommendation of fibrinogen substitution is often derived from studies applying new POC devices [13]. Even the reduction of short- and long-term mortality was attributed to POC measurement and the use of fibrinogen [13] suggesting a selection bias in this study.

In conclusion, it is not argued that fibrinogen substitution does not reduce bleeding and transfusion requirement. This might be possible, but has not yet been conclusively demonstrated, since high-quality studies are lacking. The lack of scientific evidence is in sharp contrast to the intense marketing activities for this drug. The efficacy and safety of its pre-emptive use or of high-dose administration is unknown and the most effective dosing is still unclear. On the other hand, long-term safety is not proven even admitting that no safety signals are evident in existing studies. The main and final question remains, where is the evidence?

References
Biomarkers in preoperative risk assessment and optimization in vascular surgery

Prof Dr Miodrag Filipovic
Consultant Anaesthetist and Vice Head.
Institute of Anaesthesiology, Kantonsspital St. Gallen, Switzerland. Senior Lecturer in Anaesthesia and Intensive Care. Medical Faculty, University of Basel, Switzerland

The cardiac evaluation of patients with suspected heart failure is based on symptoms, ECG, chest x-ray, echocardiography and measurement of natriuretic peptides (NP) [1, 2]. Brain natriuretic peptide (BNP) and the N-terminal fragments of its pro-hormone (NT-proBNP) are neurohormones. They are released from the myocardium in response to cardiac volume and pressure load [3]. Both are of high diagnostic value in patients with congestive heart failure [4, 5] or acute coronary syndromes (ACS) [7, 8]. Moreover, relative changes of NP after initiation of therapy for heart failure were shown to be highly predictive for future outcome [9]. In addition, NP guided management of heart failure compared to standard care was associated with favourable outcome [10,11]. It was hypothesised that the survival benefit was based on a more appropriate drug use and dosage regime.

Heart failure is also a leading cause of cardiac morbidity and mortality after non-cardiac surgery [13, 14]. In accordance with the data in non-surgical populations, multiple studies proved strong associations between pre-operatively elevated NP values and the postoperative major adverse cardiac events (including mortality) [15-22]. This association was also confirmed in meta-analyses [23-26]. Despite the strong association between NP elevation and adverse outcome, the positive predictive value of NP elevation is low. However, the negative predictive value of non-elevated NP level before non-cardiac surgery was shown to be very high: In vascular surgical patients it was 0.965 (95% CI: 0.879-0.996) in case of a pre-operative BNP value below 50 pg/l [20]. Similar results were reported in other studies in patients undergoing vascular surgery [27] and non-vascular surgery [16] and were confirmed in a recent meta-analysis by Lurati where the negative predictive value of low NT levels before surgery was 0.94 (95% CI: 0.88-0.97) [25]. However, the optimal cut-off value is a matter of debate. The meta-analysis by Rodseth and colleagues used individual patient data and proposed an optimal “general” cut-off value for BNP of 116 pg/ml and a diagnostic cut-off value of 372 pg/ml [26]. These numbers are remarkably near to the cut-off values used in the non-surgical population [2].
According to the European guidelines for the evaluation of patients at cardiac risk undergoing non-cardiac surgery, “NT-proBNP and BNP measurements should be considered for obtaining independent prognostic information for peri-operative and late cardiac events in high-risk patients (Class IIa, level of evidence B) [28]. Troponins are structural proteins of the contractile apparatus of skeletal and myocardial myocytes. Cardiac troponins are released into circulation only upon the occurrence of cardiac cell death. Postoperative troponin analyses are widely used for diagnostic and prognostic reasons [29-38]. Recently, new high-sensitive troponin tests have been introduced in clinical practice. First promising results in the peri-operative setting show high prognostic information of these analyses [39]. However, their impact in surgical patients has still to be determined. The peri-operative role of troponin analyses will be discussed in detail in the next talk. Other biomarkers have been tested in nonsurgical populations. However, data in surgical patients are lacking.

In conclusion, we use pre-operative BNP measurements to 1) confirm or rule out diagnosis of congestive heart failure, 2) monitor advances in heart failure treatment in patients who presented with symptomatic heart failure, and 3) as a prognostic marker (focusing on the high negative predictive value). We use troponin analyses to rule out or confirm myocardial cell damage after surgery. However, more studies are needed to establish how biomarker-guided management will improve care and outcome of patients at cardiac risk undergoing major non-cardiac surgery [40].

References
1. McMurray JJ, Adamopoulos S, Anker SD, et al. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012: The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. Eur Heart J 2012; 32.


28. Poldermans D, Bax JJ, Boersma E, et al. Guidelines for pre-operative cardiac risk


**P5-2**

**Perioperative myocardial ischemia: diagnosis, prognostic significance and therapeutic strategies in vascular surgery**

**Pablo Alonso**, **Pilar Paniagua**, **Philip J. Devereaux**

1. Centro Cochrane Iberoamericano, Biomedical Research Institute (IIB-Sant Pau), Barcelona, Spain;
2. Dept. Anaesthesia and Critical Care, Hospital Santa Creu i Sant Pau, Barcelona, Spain;
3. Population Health Research Institute, Hamilton, Ontario, Canada. Department of Clinical Epidemiology and Biostatistics, McMaster University, Hamilton, Ontario, Canada

Worldwide over 200 million adults have major non-cardiac surgery annually [1].
benefits associated with surgery, major peri-operative complications, including death, occur. More than 1 million adults worldwide will die within 30 days of non-cardiac surgery each year, and myocardial ischaemia is a common cause.

Peri-operative risk estimation identifies patients who require more intensive monitoring and management in the postoperative period. Moreover, peri-operative risk estimation is needed to allow for informed decision making regarding the merits of surgery. Current pre-operative risk prediction models for 30-day mortality have limitations. Some authors advocate monitoring troponin measurements after vascular surgery, and inconclusive evidence suggests that troponin measurements after abdominal aortic surgery may enhance prediction of short-term mortality. Little is known about optimal troponin threshold(s) for predicting mortality after non-cardiac surgery.

Given this background we undertook a large international study called the Vascular events In non-cardiac Surgery patients COhort evaluatioN (VISION) Study (clinicaltrials.gov, identifier NCT00512109) evaluating major complications after non-cardiac surgery [2]. Participating patients had Troponin T (TnT) measurements after non-cardiac surgery. We assessed the relationship between the peak 4th generation TnT measurement after non-cardiac surgery and 30-day mortality.

In this international prospective cohort study of over 15,000 patients who were ≥45 years of age and underwent non-cardiac surgery who required hospital admission, multivariable analysis demonstrated that 4th generation peak TnT thresholds of 0.02 μg/L, 0.03 μg/L, and 0.30 μg/L independently predicted 30-day mortality [2]. Peak TnT values after non-cardiac surgery proved the strongest predictors of 30-day mortality, and the population attributable risk analysis suggested elevated TnT measurements after surgery may explain 41.8% of the deaths. Based on the identified peak TnT values, there were marked increases in the absolute risk of 30-day mortality (i.e., 1.0% for a TnT value ≤ 0.01 μg/L; 4.0% for a value of 0.02 μg/L; 9.3% for a value of 0.03-0.29 μg/L; and 16.9% for a value ≥ 0.30 μg/L); 11.6% of patients had a prognostically relevant peak TnT value ≥ 0.02 μg/L. The higher the peak TnT value the shorter the median time to death. Our net reclassification improvement analysis demonstrated that monitoring TnT values for the first 3 days after surgery substantially improved 30-day mortality risk stratification compared to assessment limited to pre-operative risk factors.

Although non-cardiac surgery has enormous potential to help patients, many patients die within 30 days of surgery (1.9% in VISION). Our study demonstrates that prognostically relevant TnT measurements after surgery strongly predict who will die within 30-days of surgery. While at present troponin measurements are not commonly measured after non-cardiac surgery, the simplicity of this test and its prognostic power suggest it may have substantial clinical utility. Considering that over 200 million adults undergo major non-cardiac surgery annually, potentially half of these patients are ≥ 45 years of age, and 11.6% of the patients in our study had a peak TnT value ≥ 0.02 μg/L, suggests that worldwide more than 10 million adults may have prognostically relevant troponin values after non-cardiac surgery annually.

Because the majority of patients who suffer a peri-operative myocardial infarction after non-cardiac surgery do not experience ischaemic symptoms [3], physicians may have missed diagnosing some of the patients with a prognostically relevant TnT value after surgery as having a cardiac event. Consistent with our finding, the third universal definition of myocardial infarction consensus statement recommends monitoring peri-operative troponin measurements in high-risk patients undergoing non-cardiac surgery [4].

Although no randomized controlled trial has established an effective treatment for patients with an elevated troponin measurement after non-cardiac surgery, the prognosis of these patients may be modifiable. First,
the high-quality evidence for acetyl-salicylic acid (ASA) and statin therapy in the non-operative setting, and encouraging observational data from a large international peri-operative trial showing an association with use of these drugs and decreased 30-day mortality in patients who have suffered a peri-operative myocardial injury, suggests that ASA and statin therapy may benefit patients with an elevated peri-operative troponin measurement. We have previously demonstrated that a substantial proportion of patients suffering a myocardial injury after non-cardiac surgery do not receive these drugs [5]. Second, the timeline from the peak TnT value until death demonstrates that there is time to intervene.

Clinical trials are needed to establish effective interventions to improve the outcome of patients suffering a myocardial injury after non-cardiac surgery. We have recently initiated a trial to determine the impact of dabigatran (a direct thrombin inhibitor) in patients who have suffered a myocardial infarction after non-cardiac surgery, and we will use a partial factorial design (for patients not taking a proton pump inhibitor) to determine the impact of omeprazole (a proton pump inhibitor) in this setting. We call this RCT the Management of myocardial infarction After NonCardiac surgery (MANAGE) Trial.

There is a clear need for much more research in the peri-operative setting. The MANAGE Trial is just one of many more clinical trials to come.

References

P5-3
Neurological monitoring during vascular surgery

Hans Knotzer, MD
Institute of Anesthesiology and Intensive Care Medicine II, Klinikum Wels, Austria

The intention for monitoring the human brain is to detect significant cerebral hypoperfusion and/or impairment of oxygen delivery to the brain. But how much perfusion pressure, regional blood flow, or oxygen does the brain need without any damage of its cells? And how to detect this ominous threshold?

First of all the brain receives 50-60 mL/100 g/min or 750 mL/min, which is 12-15 percent of resting cardiac output. Total cerebral oxygen consumption is 40-50 mL/min or 3-3.5 mL/100 g/min of oxygen, and accounts for 15-20 percent of the basal metabolic rate. If the cerebral blood flow decreases down to 25 mL/100 g/min an increase in oxygen extraction ratio may compensate a critical shortage of oxygen. Between 10 and 25 mL/100 g/min for several minutes reversible cerebral dysfunction will occur. An irreversible cell damage is the result with a cerebral perfusion below 10 mL/100 g/min for 8-10 min. However, the intercranial distribution is quite heterogeneous due to neural control, local metabolic effects, and chemical control, making a clear prediction according the minimal oxygen delivery nearly impossible. In addition, clinical effects like hypothermia
or alterations in functional oxygen consumption due to anesthetics also influence the need of oxygen or even protect the brain tissue against an ischemic insult.

Even nowadays the „gold standard“ for cerebral monitoring is recognised to be the awake patient, where changes in speech, cerebroation or motor power following e.g. cross-clamping of the carotid artery provide a more direct monitor of cerebral perfusion. For all patients during vascular surgery receiving general anesthesia, neurological function monitoring remains rather uncommon. The reasons are undoubtedly the opinion that cerebral monitoring devices are complex and costly, and producing only spurious results. On the other hand modern neuromonitoring technologies may be used to predict and modify clinical outcomes.

The triumphal procession of neurological monitoring during vascular surgery was born in carotid endarterectomy. Several types of currently available neuromonitors in vascular and cardiac surgery are routinely used in the daily praxis, with a clear trend in favor of devices, which are easy to handle and dedecting alterations quickly.

Transcranial Doppler monitoring provides a non-invasive means of measuring cerebral artery blood flow velocity, which is an indirect measure of cerebral blood flow. Problems intraoperatively may occur, as in up to 20% of patients, transcranial Doppler cannot be performed due to relative absence of transcranial window.

Evoked potentials are the electrical responses of the central nervous system to peripheral stimulation. The signal is error-prone as it is influenced by anaesthetic agents and electrocautery, and involve high level of technical complexity. Furthermore, interpretation of evoked potential as a guide to shunt placement in carotid endarterectomy have poor sensitivity.

Electroencephalography figures the spontaneous electrical activity of the cerebral cortex recorded through a series of scalp electrodes. Although automated processed EEG systems have been developed, the interpretation of continous intraoperative multi-channel EEG monitoring is time consuming and the interpretation relative complex. Most anaesthetic agents and opioids produce dose dependent EEG slowing culminating even in burst suppression. In addition, similar to evoked potentials, sensitivity for shunt guidance in carotid endarterectomy is still low.

Near infrared spectroscopy (NIRS) provides a non-invasive means of estimating regional cortical cerebral oxygenation and its use find out increased popularity in cardiac and vascular anaesthetists. Especially in cardiac surgery and carotid endarterectomy, cerebral NIRS seems a promising monitoring technique. NIRS has been shown to be predictive of postoperative length of hospital stay and cognitive function test performance in cardiac surgery. Data regarding a monitoring benefit from NIRS in vascular surgery in general or evidence to define a clear cut-off point for the presence of perioperative cerebral ischaemia is limited. Ending with a classical statement, I have to say that large prospective cohort studies addressing these issues are urgently needed.
repaired by an endovascular route. Healthy, non diseased infrarenal aortic necks of adequate lengths are needed for durable results. Diseased infrarenal necks temper the ability to achieve sealing or fixation with current commercialized stent-grafts. With the development of fenestrated and branched stent-grafts the endovascular treatment of suprarenal, juxtarenal and thoraco-abdominal aortic aneurysm has become feasible.

While the open repair of infrarenal aortic aneurysms can be performed with low perioperative morbidity and mortality, complication rates are greater with conventional repair of supra-, juxta- and thoraco-abdominal aneurysms.

Custom configured fenestrated stent grafts and fenestrated-branched stent grafts were designed to incorporate the renal arteries, the SMA and the coeliac trunk into the repair. The proximal sealing zone is in a stable higher segment. Fenestrated and branched grafting requires detailed preoperative imaging for accurate sizing of the device, high quality of intra-operative imaging, and expertise in advanced endoluminal techniques.

By probing the endoprosthesis and the respective fenestration branch a small bridging stent graft is placed in the respective visceral artery. The access for the whole procedure is a short surgical cut in the femoral artery on both sides or access by one femoral and one access in the axilla.

This complex method shows success in 95-98% and excellent mid-term results. The 30-day mortality rate is approximately 6% and spinal cord ischaemia is approx. 5%.

The advent of fenestrated and branched endovascular techniques vastly expands the treatment options for patients with complex or extensive aortic aneurysms. Such devices have the potential to decrease the morbidity and mortality of conventional repairs, but require special skills which include familiarity with three-dimensional imaging and endovascular interventions.

**P6-2 Management of ruptured abdominal aortic aneurysms**

**Janet T Powell**  
*Professor of Vascular Medicine, Faculty of Medicine, Imperial College, London, UK*

Ruptured abdominal aortic aneurysm carries a very high mortality in population studies and the rupture is nearly always fatal, if aneurysm repair is not available. Again, on a population basis, open repair under general anaesthesia has an operative mortality of 40-50%, unchanged for many years. Endovascular repair can be begun and sometimes completed using local or regional anaesthesia rather than general anaesthesia. Endovascular repair has an operative mortality of 30-35% in population series but possibly only about half of patients are anatomically suitable for endovascular repair. Nevertheless, there is remarkable evidence available from 2 large specialist centres in Switzerland, Bern where open repair is used and Zurich where endovascular repair is used. Each of these centres has specialist teams available, including cardiovascular anaesthetists, around the clock and in each centre the operative mortality rate is just 15%.

Increasingly, vascular services in Europe are being reorganized into larger more centralised groups. Should they offer patients with ruptured aneurysm open or endovascular repair? This issue is best addressed via randomised controlled trials.

The first pilot randomised trial from Nottingham UK showed a mortality of 53% in each group. A larger trial from 3 specialist centres in the Amsterdam area has just reported and showed no difference in outcomes between open and endovascular repair, although operative mortality was reduced to about 25% in each group. A similar size trial with just over 100 patients, ECAR, is running in France. The IMPROVE trial from the UK is the largest trial, with the target of randomizing 600 patients by the end of June 2013 (now 95% recruited). The impact of an-
aesthetic issues and anaesthetist vetoes on this trial will be discussed. For further details see www/improvetrial.org.

P6-3
Anaesthetic and Postoperative Management in Endovascular Aortic Replacement

Simon Howell
Imperial College London, BJA Editorial Board Member, Senior Lecturer, Section of Translational Anaesthetic & Surgical Sciences, Institute of Molecular Medicine, University of Leeds. Honorary Consultant Anaesthetist, Leeds Teaching Hospitals NHS Trust, Leeds, UK

It is now established that endovascular repair (EVAR) of abdominal aortic aneurysms confers a short term morbidity and mortality benefit as compared with open repair. It is not clear that this benefit is continued in the longer term. In the EVAR-1 study endovascular repair reduced postoperative 30-day mortality compared to open repair (1.6% vs. 4.7%, RR = 0.34). However, the early reduction in all-cause mortality with EVAR disappeared on long-term follow up [1]. The relatively non-invasive nature of EVAR has opened the way the treatment of aortic aneurysms in patients who would be considered unfit for open repair. The EVAR-2 study compared EVAR with conservative management in patients considered unfit for open repair. The EVAR-2 study compared EVAR with conservative management in patients considered unfit for open repair. EVAR was associated with considerable perioperative mortality and did not improve long-term survival as compared with conservative management [2]. However, the interpretation of the results is made difficult by the fact that there was considerable crossover between groups; a number of patients randomised to conservative management ultimately underwent aneurysm repair. The EVAR-2 study made clear that the long-term survival in patients considered unfit for surgery is poor. Overall mortality in the EVAR-2 study population after 4 years was 64%. The unresolved challenge facing clinicians is to identify which high risk patients will benefit from EVAR. Such benefit must be measured not only in terms of survival but also in terms of quality of life. A meta-analysis of long-term quality of life outcomes after aortic surgery gave equivocal results with better outcomes for open repair in some health domains e.g. general health and for EVAR in others e.g. social function [3]. In the face of such uncertainty high risk patients are frequently offered EVAR (with an appropriate discussion of the risks and benefits prior to surgery [4].

Initially general anaesthesia (GA) was preferred for EVAR as it met the requirements of the patient keeping still for long periods, control of respiration to facilitate imaging, cardiac standstill for stent deployment and a low threshold for conversion to open repair. With technical advances surgery is shorter and need for cardiac standstill reduced. Therefore local anaesthesia (LA) and regional anaesthesia (RA) have become options [5]. There are no data from randomised controlled trials to inform the choice of anaesthetic technique and the clinician has to fall back on data from observational studies. Analysis of over 5,000 patients in EUROSTAR database showed reduced mortality, morbidity, length of stay and intensive care admission with LA and RA. Fewer systemic complications were seen with both LA and RA as compared with GA [6]. A further analysis stratified patients in the registry into low, intermediate and high-risk. For high risk patients LA and RA were associated with fewer complications than GA [7]. An analysis of the American College of Surgeons Quality Improvement Database found an association between GA, increased length of stay and pulmonary morbidity [8]. In summary the weight of observational data favours the use of local or regional anaesthesia for endovascular aortic repair. However, it should be remembered that these studies may be subject to selection bias. The clinician will assess each case on its merits. The patient must be able to lie flat and still and to breath-hold. Factors such as a potential difficult airway or
the need for TOE may also lead the clinician to choose general anaesthesia.

Both open and endovascular aortic repair carry a risk of renal impairment. Analysis of data from the EVAR studies suggests that, in the case of abdominal aortic aneurysm, the impact on renal function of open repair and of EVAR are similar [9]. Numerous methods of renal protection in EVAR have been investigated but only close attention to perioperative hydration has been shown to yield consistent benefit [10].

Mortality from surgery for ruptured abdominal aortic aneurysm is 48(95% CI 46-50)% [11]. The question of whether this perioperative mortality can be reduced by the stenting of leaking or ruptured aneurysms is pressing. A pilot study conducted in Nottingham demonstrated that stenting of ruptured abdominal aortic aneurysms is feasible [12]. A large randomised controlled trial, IMPROVE is currently being in progress [13]. Anaesthesia for EVAR of a leaking aneurysm follows a different paradigm to that for emergency open repair, the aim being to avoid interventions that may produce cardiovascular instability until the aneurysm is fully excluded by the stent graft. This is often managed by performing the procedure under local anaesthetic infiltration of the groins.

In summary, EVAR is an evolving technology which is often deployed in high-risk patients considered unsuitable for other surgery and which presents considerable challenges to the anaesthetist.

References
12. Hinchliffe RJ, Bruijstens L, MacSweeney ST, Braithwaite BD. A randomised trial of endovascular and open surgery for ruptured abdominal aortic aneurysm – results of a pilot study and lessons learned for fu-

During the last decades, a growing bulk of data demonstrate that volatile anaesthetics have cardioprotective properties. Similarities have been found between ischaemic preconditioning and pharmacological preconditioning. For surgical patients at cardiac risk, the use of volatile anaesthetics may be more attractive than to exposing them to ischaemia prior to a more significant ischaemic event.

There appear to be multiple mechanisms of cardioprotection mediated via volatile anaesthetics, of which several converge in the opening of ATP-dependent mitochondrial potassium-channels [1]. Additional pathways that induce longer-term protection include iNOS and cyclo-oxygenase transcription and prevention of the mitochondrial permeability transition-pore (mPTP) opening [2]. Additionally, neutrophil and platelet aggregation is attenuated and anti-apoptosis mechanisms are activated [3].

Optimal cardioprotection appears in early (2-4 h) and late time window (24-72 h) after preconditioning treatment [4]. Whether prolonged administration beyond what has been clinically feasible in the operating room, provides protection between these windows of cardioprotection is unclear. There are some indications that prolonged volatile anaesthetic agent exposure may be more protective than short exposure [5].
After initial attention to preconditioning with volatile anaesthetic agents in order to attenuate ischaemic injury to the myocardium, potential protective effects in other organs have been found [6]. Additionally, the phenomenon of postconditioning, attenuation of ischaemia-reperfusion with treatment after the ischaemic event, has been demonstrated [1].

In parallel, there has been increasing interest and promising clinical data regarding volatile anaesthetics for postoperative sedation [7], as well as for sedation during invasive mechanical ventilation in critically ill patients [8]. Most studies of volatile anaesthetic sedation focus on clinical sedation effects. Volatile anaesthetic sedation is easily titrated, with few reported side effects, short wake-up times and less problems with delusions and hallucinations after terminated sedation [8, 9]. Clinically, patients appear lucid and oriented at an early stage after sedation but no study has primarily compared the incidence of delirium after volatile anaesthetic sedation vs. conventional sedation.

A few studies in postoperative coronary artery bypass patients suggest that postoperative sedation with sevoflurane may be of benefit from a myocardial protection standpoint [10, 11]. With this stated, it stands unclear whether there is a significant difference in relevant cardiac outcomes, compared to intravenous sedation.

The combined findings of volatile anaesthetics as potentially organ protective and as efficacious sedatives during mechanical ventilation, make them an attractive option for postoperative sedation in patients with vulnerable cardiac and other organ function, such as those undergoing surgery with significant ischaemia-reperfusion, as sedatives to mechanically ventilated patients with unstable coronary circulation or for sedation during therapeutic hypothermia after cardiac arrest. For this latter group, the short wake-up times found in sedation studies with volatile anaesthetics and the findings of postconditioning neuroprotective effects of volatile anaesthetics [12-14] further warrants future studies of this presently off-label method.

References
Invited Lecture 2:  
Postoperative atrial fibrillation; anything new?  

Alberto Hernández  
Hammersmith Hospital – Imperial College Healthcare NHS Trust, London, UK  

Introduction  
Postoperative atrial fibrillation (POAF) is the most common arrhythmia after cardiac surgery [1] and its peak incidence is on the second or third postoperative days [2]. The prevalence of POAF varies from 25-40% after isolated coronary artery bypass surgery (CABG) to 40-50% after valve surgery and 50-60% after combined CABG and concomitant valve surgery [3]. Multiple causative factors have been described without any single factor being singled out as the principle factor of this complication. POAF has been associated with an increased incidence of postoperative complication, length of hospital stay and subsequent increase of the cost of hospitalization [4]. Currently, there are significant variations in the prevention strategies for POAF, with varied supportive evidence.  

Risk factors and predictors of POAF  
The precise pathophysiology of POAF is unknown; however most of the evidence suggests that it is multifactorial [5]. Identifying patients at risk of POAF would be useful in initiating prophylactic measures. Risk factors such as older age, previous history of AF, male gender, decreased left-ventricular ejection fraction, valvular heart surgery, left atrial enlargement, chronic obstructive pulmonary disease, chronic renal failure, diabetes mellitus, and rheumatic heart disease are associated with development of atrial fibrillation. Furthermore, the use of cardiopulmonary bypass (CPB), duration of surgery, the influence of cardioplegia and prolonged aortic cross-clamp time are possible factors responsible for postoperative occurrence of AF [6-8]. Several studies have suggested that a heightened sympathetic response predisposes a patient to developing AF. However, it is interesting to note that the highest sympathetic levels are found 24 hours postoperatively and that most episodes of POAF develop on day 2 or 3 [9-10]. At present, it is hypothesized that AF is initiated by ectopic beats predominantly originating from the thoracic veins. Re-entry, increased automaticity, and triggered activity have all been postulated as mechanisms that can cause arrhythmogenesis from the pulmonary veins [11].  

Prevention Strategies for Atrial Fibrillation  
A number of pharmacological and non-pharmacological methods are available for prevention of POAF. Beta-blockers reduce
significantly the incidence of POAF and there is evidence that they should not be withdrawn pre-operatively and should be restarted at the earliest in the postoperative period [12-13]. Amiodarone has been used both as an oral and intravenous agent for prevention of POAF and has shown effectiveness in reducing the incidence of POAF [14]. However intravenous amiodarone given postoperatively has been associated with a greater likelihood of bradycardia and hypotension when given as prophylaxis against POAF. Calcium-channel blockers also have been shown to be effective for prophylaxis against POAF although peri-operative use may be associated with an increased incidence of atrioventricular block and low-output syndrome [15]. Other drugs used for prevention of POAF include digoxin, magnesium, and other antiarrhythmic agents such ibutilide, procainamide, propafenone and anti-inflammatory drugs such corticosteroids, non-steroidal anti-inflammatory drugs (NSAIDs), statins and colchicina and others such ascorbic acid, N-acetylcysteine, coenzyme Q10. Non-pharmacological methods include atrial pacing, a maze procedure or posterior pericardiotomy which may be useful in preventing POAF [16].

References
Delirium or acute confusion is a transient mental syndrome characterized by disturbances in consciousness, cognition and perception. Recently, the reported incidence of delirium in patients after cardiac operations was very high (46%) [1]. There are three subtypes of delirium: hyperactive, hypoactive and mixed form. Hypoactive delirium is the predominately subtype after cardiac surgery. This finding is particularly important because hypoactive delirium remains unrecognized in 75% of patients in the absence of standardized assessment. Delirium after cardiac procedures is associated with increased mortality, more hospital re-admissions and reduced quality of life and cognitive function.

The most established predisposing risk factors are atrial fibrillation, prior cognitive impairment, depression, history of stroke, older age and peripheral vascular disease. Red blood cell transfusion, a low cardiac output and the use of intra-aortic balloon pump or inotropic medications seem to be the most relevant risk factors associated with postoperative delirium.

Early mobilization in the postoperative period and avoiding the use of benzodiazepines may be useful for prevention of delirium.

Routine monitoring of delirium is feasible in clinical practice using the CAM-ICU scale.

New drugs like risperidone or dexmedetomidine are useful for the treatment of delirium. In a recent guidelines for the management of delirium in ICU patients, the authors suggest the use of a continuous intravenous infusion of dexmedetomidine to reduce the duration of delirium in these patients [2].

References
Pre-operative anaemia, even to a mild degree, is significantly and independently associated with increased postoperative morbidity and mortality. This association might be aggravated by concomitant peri-surgical blood loss and (frequently unnecessary) allogeneic transfusions [1]. Although anaemia is a serious but easily treatable condition, pre-operative diagnosis and routine treatment (apart from transfusions of red blood cells) has almost never been routinely undertaken before surgery. Treatment is less costly than is transfusion and possibly improves outcome not only by increased tolerance of peri-operative blood loss and avoidance of allogeneic transfusions but also through elimination of the risk of anaemia by maintaining increased physiological haemoglobin values throughout the peri-operative period [2].

About a third of patients with pre-operative anaemia would have nutritional deficiencies, a third would have chronic disease, and a third would have anaemia from an unknown cause [3]. Because of the prevalence, treatability, and negative outcome of pre-operative anaemia, preservation and improvement of pre-operative red-blood-cell mass is essential. It is the first of the three pillars of the new patient blood management strategy period [4]. Implementation of this patient blood management strategy not only reduces transfusion requirements but also improves postoperative outcome, at least in patients undergoing orthopaedic and cardiac surgery [5,6].

Diagnosis and treatment of pre-operative anaemia is time-consuming and, therefore, detection and assessment of anaemia should be undertaken close to 28 days before scheduled surgery to enable adequate treatment. Furthermore, in case of unexplained anaemia planned surgery with substantial predicted blood loss should be rescheduled. Most importantly, pharmacologic tools available for anaemia management such as iron preparations and erythropoiesis-stimulating agents (ESAs) should be used [7].

However, some drawbacks of pre-operative anaemia treatment need to be considered. In some populations of patients, treatment with iron or erythropoiesis-stimulating drugs might be ineffective, have serious side-effects, and, therefore, might not be indicated [7]. Moreover, at least in patients with chronic disease, anaemia might be regarded as an adaptive mechanism. For such patients, treatment of mild-to-moderate anaemia with iron or erythropoiesis stimulating drugs might increase morbidity and mortality despite an improvement in functional capacity and wellbeing [8,9].

More aggressive anaemia treatment of renal failure and tumour patients was associated with increased morbidity (thrombosis or cardiovascular events) or increased mortality in the ESA-treated cohorts [10]. However, there is evidence of decreased mortality risk associated with greater use of ESAs and more frequent use of iron at lower haematocrit.
levels where mortality is the highest. In contrast, while lower overall mortality risk occurs at higher haematocrit levels, elevated mortality risk was associated with greater use of ESAs and iron in these patients [11]. Furthermore, the effect of ESA on tumour growth is still controversially discussed. Nevertheless, the use of ESAs in cancer patients should be based on the initiation of therapy in patients whose haemoglobin levels are <10 g/dL or who have symptomatic anaemia. Minimal ESA dosage should be targeted toward RBC responses sufficient for patients to benefit from ESA therapy by avoidance of or reduced allogeneic blood transfusions.

The relationship between erythropoietin, iron, and erythropoiesis and the presence of iron-restricted erythropoiesis has important implications in anaemia management [12]. An enhanced RBC production is seen in response to parenteral iron therapy in patients treated with ESA therapy, demonstrating that this functional iron deficiency can be ameliorated. Intravenous iron administration (especially when using iron carboxymaltose preparations) seems to be safe, as very few severe side-effects were observed. It may result in hastened recovery from anaemia and lower transfusion requirements. However, many of the recommendations given for intravenous iron treatment are not supported by a high level of evidence [13]. Only few peri-operative outcome studies are available, because only transfusion requirement was the primary outcome variable in most of the peri-operative studies. In elective spine surgery a higher incidence of deep vein thrombosis in patients receiving ESA compared with placebo was documented. In contrast to other clinical trials in joint replacement these patients did not receive prophylactic antithrombotic therapy [14].

Nevertheless the implementation of treatment of anaemia as part of a universal patient blood management strategy should become the standard of care in patients undergoing elective surgical procedures, particularly in those where substantial blood loss is expected. However, additional studies are urgently needed to secure the efficacy and safety of pre-operative treatment of anaemia.

References


P7-2
The bleeding patient

Marcel Levi MD
Department of Medicine, Academic Medical Center, University of Amsterdam, Amsterdam, The Netherlands

Excessive bleeding may complicate cardiac surgery and is associated with enhanced morbidity and mortality. Substantial morbidity and mortality is related to (sometimes excessive) bleeding and associated (poly) transfusion. A dilutional coagulopathy as a result of massive blood loss in combination with circumstances such as acidosis and hypothermia may aggravate the bleeding tendency. The extent of the coagulopathy is often underestimated by conventional coagulation tests. Management of bleeding consists of local control, measures to retain adequate circulation, and proper transfusion procedures. In addition to these strategies, pro-haemostatic treatment may in some cases support the treatment of (severe) bleeding.

Pharmacological strategies aimed to reduce peri-operative bleeding have been investigated in a large number of controlled trials, most of which show a reduction in blood loss. Pro-haemostatic therapy aims at an improvement of haemostasis, which may be achieved by amelioration of primary haemostasis, stimulation of fibrin formation or inhibition of fibrinolysis. These treatment strategies may be applied to specifically correct a defect in one of the pathways of coagulation, but have in some situations also been shown to be effective in reducing bleeding in patients without a primary defect in coagulation.

Besides the transfusion of platelets in case of thrombocytopenia or severe platelet disorders, a pharmacological improvement of primary haemostasis may be achieved by the administration of desmopressin. The administration of DDAVP results in a marked increase in the plasma concentration of Von Willebrand factor (and associated coagulation factor VIII) and (also by yet unexplained additional mechanisms) a remarkable potentiation of primary haemostasis as a consequence. The application of DDAVP in cardiac surgery has not been shown to contribute to better outcome.

Based on the current insight that activation of coagulation in vivo predominantly proceeds by the tissue factor/factor VII(a) pathway, recombinant factor VIIa has been developed as a prohaemostatic agent. In mostly uncontrolled clinical studies this compound has been shown to exert a potent procoagulant activity and appeared to be highly effective in the prevention and treatment of bleeding, although controlled studies with relevant outcomes are scarce. Application of rVIIa in selected cardiac surgery patients may be an interesting option but deserves better study, also in view of the potential prothrombotic effect of the drug.

Agents that exert anti-fibrinolytic activity are aprotinin and the group of lysine analogues. In recent years, aprotinin has been associated with adverse outcomes and is in most countries not available. Lysine analogues, however, are effective agents in reducing peri-operative blood loss and appear
to be relatively safe, and therefore can be considered as clinically helpful pro-haemostatic agents.

P7-3
Impact of the age of red blood cells and the outcome after cardiac surgery

Christian von Heymann
Department of Anaesthesiology and Intensive Care Medicine, Charité – University Hospital, Berlin, Germany

Cardiac surgery and bleeding associated with cardiac surgery consume relevant proportions of blood donations worldwide. While it has been shown that blood transfusions are associated with a higher incidence of adverse outcome after adult [1] and pediatric cardiac surgery [2], the causes for this association remain not elucidated.

As a possible explanation the duration of red blood cell (RBC) storage has been proposed, as the older age of RBC was associated with a higher incidence of infectious complications, longer hospital stay and a higher mortality rate [3, 4]. The rationale behind this hypothesis is the so-called “storage lesion” of RBC that is described by a depletion of adenosine triphosphate (ATP), 2,3- diphosphoglycerate (2,3-DPG), S-nitroso-hemoglobin (SNO-Hb) and a reduction in RBC membrane deformability reducing the RBCs capacity to deliver oxygen to tissues [5]. Furthermore, an immune response to the transfusion of allogeneic blood has been discussed to be involved with the higher incidence of infectious complications after surgery [6, 7].

In this regard a recent metaanalysis including studies from different clinical specialties showed that the use of old blood was associated with a higher risk of death. Of note, this finding was consistent over all surgical specialties investigated and, therefore, also applied to cardiac surgical patients. Apart from mortality a significant association between the incidence of multiple organ dysfunction and pneumonia and the transfusion of old blood was shown [8].

However, the body of evidence suggesting that old RBC is associated with adverse events in the cardiac surgical population is opposed by observational and retrospective data that do not confirm this association [9, 10]. From a methodological point of view, most of the data investigating the association of age or RBC and clinical outcome after cardiac surgery originate from observational or retrospective studies. So far, there are only 3 prospective randomized trials with a small number of patients, so that the existing evidence is still challenged by confounders [11] requiring a prospective randomized trial that is currently under way in cardiac surgery (RECESS-Trial, NCT00991341).

This lecture will
1) address the definition of the RBC storage lesion,
2) present the most recent data from clinical trials and metaanalyses on the effect of the age of RBC on the clinical outcome after adult and pediatric cardiac surgery and
3) critically summarize the existing evidence and define the gaps in knowledge that need to be addressed in further research.

References
3. Koch CG, Li L, Sessler DI, Figueroa P, Hoeltge GA, Mihaljevic T, Blackstone EH. Duration of red-cell storage and complica-

10:30 h – P8
New Drugs and Techniques in Hemostasis: better outcome?
Chairs: Marco Ranucci, Italy; Nikolaus Hoffman, Austria

P8-1
New antiplatelets. A problem in cardiac surgery?

Jose Mateo
Head, Unit of Haemostasis and Thrombosis. Department of Haematology. Hospital de la Santa Creu i Sant Pau. Barcelona, Spain

P8-2
New oral anticoagulants in cardiac surgery – management of coagulation and haemostasis

Wulf Dietrich MD, PhD
Departments of Anaesthesiology and Transfusion Medicine, Institute for Research in Cardiac Anaesthesia, University of Munich, Munich, Germany

For a long time oral coumadine or sc. heparin were the sole alternatives for long-term anticoagulation for prevention or treatment of thromboembolic events. Recently, new oral anticoagulants (NOAC) with predictable pharmacokinetics and dynamics are available for these indications [1]. Factor Xa is one important target for anticoagulant drugs due to its role as the factor in thrombin generation and amplification. The direct factor Xa inhibitors inhibit free Factor Xa and are independent of antithrombin action. This is in contrast to all species of heparin, which are indirect anticoagulants, depending on antithrombin to inhibit Factor IIa and Xa. Rivaroxaban, the first anti Xa agent, has a half-life of 5–9 h in healthy subjects and 11–13 h in the elderly. It is approved in the US and Europe for VTE prophylaxis after hip or knee replacement and for stroke prevention in patients with non-valvular AF and patients at
risk of recurrence of pulmonary embolism [2]. In different studies, rivaroxaban was not inferior to warfarin in efficacy, with no significant difference in major bleeding events [3].

Another oral, direct Factor Xa inhibitor with good oral bioavailability is Apixaban [4], which is highly protein bound, has a half-life of 8–15 h and reaches peak plasma concentration within 2–3 h after intake, providing a fast onset of action. Again, these data are obtained in healthy subjects and not in multi-morbid or elderly patients. Apixaban 2.5 mg twice daily is the recommended dose for VTE prophylaxis, based on pharmacokinetic studies. In the Apixaban for Reduction in Stroke and Other Thromboembolic Events in Atrial Fibrillation (ARISTOTLE) trial for stroke prevention, patients were excluded if they had a CrCl < 25 ml/min [4]. Thus, no dose adjustment is recommended in patients with mild (CrCl, 50–80 ml/min) or moderate renal impairment; but no data are available for patients with severe renal impairment (CrCl < 25 ml/min).

Thrombin is an alternative target of the NOACs. Dabigatran is a reversible direct thrombin inhibitor that directly, without the prerequisite of antithrombin, inhibits free and fibrin-bound thrombin. It has low bioavailability (app. 6.5%), low binding to plasma proteins in contrast to other NOACs, and undergoes renal excretion, with 80% of the drug entering the urine unchanged [5]. The low bioavailability is in contrast to the other drugs, having a high drug dosage and consequently the large size of the tablets. The peak plasma concentration is reached about 3 h after administration, and it has a half-life of 13-17 h, but again, measured in healthy volunteers and not in patients. Dabigatran is contraindicated in patients with a CrCl < 30 ml/min. It is approved in Europe for thromboprophylaxis following total hip or knee replacement based on the results of the ADVANCE trials and for stroke prevention [6].

Monitoring anticoagulation with new oral anticoagulants

Routine laboratory testing is not recommended in NOAC-treated patients, but periodic monitoring of renal function (especially in patients with pre-existing impaired renal function) is strongly recommended [7]. This must be emphasized for patients undergoing cardiac surgery. Coagulation function tests should be ordered for any anticoagulated patient presenting with an acute bleeding, suspected overdose, or requiring emergency surgery. None of the routine function tests is directly proportional to the plasma concentration and these tests are not useful for measuring the pharmacodynamic effects. However, almost all of the routine coagulation assays will be prolonged. Prolongation of thromboplastin time or partial thromboplastin time is indicative for the presence of the drug and normal results will likely indicate the absence of a clinically important anticoagulant effect [7]. TEG or Rotem show a prolongation of the coagulation parameters (r or k time) without modification of the amplitude, rendering these test not useful for routine measurement. The ecarin clotting time (ECT) may be a useful tool for estimation of clotting capability. However, all these tests provide qualitative but not quantitative information in emergency situations.

When to stop prior to surgery?

The risk of bleeding must be carefully weighed against the risk of thrombosis before discontinuing any anticoagulant medication. The indication for anticoagulation is crucial for stopping the treatment prior to operation. Patients anticoagulated for prevention of DVT or the recurrence of PE should be handled differently from patients treated for AF or ‘off label’ for mechanical valve carriers. Routine coagulation tests may be used to identify patients with still circulating drug concentrations. However again, it does not provide quantitative useful results. Postoperative neuraxial blockade for pain relief needs to be weighed against the risk of haematoma. Since the clinical practice especially in car-
Cardiac surgery is so limited, neuroaxial techniques in patients with the risk of residual anticoagulant should not be used yet [8,9]. Among patients having urgent surgery, major bleeding occurred in 18% with dabigatran 110 mg, 18% with dabigatran 150 mg, and 22% with warfarin [10].

Interventions in bleeding patients

A direct antidote for the NOACs is not available [11]. The most important question in patients undergoing cardiac surgery and having pre-operative treatment with NOACs is the possibility and effectiveness of interventions in the case of acute bleeding. Fresh frozen plasma or four-factor (II, VII, IX, X) varieties of PCCs are used to effectively replace depleted factors in warfarin-treated patients. These interventions seem to be of limited effectiveness in bleeding due to NOACs. The reason for this limited effectiveness has not yet really been elucidated [7]. Haemodialysis or haemoperfusion is one potential option for the emergency removal of anticoagulants. Especially due to its low protein binding, dabigatran can be removed by haemodialysis, while rivaroxaban and apixaban are too highly protein bound to be effectively removed by these methods.

Recombinant factor VIIa (rFVIIa), though clinically not indicated or effective in catastrophic bleeding [12], is increasingly used off-label as a universal haemostatic and reversal agent. This treatment might be effective as rescue treatment [13].

Conclusion

We are facing an explosive increase in the use of the modern oral anticoagulants. The new oral anticoagulants may in the long run, replace warfarin. Cardiac surgical patients with AF and treated with NOACs will challenge the cardiac anaesthetist in the future, especially in emergency situations. Almost all of the clinical studies have been done in controlled patients excluding mostly patients with impaired renal function or other comorbidities. More clinical studies in real-life situations are needed to determine the best method for control and reversal of the NOACs when bleeding occurs. Based on the available evidence, supportive care and interventions including dialysis for dabigatran should be considered in case of bleeding. Potential therapeutic approaches for patients treated with rivaroxaban include the use of PCCs or, as last resort, activated F VII; but additional studies are urgently needed. Whenever possible and indicated, these new drugs should be stopped pre-operatively at times based on renal function and procedure. Additional drug-specific antidotes are still also under investigation but not yet available [7].

References


P8-3
Alternatives to Heparin during Cardiopulmonary Bypass and in the Intensive Care Unit

Dave Royston
Consultant in Cardiothoracic Anaesthesia, Royal Brompton and Harefield NHS Foundation Trust, Harefield Hospital, London, UK

Heparin was introduced into clinical practice in 1935 and remains the most common anticoagulant in use today. It is estimated that 30% of all patients admitted to a hospital receive some form of heparin. However, biologic variability of action and immunogenicity limit its utility. Unfractionated heparin (UFH), is a mixture of polysaccharide chains that forms complexes with various plasma proteins including endogenous antithrombin. This heparin antithrombin complex inactivates coagulation factors Xa, Xlla, Xla) IXa and IIa.

In addition all heparins are immunogenic. Heparin in nature is not found in the vascular compartment. Heparin complexes with platelet factor 4 form a unique epitope against which an antibody (most commonly immunoglobulin G) develops. In the presence of exogenous heparin, this antibody binds to platelets and leads to platelet cross-linking and generation of procoagulant microparticles; a condition termed heparin induced thrombocytopenia (HIT) type 2. This syndrome occurs in about 1 to 3% of all patients who receive heparin. Although low molecular weight heparin (LMWH) is historically associated with a lower rate of antibody formation, about a fifth to a half of patients with antibodies associated with UFH will cross-react to LMWH. Also, plasma from about a third of patients with HIT will aggregate platelets in the presence of LMWH.
If anticoagulation is required and heparin is contraindicated there are 5 alternate agents. Three have been approved for treatment of patients with HIT type II in the UK: danaparoid, lepirudin and argatroban. Lepirudin was withdrawn from the market by the manufacturer on 1st April 2012 and there have been manufacturing problems with danaparoid which have caused a global shortage with no date for re-supply. Two other anticoagulants, bivalirudin and fondaparinux have been used without a license in patients with HIT.

Danaparoid is a mixture of heparan sulphate (85%), dermatan sulphate (10%) and chondroitin sulphate (5%) derived from porcine intestinal mucosa. The heparan sulphate portion contains the same pentasaccharide sequence as heparin that potentiates AT III activity. Danaparoid exerts its anticoagulant effect mainly through anti-factor Xa activity. It has been used extensively in the treatment of patients with HIT in a wide variety of clinical situations. None the less its long half life makes it totally unsuitable as an anticoagulant during cardiopulmonary bypass where catastrophic post-bypass bleeding as been frequently reported.

Argatroban is a small (527 Da), synthetic direct thrombin inhibitor derived from L-arginine. Argatroban binds reversibly to the catalytic domain of thrombin at only this single location, a so-called univalent inhibitor. There is activity against both free and clot-bound thrombin, with no activity against factor Xa or plasmin. Standard dosing is 2 microgram/kg/min intravenously, and the drug is titrated to achieve an activated partial thromboplastin time (aPTT) of 1.5 to 3 times control and may be monitored at point-of-care via the activated clotting time (ACT). The prothrombin time is also prolonged with argatroban, complicating transition to oral vitamin K antagonists. Argatroban undergoes hepatic metabolism and excretion with a half-life of 40 to 50 minutes. Given that it is not renally cleared, it has a predictable effect in patients with renal insufficiency. There is no specific antidote for argatroban. In the setting of percutaneous coronary intervention (PCI), argatroban is approved for use in patients with HIT.

Bivalirudin has a unique structure with a dodecapeptide attached to the active binding site moiety by 4 glycine residues. This structure binds to both the active enzymatic site and an exosite-binding site producing a so-called bivalent direct thrombin inhibitor.

The half-life of bivalirudin is 25 minutes after intravenous administration and increases to up to 4 hours in patients with renal failure undergoing dialysis. Only 20% of the drug is excreted in the urine, whereas 80% undergoes enzymatic proteolysis with a second thrombin molecule able to cleave the proline-arginine bond of the binding site moiety. Bivalirudin therapy can be monitored by aPTT or the ACT. It is approved for anticoagulation for patients undergoing PCI. In the USA it is also approved for patients with, or at risk of HIT undergoing PCI while in Canada it is approved for patients with, or at risk of HIT undergoing cardiac surgery.

Allergy to bivalirudin and argatroban is rare. Bivalirudin has renal excretion but also a unique metabolic elimination process. A second thrombin molecule can cleave the Pro-Arg bond of the active site binding moiety to metabolize bivalirudin. This obviously improves the safety of use of bivalirudin in patients with impaired renal function such as the elderly. However when used with any kind of extracorporeal support the blood in the system must never be allowed to stagnate otherwise the bivalirudin will be metabolized and the anticoagulation effect lost. This imposes massive technical challenges for the perfusionist.

Fondaparinux is a synthetic pentasaccharide that has been extensively studied for prophylaxis of venous thromboembolism (VTE) post-orthopaedic and abdominal surgery, and treatment of deep venous thrombosis and pulmonary embolism. Given the low rate of de-novo antibody formation and the apparent lack of cross-reactivity with HIT antibodies, fondaparinux may represent...
A relatively safe alternate anticoagulant agent for use in patients with a history of HIT.

A further approach to the problems of anticoagulation for extracorporeal support is to allow the use of heparin but to prevent platelet activation by administering a drug which inhibits platelet shape change such as epoprostenol or prostaglandin E1 or prevent platelet binding by administering tirofiban to inhibit the glycoprotein IIb/IIIa receptor. The latter has been well described and avoids the cardiovascular effects of eicosanoid use.

Finally a number of orally active agents have been introduced into clinical practice to prevent venous thrombosis and embolic stroke. Included in these are the thrombin inhibitor dabagatran and the anti Xa agents rivaroxaban and apixaban. Their use in the context of heart surgery has recently been tempered by the stopping of the RE-ALIGN study of dabagatran in those patients with mechanical valves who had both bleeding and thrombotic complications. Dabagatran is now contraindicated in these patients and no studies for the Xa antagonists are planned.

14:30 h – P9
ICU: Pro/Con Debate
Chairs: Alain Vuylsteke, UK; Peter Alston, UK

P9-1
Only cardiothoracic anaesthetists can be good cardiothoracic intensivists

Sven-Erik Ricksten MD, PhD
Department of Anaesthesiology and Intensive Care Medicine, Sahlgrenska University Hospital, Gothenburg, Sweden

The risk profile of patients undergoing cardiac surgery has changed over the past 2-3 decades. More extensive cardiac surgery procedures are now performed on older patients with lower left ventricular ejection fractions and higher New York Heart Association classification and with more advanced co-morbidity. The ideal intensive care unit (ICU) organisational framework for the post-cardiothoracic surgery patients with increasing complexity is under debate. In many institutions, these patients are treated in mixed surgical ICUs or even in mixed surgical/medical ICUs by certified general intensivists. In other institutions, particularly in larger centres in Scandinavian countries, ICUs dedicated to the care of the post-cardiothoracic surgical patients have been implemented for many years. These cardiothoracic ICUs have traditionally been staffed by specialists in anaesthesia and intensive care, trained in and devoted to cardiothoracic anaesthesia/intensive care.

In a recent retrospective propensity-matched study, a cohort of patients admitted to cardiac surgery ICU (CICU), were compared to a control cohort consisted of cardiac surgery patients admitted to the traditional, mixed surgical ICU (SICU) [1]. The primary outcome measures were blood product utilisation, mechanical ventilation requirement, postoperative complications and re-admission to ICU. The CICU was staffed by a daytime cardiac anaesthetist responsible for
“fast-track” patients and 24-hour-in-house consultant cardiac anaesthetists and surgeons with formal critical care training. Nursing background and experience with cardiac surgery patients were similar between the two groups. The need for transfusion of red blood cells, platelets and plasma were decreased in the CICU compared to the SICU cohort. ICU and hospital length of stays were significantly reduced in the CICU group Furthermore, the CICU patients were less likely to arrive in the ICU intubated. The incidence of complications and re-admission to the ICU were similar in the two groups.

The pathophysiology, the surgical procedures and postoperative complications of the cardiothoracic patients are truly unique to medical practice and tailored and focused ICU care of these patients is essential for good postoperative outcome. It is therefore crucial to have individuals in the staff who understand the complexity of the operation and are capable of delivering appropriate ICU care. The ICU staff member who is best suited for this is not the general intensivist, whose skills and competence are directed to a huge population of general ICU patients. Instead, the specialist in cardiothoracic anaesthesia and intensive care, can deliver both anaesthesia and intensive care from the operating room with a continuity of anaesthesia/intensive care that flows from the operating room to the ICU on a 24-hour basis. In this respect, the operating room and the ICU are interconnected sites, and the same group of physicians, providing both cardiothoracic anaesthesia and intensive care, should be those who provide peri-operative care of these patients. In conclusion, the postoperative ICU management of the post-cardiothoracic surgery patient should be performed in a dedicated cardiothoracic ICU, staffed with nurses and cardiothoracic anaesthetists/intensivists involved only in the care of the cardiothoracic surgical patient, on a 24-hour basis.

P9-2
Any intensivist can be a good cardiothoracic intensivist

*Andy Rhodes*
London, President of the ESICM

15:30 h – Invited Lecture
Chairs: Bodil S. Rasmussen, Denmark; Marcel Levi, Netherlands

Invited lecture 4: Pharmacoeconomics of Transfusion

*X Axel Hofmann MD, ME*

Institute of Anaesthesiology, University Hospital and University of Zurich, Zurich, Switzerland School of Surgery, Faculty of Medicine Dentistry and Health Sciences, University of Western Australia, Perth, Australia. Centre for Population Health Research, Curtin Health Innovation Research Institute, Curtin University, Perth, Australia. Western Australia Patient Blood Management Program Team, Office of the Chief Medical Officer, Western Australia, Department of Health, Perth, Australia

In times of escalating health care cost, it is of even greater importance to optimally allocate limited resources while maintaining a certain required standard of care. Pharmacoeconomic studies compare the cost and effectiveness of two or more competing pharmaceutical agents in order to make the best use of these resources. Although allogeneic blood components are not viewed yet as medicines or drugs, there is now broad support to add whole blood and red-cell concentrates to the World Health Organization’s (WHO) list of essential medicines [1]. The transfusion of allogeneic blood products is a highly prevalent and longstanding clinical practice, particularly in cardio-thoracic surgery [2]. For a long time, the cost of allogene-
ic transfusion has been underestimated and its effectiveness overestimated [3,4]. A listing of red-cell concentrates as a drug or medicine would encourage initiating cost-effectiveness analyses where red-cell transfusions are compared with various pharmacological treatment options to avoid or pre-empt transfusions.

The administration of blood transfusions is one of the most resource-intensive health interventions and costs tens of billions of dollars each year. At the same time, a growing body of evidence shows a dose-responsive increase in morbidity and mortality from transfusion whereas the scientific proof for benefit is almost non-existent.

Reported adverse outcomes associated with transfusion include infection, sepsis, delayed wound healing, transfusion-related acute lung injury (TRALI), multi-organ failure (MOF), systemic inflammatory response syndrome (SIRS), acute respiratory distress syndrome (ARDS), vasospasm, low-output heart failure, atrial fibrillation, cardiac arrest, renal failure, stroke, myocardial infarction, thromboembolism (arterial, venous), diminished postoperative functional recovery, bleeding requiring re-operation, cancer recurrence and increased mortality [5, 6].

More recent level-1 evidence comparing liberal versus restricted transfusion thresholds corroborates the published findings from large observational trials, demonstrating that transfusion significantly increases morbidity and mortality [7, 8]. With the exception of extreme patient settings, robust pharmacoeconomic analyses might therefore expose red-cell transfusions as a counter-productive rather than a cost-effective medicine. In contrast, a number of evidence-based treatment options to pre-empt and reduce allogeneic transfusions, namely Patient Blood Management (PBM) modalities are available [9, 10]. PBM programmes have already shown favourable cost-effectiveness ratios. Therefore a broader implementation is clearly indicated [11-17]. To benefit both patients and payers, the PBM concept has recently been endorsed by a World Health Assembly resolution WHA63.12 [18].

References


16:30 h – P10
Anything new in Cardiac Anaesthesia?

**Chairs:** Sven Erik Riksten, Sweden; Fernando Guillen, Spain

**P10-1**
Total circulatory arrest. What is new?

**Pascal Colson**
Head of Department of Anaesthesia and Critical Care, Hôpital Arnaud de Villeneuve, Montpellier, France

Complete cessation of the circulation is required when vessels are difficult to be surgically controlled to obtain a bloodless surgical field. It is indicated for great vessels surgery (ascending and arch aorta aneurysm or dissection, and pulmonary thromboendarterectomy), complex congenital heart defects, and rarely, neurosurgery (repair of giant cerebral aneurysms, resection of cerebral arterio-venous malformations), or excision of extensive hepatic and renal cell tumours. Complete cessation of the circulation necessitates the use of profound systemic hypothermia, so called deep hypothermic circulatory arrest (DHCA) to ensure organ protection. The brain is the organ most susceptible to ischaemia but the safe period of cerebral ischaemia could be increased by decreasing core temperature. Cerebral metabolism decreases by 6% every 1 °C, 18-20 °C allowing 30 min of DHCA without brain damage in most patients. However, DHCA prolongs CPB times as it requires careful management of cooling and rewarming and favours coagulopathy, factors known to impact intubation time, and ICU stay. Therefore, alternatives to DHCA have been proposed in cardiac surgery where cerebral circulation can be selectively perfused, while other organs can tolerate circulatory arrest at higher core temperature. These new strategies appear at least as safe as DHCA alone and represent the most recent evolution in the field as underlined by this short review on what’s new on DHCA.
**Time limits**

Most patients tolerate 30 min of DHCA at 18-20 °C without significant neurological dysfunction but there is an increased risk of brain injury above 40 min, and the majority of patients suffer irreversible brain injury when DHCA exceeds 60 min. Using selective cerebral perfusion, either retrograde (RCP) or antegrade perfusion (ACP), allows prolongation of the duration of circulatory arrest without compromising safety even at higher temperature (25-30 °C) [1-3]. Whether ACP is more effective than RCP is still matter of debate [4-7]. DHCA alone or associated with ACP or RCP is recommended in the guidelines edited by the ACCF/AHA task force in 2010 (Grade IIa, level of evidence B) [8]. However, if DHCA is good enough for 30 min, safety is improved by adjunction of RCP or ACP.

**Cooling and rewarming**

It has been known for years that cooling and rewarming should be gradual, long enough to achieve a homogeneous change in temperature of all organs. Tympanic membrane temperature is still considered as closest to the brain temperature. Rapid cooling or rewarming may create imbalance between oxygen supply and demand, and it might jeopardize brain protection.

**Acid-base management**

There is no evidence of the superiority of a-stat over pH-stat in adults. In piglet models of DHCA and in neonatal humans, however, the use of pH-stat during cooling appears to be associated with improved histological and clinical neurological outcomes. Therefore, it may be recommended that pH-stat be used during cooling before DHCA. During rewarming, the use of a-stat is thought to be beneficial as it prevents increased cerebral blood flow and the risk of cerebral oedema. If DHCA is not used, pH-stat is not advocated [9].

**Glycaemic control**

Hyperglycaemia during hypothermia worsens the impact of ischaemia through increased glycolysis and intracellular acidosis. A retrospective analysis of patients undergoing aortic arch surgery revealed that hyperglycaemia more than 250 mg/dL (13.35 mmol/L) was associated with an adverse neurologic outcome. Most patients undergoing DHCA develop impairment of glucose metabolism and will require control of glucose with insulin when glycaemia exceeds 180 mg/dL. If an insulin infusion is started in the pre-operative period, it should be continued in the intra-operative and early postoperative periods to keep the level below 180 mg/dL. The blood glucose level should be monitored every 30 to 60 minutes during insulin infusion with more intense monitoring (every 15 minutes) during the administration of cardioplegia, cooling, and rewarming [10].

**Pharmacologic Protection**

Many pharmacologic interventions have been proposed for brain protection during DHCA but no conclusive evidence of benefits, specially of drugs that reduce cerebral oxygen consumption (barbiturate) or systemic inflammatory response (corticoids).

**Neurophysiological monitoring**

Neurophysiologic monitoring may include EEG, somatosensory evoked potentials, but indices of cerebral oxygen delivery-consumption imbalance are more likely assessed by oxygen saturation of the jugular venous bulb (SjO₂), or near-infrared spectroscopy (NIRS). Oxygen saturation of the jugular venous bulb (SjO₂) has been advocated as a marker of global cerebral oxygenation and decreased values of SjO₂ indicate a decreased oxygen supply relative to demand. During cooling, SjO₂ values increase by a hypothermic decrease in cerebral oxygen consumption. Inversely, SjO₂ values decrease during rewarming and levels < 50% during rewarming have been associated with postoperative cognitive decline [11].
NIRS is a non-invasive monitoring technique that measures regional cerebral oxygen saturation (rSO$_2$). During cardiovascular surgery, decreasing rSO$_2$ trends seem to reliably reflect decreasing cerebral oxyhaemoglobin saturation. Before DHCA any decrease in cerebral oxygenation as detected by NIRS should lead to check: the position of aortic and superior vena cava cannulae including head and neck position, cerebral perfusion pressure including mean arterial pressure, arterial oxygen content, partial pressure of carbon dioxide, and haemoglobin level [12]. During cooling, cerebral oxygenation increases to $\geq$ 90% after 15 min of cooling to a nasopharyngeal temperature of 17-18 °C. After the onset of deep hypothermic circulatory arrest, there is an incremental decrease in cerebral oxygenation to a low value of 45-55% [13]. During aortic arch surgery under DHCA and ACP, sustained decreases in rSO$_2$ ($< 55\%$, $> 5$ minutes) are associated with the occurrence of postoperative neurologic adverse events [14]. NIRS has several limitations. Only a limited region of the brain is monitored, the use of electrocautery may interfere, and the different causes of declining rSO$_2$ (embolus and malperfusion) cannot be differentiated. It is essential to follow trends in oxygen saturation changes rather than absolute values.

In conclusion, DHCA is an established technique used during repair of aortic arch and other major vessels. Various methods such as ACP or RCP seem to augment the safety of DHCA, and may offer alternatives to deep hypothermia. Advances in cerebral monitoring are essential for improving patients’ outcome.

References

P10-2
Difficult weaning from CPB: something different since 2000?

Olivier Bastien MD, PhD
Professor of Anaesthesiology, Service d’Anesthésie-Réanimation, Hôpital Cardiovasculaire et Pneumologique L. Pradel, University Cl Bernard Lyon, France

As severity of disease and age of patients are increasing, less invasive procedures including hybrid interventions, mini-CPB, and video surgery are trying to decrease postoperative complications.

Difficult weaning from CPB is still a challenge for anaesthesiologist in cardiac surgery. Improvements are related to a pharmacological approach and mechanical support of the failing heart, but are very different depending on the aetiology. Three of them are mainly concerned with CPB weaning: peri-operative ischaemic disease, pre-operative poor left ventricular function and right ventricular failure related to pulmonary hypertension.

Peri-operative ischaemic disease

As many patients are diabetic or scheduled for redo, assessment of a previous by-pass is mandatory and should be checked if necessary, even in the immediate postoperative period. The intra-aortic balloon pump (IABP) is now controversial [1, 2] as many randomised control trials, including meta-analysis, don’t demonstrate any improvement in mortality in acute myocardial shock. Nevertheless clinical efficiency on endocardial ischaemic episodes as observed during the peri-operative period is still discussed [3].

Mechanical assistance by a ventricular assist device is now routinely used. The most simple and easy mode is ECMO, but others systems are available such as Impella, tandem Heart or Levitronix. No delay and rapid institution are clearly a goal for success, but mortality is still high and close to 35% [4].

Pre-operative poor left ventricular function

Ejection fraction of the left ventricle is a simple assessment of systolic LV function. Progress in mitral valve regurgitation surgery is responsible for an increasing number of patients scheduled for valvuloplasty with poor LV function. Many reviews emphasise diastolic dysfunction as detected by echocardiography but this aetiology is more related to postoperative instability than to difficult weaning from CPB.

All RC trials regarding mortality with inotropes are non-significant [5, 6] in large series of heart failure. Nevertheless all these
trials are non-surgical patients. Only small cohorts have been included after cardiac surgery. Enoximone [7] and levosimendan [8,9] are the more innovative drugs currently used during this decade, in adults as in paediatrics. New RCTs are necessary with acceptable methodology [10]. Responders during the early phase is possibly an option to rational use of these new and cost effective drugs [11].

**Right ventricular failure related to pulmonary hypertension**

RVF and PAH management is probably the most important improvement postoperatively. iNO and inhaled prostacycline are widely used in cardiac surgery. Disappointing results have been published by the Berliner group after left ventricular assistance, but in a very specific and long term medical problem.

Inhibitors of phosphodiesterase V (sildenafil and analogues) are safe in the postoperative period and could be easily used after extubation. The dose regimen is still debated especially in children. Tricuspid regurgitation surgery has been proposed as a complementary procedure for right dilated heart, but is a high risk for difficult weaning.

Pharmacological innovative drugs and new mechanical assistance devices could not be optimised if diagnosis and medical algorithms are not perfect. An important development is to clearly define and classify heart failure as with the INTERMACS scoring system. It has also been demonstrated in 2012 that the quality of cardiac surgeons might improve with a span from 1 to 10 for some complications [12]. This is reason to develop a bundle between anaesthetist and surgeon for this specific period.

**References**


10. Mebazaa A, Nieminen MS, Packer M, Cohen-Solal A, Kleber FX, et al SURVIVE In-


P10-3
Pulmonary hypertension and right ventricular failure: new tools for an old problem?

Didier Payen
Paris, France

Room 114

08:30 h – Invited Lecture + Oral Session
Chairs: Maria Jose Oliveira, Portugal; Alberto Hernandez, Spain

Invited Lecture 5:
An evidence-based approach to support the routine use of ultrasound for vascular access

Erik Sloth
Department of Anaesthesiology & Intensive Care, Aarhus University Hospital, Skejby, Denmark

Introduction
Vascular needle puncture or cannulation is the most common invasive procedure performed in the healthcare system. The exact number is not known, but probably it accounts for a two fold million procedures every day. Neither is the first attempt success rate known, but failures are very likely under reported. In a recent study, in the emergency department, where we tried to disclose the rate of success and failures for traditional peripheral vascular access without ultrasound (US) guidance we had to stop data collection due to resistance from the entire team. We can only speculate why!! Increased number of attempts has been shown to increase the risk of complications including vessel occlusion, pseudo-aneurysm, infection and haematoma. It is therefore not surprising that recommendations on US guided vascular access are emerging although the scientific evidence on specific US technique is sparse. In a recent published statement paper on US guided vascular access from WINFOCUS, a total of 47 final recommendations are given. Most of them are classified as having a strong recommendation, with very good degree of consensus although the evidence is still relatively weak in several areas [1].

The growing interest on the topic is mirrored in the growing number of publications during the last couple of years [2-4].
US guided venous cannulation

The term ultrasound guided vascular cannulation makes most physicians think about central venous catheterization (CVC), because this was the starting point. The advantages are well described in the NICE guidelines [5] and the procedure well accepted by many physicians. However, US guided CVC is only a minor fraction of applications and according to the WINCOFUS statement paper it is reasonable to expect that the experience from CVC can be extended to all venous access sites [1]. Actually we expect the number of CVC’s to decrease by 75% over the next 10 years as US guided venous access emerges, potentially to the entire venous system.

US guided arterial cannulation

US guided arterial cannulation is also heavily developing although the published evidence is limited at the moment. Unpublished data from our group in a randomized, cross-over and patient blinded study, showed that US guided radial artery cannulation was superior compared to the conventional landmark technique with respect to: time consumption, first time success rate, skin perforations and attempts targeting the artery. These data clearly demonstrate the true benefit of US, namely avoidance of failures and avoidance of multiple failures in particular!

US technology and upcoming devices giving rise to new clinical potentials

Approximately 1-2% of the population cannot act as blood donors due to so-called “difficult vascular access” experienced by the healthcare worker performing the puncture. Healthcare workers also experience increasing difficulties in taking blood samples from obese patients in particular. New kits have been developed to overcome this problem now making it possible to do US guided blood sampling from a sterile puncture field without any ultrasound gel on the puncture site.

Equipment and US techniques for vascular access

Commercially available machines and probes are massive. In general the frequency span is between 6–16 MHz with arrays of crystals, linear or as a hockey stick transducer. True pocket sized devices of sufficiently quality and at reasonable cost are expected to be on the market very soon.

In general two techniques for US guided vascular access exists: In plane where the needle is visualized in long-axis and or out-of-plane where the needle is displayed on the screen in short axis. It has been proved that the out-of-plane technique called Dynamic Needle Tip Positioning (DNTP) is the easiest applicable by US novices [6]. In DNTP the needle tip is kept successively in or out of the imaging plane by an alternating movement of the transducer or the needle in the same direction [6].

Education

No matter the lack of consensus on standards of training and certification, formal training prior to implementation is recommended. A learning curriculum should, as a minimum, include basic physics, knobology, US sono-anatomy, needle guidance and practical hands-on training. At Aarhus University all medical students now get access to interactive e-learning of approximately 60 minutes duration before hands-on training in phantoms and finally performance of US guided venous catheterization on each other.

Conclusion

The difficult or impossible vascular cannulation does not exist anymore. You can suffer from lack of suitable equipment, lack of timely skill or both!

Four Facts

1. Ultrasound guided vascular access reduces the overall complication rate.

2. US guided venous access is not only for CVC but also for peripheral venous cannulation.
3. US guided radial artery cannulation is superior compared to landmark technique.
4. The combination of US and new devices has given rise to new important clinical applications.

**Four Predictions**
1. The number of CVC’s will decrease by approximately 75% over the next 10 years.
2. The majority of radial artery cannulations will be US guided within 5 years.
3. Suitable US pocket devices at low cost will be available in very near future.
4. Most medical schools will teach their students US guided vascular access within 5 years.

**References**
Despite major advances in pharmacologic treatments for heart failure with left ventricular pump dysfunction, the number of hospitalizations for treatment of decompensated heart failure is increasing and most patients will ultimately die of complications of the disease. Short-term mechanical circulatory support devices are indicated in patients with medical (acute myocardial infarction, myocarditis, intoxication with cardiotoxic drugs or end-stage dilated cardiomyopathy), and postcardiotomy or post-transplantation acute and refractory cardiogenic shock. Most of these “crash and burn” patients receive a device as salvage therapy after having already developed signs of multiple organ failure. In these situations, mechanical assistance is used as a bridge to decision making or to “whatever seems reasonable” if the patient survives the first days following implantation to reach the “decision-making” point. In patients with potentially reversible cardiac failure (myocarditis, myocardial injury secondary to myocardial infarction) a short-term device might also be used as a bridge to recovery.

Devices inserted in such situations are catheter or cannula-based pumps. The Impella CardioSystem AG is a catheter-based axial flow pump, that has a propeller at the tip of the catheter and which is positioned retrograde across the aortic valve into the left ventricle. The TandemHeart is a percutaneous ventricular assist-device which consists of an extracorporeal centrifugal continuous flow pump that sucks blood from the left atrium via a cannula introduced trans-septally through the femoral vein. Blood is then pumped back to the femoral artery at a flow up to 3.5 L/min. The Levitronix CentriMag is a continuous-flow, centrifugal-type rotary blood pump that is placed outside the body (extracorporeally). The pump can rotate at speeds of 1,500 rpm to 5,500 rpm and can provide flow rates of up to 9.9 litres per minute. However, in recent years extracorporeal membrane oxygenation (ECMO) or extracorporeal life support (ECLS) has become the first-line therapy in the setting of acute cardiogenic shock, because of its easy insertion, even at the bedside, the elevated flow it provides and because it is associated with less organ failures after implantation compared to biventricular assist-devices.

ECMO as the first line support for refractory cardiogenic shock

The ECMO extracorporeal system consists of venous and arterial cannulae, polyvinyl chloride tubing, a membrane oxygenator and a centrifugal pump. It provides both respiratory and cardiac support. Using the peripheral veno-arterial configuration, where femoral vein and artery are percutaneously cannulated, the circuit is perfectly suited for emergency situations. It can be inserted in less than 30 minutes, under local anaesthesia, can supply blood flow up to 8 L/min and is either more efficient and durable or less costly than other first-line devices. Several considerations must be weighed in making the decision to institute ECMO. First, the device should be inserted before the patient has developed multiple organ failure or myocardial failure has led to refractory cardiac arrest, since these conditions have been associated with a significantly poorer outcome. Second, highly unstable patients may benefit from urgent and on-site ECMO initiation by a rapid resuscitation team, able to operate a...
portable and quick-to-prime ECMO circuit, before transportation to the ECMO referral centre. Third, cardiac failure and other organ injuries should be deemed reversible and the patient’s underlying condition should not contraindicate a bridge to a more permanent device or to transplantation. Fourth, management of patients on ECMO for refractory cardiogenic shock is complex and should be conducted in experienced medical-surgical centres.

ECMO can also be configured using central cannulation where right atrium, ascending aorta and sometimes left atrium or left ventricle are directly cannulated. This configuration is used first-line in case of post-cardiotomy or post-transplantation cardiogenic shock or if peripheral ECMO has failed to deliver adequate flow or has been complicated by severe pulmonary oedema.

In most patients the duration of ECMO support is approximately one week. However, ECMO can be maintained for weeks, especially if the central configuration is used. ECMO weaning is discussed in the following circumstances:- partial or full cardiac recovery or bridge to transplantation or to VAD implantation because of absence or LV function recovery. ECMO can also be simply withdrawn in case of therapeutic futility (severe brain lesions, end-stage multiple organ failure or absence of myocardial recovery in the context of definitive contraindication to transplantation or to VAD implantation).

**Table 1**

<table>
<thead>
<tr>
<th>INDICATION</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge-to-decision</td>
<td>Fast initiation of non-durable MCS in patients with cardiogenic shock to prevent prolonged hypoperfusion leading to early multiple organ failure (length days to weeks)</td>
</tr>
<tr>
<td>Bridge-to-recovery</td>
<td>Short-term use of non-durable MCS, with the aim of re-remodelling and recovery of cardiac performance (length days to weeks)</td>
</tr>
<tr>
<td>Bridge-to-transplantation</td>
<td>Instituted in candidates for cardiac transplantation, failing conventional medical therapy (length days to weeks)</td>
</tr>
<tr>
<td>Destination therapy</td>
<td>Instituted in patients that are not candidates for cardiac transplantation, failing conventional medical therapy as an alternative therapy to transplant (length years).</td>
</tr>
</tbody>
</table>

**P12-2**

Are new technologies improving heart failure? VAD is best

*Michael Sander*
Professor of Anaesthesia, Chair Department of Anaesthesiology and Intensive Care Medicine, Charité Universitätsmedizin Berlin, Berlin, Germany

**Indications**

Ventricular assist devices (VAD) are indicated for treatment of advanced heart failure. According to the recent recommendations for the use of mechanical circulatory support (MCS) device strategies from the American Heart Association, patients and device selection are based on the indication for placement of VADs (Table 1) (Peura et al. 2012; Slaughter et al. 2009; Authors Task Force Members et al. 2010). Indications for the placement of VADs include “Bridge-to-recovery”, “Bridge-to-transplant”, and “Destination therapy”. Another indication for the placement of non-permanent VADs is a “Bridge-to-decision” strategy (Peura et al. 2012; Maybaum et al. 2007; Birks et al. 2006). According to the latest guideline for the treatment of heart failure (Authors Task Force Members et al. 2012), mechanical cardiac support must be initiated immediately in patients with therapy refractory cardiogenic shock to achieve the best long-term survival as prolonged hypoperfusion leads to early multiple organ failure. In this situation, im-
plantation of long-term, definitive mechanical cardiac support devices (MCS) has been associated with poor outcomes. Therefore in these acute settings, implantation of non-durable VADs as a “Bridge-to-decision” allows early support and ventricular unloading until clinical stabilization for a more definitive therapy.

Types of VADs

After the decision for implantation of a MCS is made, the next decision will focus on the site of implantation and the type of the system. Because there are durable and short-to-medium term MCS options, extracorporeal, implantable, or percutaneous strategies for MCS, the available systems need to be identified. Some important factors needing to be taken into consideration during device selection process are therefore the expected duration of support and type of support required (right, left or biventricular assist). Most commonly MCS is started with implantation of a left ventricular assist device (LVAD). Implantation of a LVAD has proved to be a successful treatment option for patients with end-stage heart failure. However, a significant proportion of these patients develop right ventricular failure that makes implantation of a right ventricular assist device (RVAD) necessary. Risk factors for right heart failure after LVAD placement that might lead to implantation of a biventricular assist system or a VA ECMO system were published recently (Drakos et al. 2010; Matthews et al. 2008; Schmid & Radovancevic 2002).

First Generation Mechanical Circulatory Assist Devices

The first generation of VADs were designed to provide pulsatile blood flow to mimic physiology of the circulation. The Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial demonstrated improved survival and quality of life for patients with end-stage heart failure (NYHA Class IV) treated with VADs versus optimal medical management (Rose et al. 2001). The authors found one-year survival rate of 52% in the device group versus 25% in the medical therapy group, while at 2 years, survival was 23% and 8%, respectively. Subsequently, Lietz et al described improved one-year and 2 years outcomes compared to REMATCH study (Lietz et al. 2007).

Second generation Mechanical Circulatory Assist Devices

The second generation of MCS represent continuous flow LVADs. Continuous flow LVADs can be further divided into axial flow devices and centrifugal pumps. Axial flow devices are smaller, compacter and therefore less invasive.

Third Generation Mechanical Circulatory Assist Devices

Recent development of third generation MCS promise further improvements (Sylvin et al. 2010). These axial flow devices are similar to second generation MCS, however the major improvement is the non-contact design of third generation MCS. To achieve this third generation MCS use either hydrodynamic or magnetic levitation of the impeller. Impeller rotation to augment blood flow through the device is achieved through magnetic coupling to the pump motor. This results in reduced risk of thrombus formation and therefore reduced need of intense antithrombotic therapy with reduced bleeding and thromboembolic complications (Ziemba & John 2010).

Extracorporeal Membrane Oxygenation (ECMO) as MCS

In some centres veno-arterial Extracorporeal Membrane Oxygenation (ECMO) is used as an MCS system. ECMO can be used in cardiac patients as a bridge-to-surgery, bridge-to-recovery, bridge-to-transplant, or bridge-to-decision (Scherer et al. 2011; Scherer et al. 2009; Fitzgerald et al. 2010; Ziemba & John 2010; Hsu et al. 2010). Indications for ECMO in cardiac patients include hypotension and low cardiac output, persistent shock despite optimal medical therapy, and IABP.
The main advantages are in postcardiotomy shock where the cannulation sites of the CPB can be used as access to the ECMO system and poor oxygenation can be treated effectively. On the downside there is a need for full anticoagulation with heparin to maintain an ACT of 160 to 200 seconds. Another disadvantage is that for patients with significant aortic regurgitation, left ventricular decompensation may occur secondary to increased regurgitant volumes and ventricular dilation. Inotropic support should be maintained with ECMO if there is evidence of cardiac failure. Intra-aortic balloon pump should also be considered as ECMO is excellent for unloading the right ventricle, but not the left heart very well. Medical management should focus on inotropic support and relief of left ventricular distension. Inotropes should be used to ensure adequate emptying of the left ventricle and to maintain some contractility. Poor contractility will increase the risk of thrombus in the LV from low flow and stasis. Bleeding, thromboembolism and resulting cerebral ischaemia and haemorrhage are major complications associated with ECMO support due to platelet destruction and need for high levels of anticoagulation.

**Outcomes after MCS placement**

After introduction of MCS mortality was high, but declined within the last years with introduction of newer devices. Data from the STS database showed mortality rates exceeding 60% at the end of the last century, declining to 40% until 2005 (Hernandez et al. 2007). For the inpatients setting, recently a risk stratification model was published. The Acute Decompensated Heart Failure National Registry (ADHERE) showed further decrease of mortality in this selection of patients and provides a model for in-hospital patients based on three variables at admission: serum creatinine, blood urea nitrogen, systolic blood pressure (Fonarow et al. 2005). According to this model mortality ranges between 2% and 22% with this high mortality being reported for patients with cardiogenic shock (Peura et al. 2012). Long-term survival after salvage MCS placement after postcardiotomy shock is lower and warrants further evaluation to find the best mechanical and medical therapeutic strategy for these selected patients.

**References**

2. Authors Task Force Members et al., 2012. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012: The Task Force for the Diagnosis and Treatment of Acute and Chronic Heart Failure 2012 of the European Society of Cardiology. Developed in collaboration with the Heart Failure Association (HFA) of the ESC. Euro Heart J 2012; 33: 1787-1847.


16:30 h – P13

Do new technologies improve postoperative outcome?

Chairs: Michael Sanders, Germany; Isidro Moreno, Spain

P13-1
Goal directed Monitoring in cardiothoracic and vascular intensive care

Christof K. Hofer
Institute of Anaesthesiology and Intensive Care Medicine, Triemli City Hospital, Zurich, Switzerland

Organ perfusion, i.e. O2 delivery to the tissue in cardiac and vascular patients with limited cardiopulmonary reserve may be impaired as result of the body’s inability to compensate for changes of cardio-respiratory and metabolic demands during surgery. Intermittent reduction of the gut oxygenation due to intraoperative hypovolemia and hypotension has shown to result in an increased incidence of postoperative complications. Moreover, impaired O2 delivery and increased O2 extraction after surgery have been identified as independent predictors of prolonged ICU stay.

Goal-directed therapy (GDT)
- GDT using advanced minimally-invasive (but also invasive) hemodynamic (HD)
monitoring aims at optimizing O2 delivery in order to prevent perioperative tissue hypoxia.

- Cornerstones in the GDT strategy are preload optimization by fluid administration and modulation of cardiac contractility by inotropic support according to preset hemodynamic goals.
- In recent years there is growing evidence that GDT has beneficial effects on outcome in septic and high-risk surgery patients.

**GDT in Cardiac and Vascular Surgery**

- Only a limited number of GDT studies in cardiac and vascular surgery are available today. In these studies different strategies in terms of monitoring tools, hemodynamic goals, start of therapy and measures were used (Table A).
- Interestingly, only in 5 of 11 studies newer less-invasive monitoring was applied.

- Hemodynamic parameters used were cardiac index (CI), stroke volume index (SVI), mixed or central venous oxygenation (S/c vO2), standard pressure preload (CVP/ PcWP) and functional hemodynamic (SVV) parameters.

**GDT and Outcome in Cardiac and Vascular Surgery**

- Two meta-analyses (1,2) on GDT in cardiac and vascular surgery have been performed recently. Results are summarized in table B.
- GDT had no impact on mortality, incidence of complications and hospital length of stay (HLOS) was reduced in cardiac, but not in vascular surgery.
- The lack of a GDT effect on mortality especially in cardiac surgery patients may be explained by a low mortality of the control group. However, these results must be carefully interpreted considering the very

<table>
<thead>
<tr>
<th>Cardiac</th>
<th>HD Tools</th>
<th>HD Goals</th>
<th>Start</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mythen</td>
<td>OE Doppler</td>
<td>SV optimization; CVP increase &lt; 3 mmHg</td>
<td>Intraop</td>
<td>F</td>
</tr>
<tr>
<td>Polonen</td>
<td>PAC</td>
<td>SvO2 &gt; 70%; Lactate &lt; 2 mmol/l</td>
<td>Postop</td>
<td>F + I</td>
</tr>
<tr>
<td>McKendry</td>
<td>OE Doppler</td>
<td>SVI &gt; 35 ml/m²</td>
<td>Postop</td>
<td>F</td>
</tr>
<tr>
<td>Kapoor</td>
<td>PWA: FloTrac</td>
<td>CI &gt; 2.5 l/min/m²; ScvO2 &gt; 70%; SVV ≤ 10%</td>
<td>Postop</td>
<td>F + I</td>
</tr>
<tr>
<td>Smetkin</td>
<td>PWA: PiCCO</td>
<td>ScvO2 &gt; 60%; ITBV 850-1000 ml/m</td>
<td>Intraop</td>
<td>F + I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vascular</th>
<th>HD Tools</th>
<th>HD Goals</th>
<th>Start</th>
<th>Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berlauk</td>
<td>PAC</td>
<td>CI ≥ 2.8 l/min/m²; SVR ≤ 1100 dy/s/cm³; PcWP 8-14 mmHg</td>
<td>Preop</td>
<td>F + I</td>
</tr>
<tr>
<td>Bender</td>
<td>PAC</td>
<td>CI ≥ 2.8 l/min/m²; SVR ≤ 1100 dy/s/cm³; PcWP 8-14 mmHg</td>
<td>Preop</td>
<td>F + I</td>
</tr>
<tr>
<td>Ziegler</td>
<td>PAC</td>
<td>SvO2 &gt; 65%; Hb ≥ 10g/dl; PcWP ≥12 mmHg</td>
<td>Preop</td>
<td>F + I</td>
</tr>
<tr>
<td>Valentine</td>
<td>PAC</td>
<td>CI ≥ 2.8 l/min/m²; SVR ≤ 1100 dy/s/cm³; PcWP 8-15 mmHg</td>
<td>Preop</td>
<td>F + I</td>
</tr>
<tr>
<td>Bonazzi</td>
<td>PAC</td>
<td>CI ≥ 3 l/min/m²; SVR ≤ 1450 dy/s/cm³; PcWP 10-18 mmHg</td>
<td>Preop</td>
<td>F + I</td>
</tr>
<tr>
<td>Van der Linden</td>
<td>PWA: FloTrac</td>
<td>CI ≥ 2 l/min/m²; CVP ≤ 15 mmHg</td>
<td>Intraop</td>
<td>F + I</td>
</tr>
</tbody>
</table>

OE = Oesophageal, PAC = Pulmonary artery catheter, PWA = Pulse wave analysis, F = intravenous fluids, I = Inotropes
small number of studies and the obvious heterogeneity of these studies in terms of parameters and protocols used.

Conclusions and perspectives

- GDT may have a positive impact on outcome with a reduction of postoperative complications in cardiac surgery but not in vascular surgery, but today there is no strong body of evidence.
- Use of HD parameters & HD goals need to be clarified.
- Optimal GDT protocols for selected patient groups need to be defined and investigated.

References


![Echocardiography in cardiothoracic intensive care: just a new tool?](image)

Isabelle Michaux
Cardiothoracic Intensive Care Unit, Mont-Godinne University Hospital, Université Catholique de Louvain, Yvoir, Belgium

Bedside echocardiography is indeed a new tool in the hands of intensivists but it is also becoming an indispensable diagnostic and sometimes monitoring tool, that we have now in our armamentarium. For a long time, transoesophageal echocardiography (TOE) was thought to be the only usable modality in cardiothoracic surgical and ventilated patients and was restricted to trained cardiac anaesthesiologists and cardiologists. However, emergence of new transthoracic probes (with harmonic imaging) improving the resolution of images acquired by transthoracic echocardiography (TTE), even in ventilated patients, and the development by the industry of true portable, battery-powered devices, make TTE more suitable for the environment of the ICU. Some indications to perform a TOE in the ICU are remaining: investigation of the ascending and descending aorta, of the left atrial appendage or of a mechanical prosthesis, and search for intracardiac thrombus. Despite the good performance of the TTE probes, obesity or emphysema, surgical wounds or patients in a strict

<table>
<thead>
<tr>
<th>Table B: Outcome of GDT in cardiac and vascular surgery patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
</tr>
<tr>
<td>OR [95% CI]</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td><strong>Cardiac</strong></td>
</tr>
</tbody>
</table>
| Giglio | 0.68 [0.19, 2.38] | 0.34 [0.18, 0.63] | n.a.
| Interact CardioVasc Thorac Surg 2012 | p = 0.55 | p = 0.006 | |
| Aya | 0.69 [0.19, 2.56] | 0.33 [0.15, 0.73] | –2.44 [–4.03, –0.84] |
| Brit J Anaesth 2013 | p = 0.58 | p = 0.006 | p = 0.003 |
| **Vascular** | | | |
| Giglio | 1.09 [0.30, 3.99] | 0.84 [0.45, 1.56] | n.a.
| Interact CardioVasc Thorac Surg 2012 | p = 0.90 | p = 0.58 | |
supine position remain sources of poor TTE acoustic window.

Echocardiography is not just a new fashion tool. Echocardiography is accepted as a category 1 indication in assessing critically ill patients with circulatory and/or respiratory compromise [1]. Studies investigating the impact of echocardiography (mostly TOE) after cardiac surgery confirmed its positive diagnostic and therapeutic impact. In the study of Schmidlin et al., new diagnosis was established and pathologies were excluded in 45% of their surgical patients, treatment was modified by echocardiography in 73% of the cases [2]. Costachescu et al. demonstrated the superiority of TOE compared to the pulmonary catheter in diagnosing and/or excluding causes of haemodynamic instability after cardiac surgery [3].

The principal reasons to favour the use of echocardiography in cardiothoracic ICU are: 1) Echocardiography gives a real-time access to morphological and functional information on the heart and great vessels, identifying the physiopathologic mechanisms of circulatory failure, 2) Echocardiography is less invasive than the pulmonary catheter, 3) Echocardiography is an invaluable tool to evaluate right-sided heart function and interventricular interaction [4], 4) Filling pressures derived from a pulmonary catheter or a central venous line do not predict accurately fluid responsiveness [5]. 5) Cardiac output measured with a thermodilution pulmonary catheter is underestimated in case of significant tricuspid regurgitation or right ventricular dysfunction [6].

However, we have to recognise some limitations of the technique. TOE remains invasive, even if major complications remain rare, with an incidence of 0.1 to 0.01%. This is a reason to favour the first line use of TTE in the ICU, TTE being harmless. Echocardiography is not a continuous tool, unlike the majority of our monitoring tools, and therefore is, in my opinion, more a diagnostic tool than a monitoring tool. Vieillard-Baron et al. published recently their experience in monitoring ventilated patients with a single-use miniatu...
delivery of echocardiographic education and supervised training. Above this local level of teaching, national and international scientific societies are in charge of the accreditation process, like EACTA with the annual ECHO EACTA courses.

In addition to the use of ultrasound to perform echocardiography in the ICU, bedside use of ultrasound is very useful to perform ultrasound-guided procedures (venous puncture, pleural effusion drainage) and to investigate other structures such as the lungs or the abdomen.

In conclusion, the ultrasound machine is not just a new tool in the cardiothoracic ICU. It will rapidly be integrated into our daily clinical practice and the teaching of the use of ultrasound should start at the level of the medical school and be prolonged throughout the entire specialist training.

References

P13-3
ECMO in organ failure: a step too far?

Alain Vuylsteke
Cambridge, UK
Fluid requirements vary widely between patients and procedures and ultimately represent the sum of preoperative deficits, maintenance requirements, and ongoing losses. Preoperative fluid deficits in patients with severe esophageal disease may be substantial, though they have not been well defined [1]. Fluid requirements in patients undergoing esophageal procedures may be complicated by the fact that patients may be relatively hypovolemic after long preoperative fasts, particularly if esophageal obstruction or dysphagia limit fluid intake. Perioperative losses occur via a number of mechanisms including urinary, gastrointestinal, and evaporative losses, bleeding, and interstitial fluid shifting. This shift of fluid from the vascular compartment into the interstitial space accompanies surgical trauma and is likely to reflect vascular injury and loss of endothelial integrity. So called “third space” losses describe fluid loss into non-interstitial extra-cellular spaces which are not in equilibrium with the vascular compartment and thus considered to be a “non-functional” extra-cellular fluid compartment. However this space has not been well characterized and recently its existence has been questioned [2].

Fluid management for esophageal resection is particularly challenging because thoracic epidural analgesia has been shown to improve outcome for these patients [3] but tends to contribute to hypotension. Hypotension is well known to contribute to ischemia of the gut anastomosis [4]. Treatment with excessive fluids is likely to exacerbate the problem [5]. However, many surgeons are concerned about the effects of vasopressors on the gut blood flow [6]. However, several recent animal studies suggest that treatment of intraoperative hypotension with nor-epinephrine does not cause any reduction of gut blood flow [7, 8].

An ideal fluid regimen for major surgeries including esophageal surgeries is individualized and optimizes cardiac output and oxygen delivery while avoiding excessive fluid administration. There is some evidence that fluid therapies which are designed to achieve individualized and specific flow-related hemodynamic endpoints such as stroke volume, cardiac output, or measures of fluid responsiveness such as stroke volume variation (collectively referred to as goal directed fluid therapy (GDFT)) may provide a superior alternative to fixed regimens or those based on static measures of cardiac filling such as central venous pressure which does not predict fluid responsiveness or correlate with circulating blood volume after transthoracic esophagectomy [9, 10].

In addition to the potential importance of the amount and timing of fluid administration, there is some clinical evidence that the choice of fluid type may be important in affecting clinical outcomes [11]. Intravascular colloid retention during treatment of hypovolemia may approach 90% vs. 40% during normovolemia [12].

It has been a serious concern for Anesthesiologists that fluid restriction in thoracic surgery may contribute to postoperative renal dysfunction which previously was reported to be associated with a very high (19%) mortality [12]. In a recent review of > 100 pneumonectomies at our institution acute kidney injury (AKI) as defined by the RIFLE classification occurred in 22% of patients. However there was no association
of AKI with fluid balance and there was no increased mortality in the AKI patients [13]. AKI was associated with preoperative hypertension and complex surgical procedures such as extra-pleural pneumonectomy.

The relationship of hydrostatic and oncotic pressure to determine fluid flux across a semi-permeable membrane was described in an equation developed in 1896 by Starling. However, several clinical observations such as the relative resistance of the intact organism to develop edema are not clearly explained by the Starling formula. This discrepancy is now attributed to the glycocalyx, a micro-cilial layer that lines the endothelium and acts as a molecular sieve [12]. This layer tends to increase the oncotic pressure on the inner surface of the endothelium and decrease leukocyte and platelet adhesion to the endothelium. The glycocalyx deteriorates during ischemia-reperfusion and in the presence of a wide variety of inflammatory mediators and probably contributes to the increased vascular permeability seen in these situations. Also, the glycocalyx deteriorates in the presence of atrial natriuretic peptide and may explain the increase in plasma protein filtration that has been seen with colloid boluses. Protecting the glycocalyx may be among the Anesthesiologist’s most important duties perioperatively.

Summary

Several new important guidelines are: the fasting deficit in most patients is very small or nil [14]. Basal fluid loss during a major procedure such as esophagectomy is probably only 1 ml/kg/h. The third space probably does not exist. Hypotension (mean BP < 70) is harmful to the gastric tube blood flow [15]. Treatment of hypotension with excess fluids is probably harmful. Treatment of hypotension with sympathomimetic vasopressors (Nor-epinephrine or Epinephrine) is probably beneficial.

References


P14-2
Free fluid therapy is best.
Liberal or restricted fluid administration: Are we ready for a proposal of a restricted approach?

Della Rocca G, Tripi G, Pompei L
Department of Anesthesia and Intensive Care Medicine of the University of Udine, Udine, Italy.

Background
Fluid management during surgery represents a great matter of debate among anaesthesiologists. Several studies have demonstrated that the strategy of fluid therapy, i.e. total amount and type of fluid, may influence the post-operative outcome. However an optimal strategy remains uncertain [1].

The practice of aggressive fluid replacement of hypothetical third space fluid loss gained widespread popularity in intra-operative anaesthetic practice although it is more than 30 years that direct measurements of basal evaporation rate from the skin and airway during surgery showed that topical fluid loss was 0.5-1.0 mL/kg⁻¹/h⁻¹ in major abdominal surgery [2].

Physiological aspect
The endothelial cell line, as suggested by the Starling Principle, is not the sole factor for the vascular barrier function. This task is mainly carried out by the Endothelial Surface Layer (ESL), which seems to act as a molecular filter. The ESL is involved in many processes (vascular barrier, inflammation and coagulation) and various agents and pathologic states can impair its behaviour (ischaemia-reperfusion injury, inflammation response, several circulating mediators) [3].

Inappropriately high fluids administration may cause iatrogenic ESL dysfunction by liberation of atrial natriuretic peptide, which leads to fluid shifts into the extravascular space [4]. This pathologic shift is caused by a dysfunction of the vascular barrier, basically because of 3 reasons:- surgical manipulation, reperfusion injury and iatrogenic hypervolaemia, regardless of the kind of fluids administered (colloids or crystalloids). Fluid reloading because of an overnight fasting period is unjustified and fluid loss from insensible perspiration is also overestimated. It should be adequate to substitute only the losses to maintain a normal intravascular blood volume. A restrictive approach seems to be rational and supported by physiology.

According to these findings, more recent evidence suggests that a large amount of fluids can increase peri-operative complications, so a restricted approach has become more common [5]. Many trials investigated a liberal or a restricted fluid therapy during the intra-operative period, but in the literature there is not a clear definition of what a restricted or liberal fluid approach is.

Liberal vs. restricted: is a definition possible?
Holte K, et al. [6] defined a liberal approach where 30 mL kg⁻¹ h⁻¹ of crystalloid was administered during surgery and restrictive an infusion of 10 mL/kg⁻¹/h⁻¹ of the same solution.

In another study the same author administered 5-7 mL/kg⁻¹/h⁻¹ of Ringer’s lactate solution plus 7 mL/kg of hydroxyethyl starch
(HES) 130/0.4 in the restrictive group, and 18 mL/kg⁻¹/h⁻¹ of Ringer’s lactate solution plus 7 mL/kg of HES 130/0.4 in the liberal group, in patients undergoing fast-track colonic surgery [7].

Abraham-Nordling M. et al. [8] identified as a liberal approach the administration of 5 mL/kg⁻¹/h⁻¹ of Ringer’s acetate solution plus 2 mL/kg⁻¹/h⁻¹ of buffered glucose 2.5%, and only 2 mL/kg⁻¹/h⁻¹ of buffered glucose 2.5% in the restrictive group intra-operatively.

Lobo S. et al. defined a liberal approach by the administration of 12 mL/kg⁻¹/h⁻¹ of Ringer’s lactate solution and restrictive the administration of 5 mL/kg⁻¹/h⁻¹ of the same fluid [9].

So a clear and standardized definition of restrictive and liberal approach is now still impossible. We can only say that the restrictive strategy represents a lower amount of fluids administered compared with a traditional approach used in that institution. On the other hand, in high risk surgical patient (HRSPts – see table 1) [10] undergoing intermediate or major risk surgery, evidence based medicine support the application of a goal directed therapy (GDT) where administration of fluid is targeted on haemodynamic parameters (i.e. stroke volume) aiming to maximize oxygen delivery and then avoiding oxygen debt [11].

**Patient population and type of surgery**

The choice of patient is very important in applying a liberal or restricted fluid management.

Patients with compromised pulmonary or cardiac function are HRSPts and appear to be more prone to complications than normal counterparts. So these patients would benefit from a GDT [12, 13].

The type of surgery is also another important factor. Many studies demonstrated that a restrictive approach in major surgery improves outcome, diminish length of in hospital stay, reduce anastomotic leakage and surgical site infection [5, 9, 14].


**Evidence Based Medicine in restrictive and non restrictive approach**

In clinical practice many studies investigated if a restrictive approach especially in major abdominal surgery setting can improve outcome. Lobo et al. demonstrated an improved gastrointestinal function after elective colonic resection. They also demonstrated a reduced length of hospital stay (LOS) from 9 to 6 days in the restrictive group [16]. Brandstrup demonstrated that in colorectal surgery reduced post-operative complications and death [5]. Nisanevich [14] found that in patients who underwent major abdominal surgery there were less postoperative complications such as pneumonia, wound infection and arrhythmias.

However, other studies showed no difference in outcome and postoperative complications between liberal vs. restricted fluid management [17, 18].

Part of the literature seems to suggest that in low-risk patients undergoing minor or intermediate risk surgery, liberal strategy (non restrictive) may be preferable. It reduces some postoperative complications such as nausea, vomiting, drowsiness, dizziness and length of stay [6,19,20]. In patients undergoing minor surgery, mostly in the ambulatory setting, liberal fluid administration may improve early recovery measures and symptoms of dehydration (dizziness, nausea and thirst) [21].

In conclusion, a well defined and overall standardized definition of liberal and restrictive is still impossible with current literature data. We would like to suggest an approach for intra-operative fluid management (fig. 1), based on human physiology and the current literature [22].

The steps reported in figure 1 should represent a rational approach to fluid management in *ASA I-III patients* who do not need either GDT or an advanced haemodynamic monitoring during the intra-operative period.
During the intra-operative period as much fluid as required by that single patient should be given. Either hypovolaemia that causes organ hypoperfusion, or hypervolaemia that increases postoperative complications, should be avoided.

In all patients ASA I–III undergoing general or other specialized surgery, excluding cardiac surgery or transplantation, 1 mL/kg⁻¹/h⁻¹ of crystalloid solution (if the patients do not observe overnight fasting or do not have bowel preparation) should be given.

In fasted patient or those undergone bowel preparation, 3 mL/kg⁻¹/h⁻¹ should be given for the overall surgical procedure time.

In all those patients who are ASA IV and/or HRSPts and/or in those who undergo high risk surgery a Goal Direct Therapy is strongly suggested.

Blood loss is replaced with colloids until Hb level is at least over 7 g/dL if the patient does not have cardiovascular or respiratory coexisting disease.

In case of diuresis monitoring, the total amount will be replaced with balanced crystalloid solution (unless contraindicated).

In case of hypotension soon after general anaesthesia induction or during the intra-operative period, it is necessary to check the anaesthesia level and consider the use of vasopressors before administering fluids.

In the postoperative period it is mandatory to restore oral hydration and feeding as soon as possible (unless contraindicated).

References


---

10:30 h – P15

**Thoracic Pro/Con debates**

*Chairs: Edmond Cohen, USA; Peter Slinger, Canada*

**P15-A**

**Lung Recruitment in Thoracic Surgery, is necessary?**

**P15-A-1**

**Pro position**

*Mª Carmen Unzueta, MD, PhD*

*Hospital Santa Creu i Sant Pau, Barcelona, Spain*

Deterioration of gas exchange during one-lung ventilation (OLV) is mainly due to the shunt originating from blood flowing through the capillaries of the non-ventilated non-dependent lung. However, as the result of anaesthesia induced atelectasis, shunt also occurs in the collapsed tissue of the dependent lung [1]. Besides, high inspired oxygen concentrations in poorly ventilated alveoli will cause absorption atelectasis, transforming low V/Q areas to shunt. Lung recruitment is a ventilator manoeuvre aimed at opening up the lungs and keeping them open afterward by means of a brief controlled increase in airway pressure [2, 3].

Previous studies showed that during anaesthesia for thoracic surgery, a recruitment manoeuvre combined with an adequate level of PEEP applied selectively to the dependent lung improved oxygenation and ventilation efficiency during OLV [4-7]. An experimental study showed that a bilateral lung recruitment manoeuvre before OLV was associated with a more homogeneous distribution of lung aerated tissue in the dependent ventilated lung [8]. This effect was sustained during OLV and resulted in an improvement of oxygenation and respiratory compliance. A clinical study proved that bilateral lung recruitment just before starting OLV improved arterial oxygenation and the efficiency of
ventilation by decreasing the alveolar component of dead space [9]. Such recruitment-induced improvement in lung physiology was sustained throughout the entire surgical procedure. These data are also in agreement with findings that showed that a lung recruitment manoeuvre applied before OLV in patients with normal pre-operative pulmonary function improved PaO2 during OLV [10].

Ventilator-induced lung injury is proportional to the stress on lung tissue determined by the size of VT and Ppl applied during OLV [8]. As lung recruitment decreases dead space, VT and Ppl could be reduced because ventilation and thus the clearance of CO2 are more efficient. The implementation of lung-protective ventilatory strategy including recruitment manoeuvres in patients undergoing thoracic surgery led to a reduction in the incidence of postoperative atelectasis and acute lung injury [11]. Besides, as lung recruitment improves arterial oxygenation throughout thoracic surgery, it could increase the margin of safety for hypoxaemia throughout the entire surgery. Moreover, lung recruitment has an additional clinical value as a rescue therapy in severely hypoxaemic patients as it can increase PaO2 to a safer level instantaneously [6].

High intrathoracic pressure resulting from the recruitment manoeuvre decreases venous return and cardiac output [12,13]. As a consequence, there is a transient drop of approximately 10% in cardiac index and arterial pressure.

In conclusion, lung recruitment should be performed in thoracic surgery. Its intraoperative benefits are the improvement of oxygenation and the decrease in alveolar dead space that would allow a reduction in VT applied during OLV. A decremental PEEP trial following the recruitment phase could help to identify the PEEP level required to prevent lung re-collapse [14]. Anaesthesiologists have to be aware of haemodynamic side effects especially in hypovolaemic patients. Further studies are needed to assess its influence on the incidence of postoperative acute lung injury.

References
Lung Recruitment in Thoracic Surgery. Con position

**Peter Slinger, MD, FRCPC**
*University of Toronto, Canada*

It is generally appreciated that lung recruitment improves oxygenation during thoracic surgery. However the following caveats must be appreciated:

1. Lung recruitment without PEEP is of little sustained benefit [1].
2. Lung recruitment can have negative hemodynamic effects [2].
3. Lung recruitment strategies do not have to be complicated [3].
4. Maximizing oxygenation during one-lung ventilation may be harmful [4, 5].

References:


Near-infrared spectroscopy (NIRS) in One Lung Ventilation, are really useful?

**PRO position**

**Della Rocca G**
*Department of Anesthesia and Intensive Care Medicine of the University of Udine, Udine, Italy*

During Thoracic anesthesia One-lung ventilation (OLV) is used for open and thorascopic thoracic procedures. With thorascopic procedures, OLV is considered to be mandatory to facilitate the surgical procedure and avoid the need for open thoracotomy. During OLV, in the presence of hypoxic pulmonary vasoconstriction, intrapulmonary shunt increases resulting in alterations in systemic oxygenation. There are limited data examining the end-organ effects (including CNS) of the alterations in respiratory and cardiovascular function which may occur during OLV.

Near infrared spectroscopy (NIRS), known as cerebral oximetry, is a non-invasive device that uses infrared light to estimate brain tissue oxygenation ($rSO_2$). [1] The use of NIRS as monitoring of cerebral oxygenation was first suggested by Jobsis.
in 1977 [2]. NIRS uses infrared light to penetrate living tissue and estimate brain tissue oxygenation by measuring the absorption of infrared light by tissue chromophores such as haemoglobin. After the infrared light penetrates living tissue, the relative absorption of the different wavelengths is dependent on the concentration of the various hemoglobin species (unoxgenated vs oxygenated). Based on the relative absorption of the infrared light at various wavelengths, the specific concentration of the hemoglobin species can be determined using a modification of the Beer-Lambert law [1-3].

Previous studies have suggested that decreases in cerebral oxygenation as measured by NIRS may occur even without changes in routine intraoperative monitoring techniques including heart rate (HR), blood pressure (BP), and oxygen saturation measured by pulse oximetry (SaO2) [4-7]. Additionally, it has been demonstrated that these episodes of cerebral oxygen desaturation may correlate with postoperative neurocognitive dysfunction and that monitoring and treating these episodes may decrease the incidence of postoperative neurocognitive dysfunction. [6, 7] In particular Casati et al showed interesting results, but not so many experience followed those initial brilliant results [6].

To date, there are no studies evaluating changes in rSO2 which may occur during OLV apart a single study performed 5 years ago whose results showed that significant changes in rSO2 occurred during OLV for thoracic surgical procedures. The authors remarked that future studies were needed to determine the impact of such changes on the postoperative course of these patients [8]. So far no new data are available to understand the real role of this interesting tool during one lung ventilation.

References
Near-infrared spectroscopy (NIRS) in One Lung Ventilation, are really useful?

CON position

Béla Fülesdi, Tamás Végh
Department of Anaesthesiology and Intensive Care, University of Debrecen, Health and Medical Science Centre, Debrecen, Hungary

Recent reports suggest that during single lung ventilation (SLV) desaturation of the cerebral parenchyma may occur [1]. It has been also demonstrated that > 20% desaturation occurs in at least 50% of patients during SLV and cerebral tissue desaturation correlates with postoperative cognitive deficits [2, 3]. Based on this, several authors recommend the use of near infrared spectroscopy for intra-operative monitoring.

In our opinion, there are still questions remaining that should be addressed in further studies before the use of NIRS becomes widespread in thoracic anaesthesia.

There are several factors that may influence cerebral tissue oxygenation (rSO2). Among others, the most important is taking the regulation of brain circulation into account. The arteriolar tone of the brain is regulated by two factors, the partial pressure of CO2 and oxygen. When PaCO2 decreases, there is a decrease in cerebral blood flow and blood volume due to vasoconstriction induced by the hypocapnia. In contrast to this, increase in PaCO2 results in vasodilation of the arterioles, resulting in increased blood flow and blood volume. Thus, while assessing the cerebral tissue oxygen saturation during SLV, not only PaCO2, but also changes in PaCO2 have to be taken into account during intra-operative ventilatory management.

In fact, in the studies of Hemmerling et al. and Kazan et al., the gradual decrease of PaCO2 during SLV might have been associated with cerebral arteriolar vasoconstriction and a consequent decrease in rSO2. In a recent study, Végh et al. [4] demonstrated that maintenance of normocapnia during SLV may prevent or decrease cerebral desaturation. Thus, intra-operative ventilatory management taking PaCO2 levels into account may contribute to the avoidance of cerebral tissue desaturation.

The second issue of NIRS monitoring is defining adequate threshold levels of rSO2. In some studies an rSO2 below the absolute level of 60% has been defined as clinically significant. In others, a relative change of the rSO2 between 20-25% served as the threshold definition. If the relative change of rSO2 should be accepted, which rSO2 value should serve as baseline: the awake value before induction or the rSO2 measured after anaesthetic induction but before initiating SLV. If the latter is the case, pre-oxygenation may again result in washout of CO2 and consequently result in a false baseline value. These are questions that need to be clarified in further studies. In fact, we do not have clear information on what exactly is the necessary amount of oxygen of the brain parenchyma during general anaesthesia. It is known that the majority of anaesthetics decrease cerebral metabolic rate of oxygen (CMRO2) and this effect is different when using propofol or sevoflurane [5].

Finally, based on comparative studies, it is proven that there are considerable individual variations in arterio-venous ratios of blood in the brain. Therefore, it is conceivable that these variations may influence the results of NIRS monitoring. Individual variations may also play a significant role in patients suffering from general diseases affecting the reactivity of the brain arterioles to decreases in systemic blood pressure and PaCO2 levels. Among others, hypertension and diabetes mellitus are proven to influence arteriolar reactivity [6]. These altered reactions may play a modifying role in the accurate diagnosis of cerebral desaturation.

In conclusion: there are reports suggesting that cerebral desaturation may occur during SLV. Before NIRS becomes a recommended monitoring tool in thoracic anaesthesia, further studies are needed that take several factors into account while assessing
cerebral desaturation during SLV. So far not enough evidence exists to support routine use of this monitor.

References

P15-C
The best way to isolate the lung is:

P15-C-1
Double-lumen tubes (DLTs) are obsolete, the future is bronchial blocker

Edmond Cohen
Department of Anesthesiology, Mount Sinai Medical Center, New York, USA

(Editorial published in Anesthesiology 2013; 118: 550-561)

P15-C-2
DLTs are still the best for lung separation

Joseph Marc Licker
Geneva, Switzerland

P15-D
Are right-sided DLTs still useful?

P15-D-1
Left-sided DLTs for everyone

Mert Sentürk
Professor of Anaesthesia, Department of Anaesthesiology, Istanbul Univ. Istanbul Medical Faculty, Istanbul, Turkey

Using a Double-Lumen tube (DLT) is the standard method for lung separation. Although this method is generally safe and easy to use, a disposition of the tube can cause serious problems. Some anaesthetists choose the left-sided DLTs for right thoracotomy and visa versa, whilst some others prefer DLTs almost always, unless there is some contraindication.

There are different reasons to prefer left-sided DLTs in all possible operations. The right main bronchus (i.e. the distance between carina and the right upper lobe) is much shorter than the left bronchus. Al-
though there is a second lateral slot (the “Murphy eye”) in the right-sided DLT for the right upper lobe, there is still a greater risk of upper lobe obstruction with a right DLT. In as many as 3% of the population, the right upper lobe bronchus originates at the carina or even the trachea, In these groups of patients correct placement (both of the tube and the “eye”) can be impossible. Prior to intubation with a right-sided DLT, the patient’s CT-scan should be examined whether there is such a variation of the right upper lobe to challenge the success of the DLT-intubation; but this, in daily practice is not always the case.

Moreover, even if the right main bronchus is in the “correct” location for the right DLT, an “optimal” positioning of the tube is never as easy as a left-sided DLT, even for the experienced anaesthetist. Correct positioning can be achieved after intubation; but this can very easily change after turning the patient to the lateral decubitus position and/or with surgical manipulation. On the other hand, achieving and keeping the correct position is much easier with a left-sided DLT. In a series of 1170 patients, the intubation was successful at the first attempt in 75.9%. The left-sided DLT has a tight curve on the bronchial lumen increasing the success rate for entering the left bronchus.

Using the fibreoptic bronchoscopy (FOB) for the confirmation of DLT position is now considered standard practice. However, many anaesthetists still do not routinely use the FOB. It should be underlined that it may be acceptable not to use a FOB for the left-sided DLTs only. For the right-sided DLTs, a correct position without a FOB is, even in the anatomically correct patients, almost impossible.

Assuming that the anaesthetists who have less experience/familiarity with FOB have probably fewer patients requiring lung separation and OLV, it can be argued that especially in the units with less volume of thoracic surgery, a left-sided DLT should be the method of choice, unless there is a contraindication. Using a right-sided DLT should be limited to patients with an obstruction of the left main bronchus or to operations involving the proximal left bronchus.

References

P15-D-2
Right-sided DLTs for left pulmonary resections

Laszlo L. Szegedi
Department of Anesthesiology and Perioperative Medicine, and Acute & Chronic Pain Therapy, Universitair Ziekenhuis Brussel, Brussel, Belgium

Left-sided double-lumen tubes are perceived to be safer than right-sided tubes, because they may be less prone to malposition [1]. If this is true, then the incidence and severity of hypoxaemia, hypercapnia, and high airway pressures should be higher for right-sided tubes during thoracic surgery than for left-sided tubes. However, the supposition that left-sided DLTs are safer than right-sided DLTs where intra-operative hypoxaemia, hypercapnia, and high airway pressures are used as criteria, even when these tubes are used by infrequent users, is not supported by the data.

References
P16-1
Optimalisation of ventilation using a new impedance tomography monitor

Laszlo Szegedi
Department of Anesthesiology and Perioperative Medicine, and Acute & Chronic Pain Therapy, Universitair Ziekenhuis Brussel, Brussel, Belgium

Respiratory care has come a long way over the years, but even so, complications attributed to inappropriate ventilator settings continue to have an adverse impact on patient outcome, and this is even more applicable for one-lung ventilation. Today, lung protective ventilation strategies largely rely on physiological parameters. Complications of atelectasis and overdistension are well known. CT and chest x-rays provide specific information, but only as a snapshot in time. Determining how different lung regions respond to therapeutic interventions over time is challenging without continuous regional information. Measurement of ventilation/atelectasis is facilitated since the recent introduction of electrical impedance tomography (EIT). Electrical impedance tomographic monitoring measures can be taken to individually tailored ventilator settings [1-3]. The EIT gives a continuous visualisation of global and regional lung ventilation. PulmoVista® 500 by Dräger, is an EIT which has been specially designed for use as clinical routine. Data are continuously displayed in the form of images, waveforms and parameters. Simply put, it lets you visualise the distribution of ventilation.

Steinmann et al. [4], studied the use of electrical impedance tomography for correct positioning of double-lumen tubes (DLT). The DLTs are frequently used to establish one-lung ventilation and their correct placement is crucial. The hypothesis of the authors was that if an electrical impedance monitor reliably displays distribution of ventilation between left and right lung, it might be thus used to verify the correct position of the DLT. Indeed, the electrical impedance tomographic monitor displayed correctly a right or left contralateral switch of a double-lumen tube. However for correct placement of a DLT, electrical impedance tomography is not enough, fibreoptic bronchoscopy remaining the “routine golden standard” for their positioning.

Titrating volume and frequency during one-lung ventilation sometimes may be difficult. However, under direct electrical impedance visualisation it may be facilitated to avoid collapse or alveolar stretching and injury.

Alveolar recruitment strategy during one-lung ventilation may increase oxygenation [5]. The strategy for alveolar recruitment described by Tusmann [5] was the increase in peak inspiratory pressure to 40 cmH2O together with a positive end-expiratory pressure (PEEP) of 20 cmH2O for ten respiratory cycles. However, without direct visualisation, the lung may be either overdistended or not recruited enough. By using an electrical impedance tomographic monitor, the dependent lung can be visualised for the alveolar recruitment strategy.

For the non-dependent operated lung during open procedures, at the end of the surgery, alveolar recruitment is done and the collapsed lung may be inflated under direct vision. However, at the end of the surgery during thorascopic procedures, direct visualisation of the lung is sometimes difficult and electrical impedance tomography may be helpful to correctly inflate the nondependent lung, (either overdistended or atelectatic).

High frequency jet ventilation may be a valuable alternative for one-lung ventilation to create optimal surgical conditions. However, in a recent study (Szegedi et al., not yet published), when comparing these two methods, we have found that instead of uni-
lateral atelectasis as found during one-lung ventilation, during high frequency jet ventilation only the central regions of both lungs were ventilated and the atelectasis was peripheral, uniformly distributed to both lungs, creating huge atelectatic regions.

Certainly, electrical impedance tomographic monitoring has some inconveniences, one of the major being the impossibility of use during electrocoagulation because of electrical interference. Moreover, its use during open chest thoracic surgery may be difficult, given the fact that a belt is placed around the chest of the patient and the level of its placement obviously interferes with the surgical field.

References

P16-2
Usefulness of extracorporeal support systems during thoracic surgery

Mert Sentürk
Professor of Anaesthesia, Department of Anaesthesiology, Istanbul Medical Faculty, Istanbul, Turkey

Improvements in medical technology offer new horizons in the treatment of critically ill patients. Extracorporeal lung support systems have existed for a long time. However new developments have been reported, whose efficacy has to be confirmed.

Generally, there are two major indications for extracorporeal ventilation. It can be applied to give the injured or diseased lung a chance to heal (bridge to recovery) or in an end-stage lung disease, it might be used as a bridge to lung transplantation. Moreover, it is also indicated in the infra-operative period of complex trachea operations and combined cardiac and pulmonary procedures. It is also considered as a possible approach to hypoxaemia during one-lung ventilation; but very rarely and only as a “final chance”. On the other hand, it has been reported that there is an increased use of this technique in the treatment ARDS.

Extracorporeal membrane oxygenators (ECMO) and pump-less extracorporeal lung support (interventional lung assist [iLA]) (NovaLung™) have been increasingly used as bridges to transplantation. ECMO can be applied either in a “VV” (veno-venous) (mainly indicated in respiratory failure not responding to mechanical ventilation) or in “VA” (veno-arterial) (in cases where both respiratory and cardiac support are necessary) configuration. For iLA, an “AV” (arterio-venous) bypass system, into which a gas exchange membrane is integrated, is used. iLA provides effective CO2 elimination but only a moderate improvement in oxygenation. Both methods have advantages and disadvantages regarding their capabilities and technical difficulties.
During and after thoracic surgery, both techniques are indicated mainly in patients with bronchopleural fistulas after lung resection, severe lung contusion in trauma patients, life-threatening hypoxaemia caused by pneumonia, lung transplantation as well as primary graft failure in order to prevent ventilator-induced lung injury and to reduce inspiratory peak pressures. During mechanical ventilation in the postoperative period of thoracic surgery, “protecting” the lung against ventilator injury (while still achieving adequate oxygenation and/or gas exchange) can be very challenging. In these cases, there are reports showing the beneficial effects of the extracorporeal techniques. However, more studies showing the effects (but also the unwarranted effects) are necessary.

The use of these systems is appropriate only if it is considered that the lung failure is reversible with therapy and there would be gain time for recovery In irreversible cases, these systems can help as a bridge to transplant.

Reference

P16-3
Volumetric capnography for monitoring and predicting the effect of PEEP on oxygenation during one-lung ventilation

Tamás Végh
Debrecen, Hungary. Department of Anesthesiology and Intensive Care, University of Debrecen, Debrecen, Hungary; Outcomes Research Cosortium, Cleveland, USA

Even if the incidence of intra-operative hypoxia is lower than in previous decades, it remains a complication of one-lung ventilation (OLV) [1]. There are numerous methods to treat the intra-operative hypoxia during OLV, including increasing the fraction of inspired oxygen, ventilation of the operated lung, application of CPAP to the operated lung, performing recruitment manoeuvres and applying PEEP to the non-operated lung [2].

However, ipsilateral lung inflation cannot be used to treat hypoxia during video assisted thoracic surgery. In these cases one has to treat the hypoxia with manipulation of the non-operated lung [3]. These manoeuvres include increasing the tidal volume, augmenting the inspired oxygen fraction, or applying PEEP to the non-operated lung. PEEP, though, does not improve the oxygenation in all cases. In fact, Slinger et al report that only a small fraction of patients benefit [4].

Volumetric capnography (VC) plots expired CO₂ against expired volume during exhalation and represents the production, transport and elimination of CO₂ [5]. In patients who have benefited from application of external PEEP during mechanical ventilation means a lung recruitment process. Application of external PEEP leads to improvement in V/Q ratio by opening previously collapsed pulmonary capillaries and alveoli. Arterial oxygenation and CO₂ elimination thus increase. In other patients, though, external PEEP worsens oxygenation and CO₂ elimination by compressing pulmonary capillaries via over-distension of alveoli, leading to worsening of V/Q ratio.

Volumetric capnography can dynamically reflect the effects of the recruitment process and PEEP application using CO₂ as a marker of lung perfusion and ventilation. Specifically, CO₂ cannot reach the capnography sensor unless the alveoli are ventilated and perfused. The real-time volume of CO₂ per breath (VCO₂) thus depends directly on lung perfusion. In newly recruited lung units, reperfusion leads to increasing of VCO₂. In contrast, compression of capillaries due to overdistension of alveoli leads to a decrease in VCO₂ [6].

With breath-by-breath measurement of dead spaces (VD) and alveolar ventilation
(VA) during mechanical ventilation, volumetric capnography can help assess effectiveness of ventilation. While the effects of PEEP on airway deadspace ($V_{DAW}$) is variable, the effects on alveolar dead space ($V_{DALV}$) is clear. $V_{DALV}$ always decreases after recruitment. In patients who benefit from PEEP, a recruitment manoeuvre reduces dead space, thereby reducing the ineffective portion of each tidal volume [7].

During two-lung ventilation dead-space variables have a close relationship with lung collapse-recruitment phenomena and are useful parameters for monitoring the effect of PEEP and recruitment on oxygenation. $V_{DALV}$ is one of the most sensitive parameter for monitoring the effect of recruitment manoeuvres [7].

Monitoring dead space parameters, VCO$_2$, alveolar ventilation with volumetric capnography is simple, non-invasive and real time. The dead space parameters have advantages over PaO$_2$, because the former adequately reflects the effects of alveolar overdistension, while PaO$_2$ seems to be insensitive [8].

**Recent work**

As it has been noted, only a small fraction of patients benefit from application of PEEP during OLV [4]. In this case, the anaesthesiologist has to choose an alternative method to improve oxygenation. Our aim was to detect those patients who have no benefit (no or negative effect) from application of external PEEP [9].

**Patients and methods**

Data were obtained from 20 patients with a wide range of pulmonary hyperinflation during OLV for thoracic surgery, who were ventilated with an AVEA (VIA-SYS Healthcare) critical-care ventilator. The patient's trachea was intubated with a double-lumen endotracheal tube. During two-lung ventilation (TLV) and OLV anaesthesia was maintained with propofol TCI in oxygen-air mixture with FiO$_2$ of 0.8 and 8 ml/kg tidal volume with 10 min$^{-1}$ respiratory rate. OLV was started with the same ventilatory patterns as described above without external PEEP. After 20 minutes ventilation 5 cmH$_2$O external PEEP was applied for ten minutes, then PEEP was withdrawn. During each period, arterial blood gas partial pressure, volumetric capnographic parameters, respiratory and haemodynamic values and intrinsic PEEP were recorded. The I:E ratio and FiO$_2$ were kept constant throughout the study. From the time of closure of the thoracic cavity, TLV was started with the pattern described above and FiO$_2$ 0.4 oxygen in air was used to avoid absorption atelectasis in the postoperative period.

A 20% change (decrease or increase) in PaO$_2$ was accepted as significant ($P < 0.05$) effect of PEEP on PaO$_2$ [4]. More than 20% increase in PaO$_2$ was accepted as positive effect of PEEP (signed as outcome “0”), while less than 20% percent increase or decrease and more than 20% decrease in PaO$_2$ was accepted as no and negative effect of PEEP respectively (signed as outcome “1”).

**Results**

In eight patients PaO$_2$ increased significantly after application of PEEP (Subgroup 1, n = 8), in six patients there was no significant change in oxygenation and in six patients significant decrease was found in PaO$_2$ values after application of PEEP (Subgroup 2, n = 12). There were no significant differences in demographic data or pre-operative lung function test values, except in residual volume (RV predicted % Subgroup 1: 107 ± 12 vs. Subgroup 2: 150 ± 30%, $P < 0.001$).

Significant correlation was found between the percent change in PaO$_2$ and percent change in VC parameters after application of external PEEP.

The analysis of receiver operating curve (ROC) demonstrated high sensitivity and specificity of VC parameters for detecting no or negative effect of PEEP on oxygenation (Fig. 1).
Conclusions
Volumetric capnographic parameters, as fast reacting parameters, can be helpful tools for monitoring and predicting the effect of PEEP on oxygenation during OLV. Those hypoxic patients who have no benefit from application of PEEP can be safely detected by use of VC. As the parameters measured with VC are changing faster than PaO₂, anesthesiologist can avoid permanent hypoxic episodes during OLV.

Table 1: Correlation between the change in PaO₂ (%) and change of volumetric capnographic parameters (%) during OLV after PEEP application.

(VDphys: physiological dead space, PaCO₂-EtCO₂: arterial to end-tidal carbon dioxide difference, Vd/Vt: dead space to tidal volume ratio, VDalv: alveolar dead space, VA: alveolar ventilation, VCO₂: volume of exhaled carbon dioxide per breath)

<table>
<thead>
<tr>
<th></th>
<th>ΔPaO₂ (%)</th>
<th>r</th>
<th>95% CI for r</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔVphys (%)</td>
<td>–0.68</td>
<td>(–0.86) – (–0.35)</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>ΔPaCO₂-EtCO₂ (%)</td>
<td>–0.49</td>
<td>(–0.77) – (–0.06)</td>
<td>&lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>ΔVd/Vt (%)</td>
<td>–0.46</td>
<td>(–0.75) – (–0.25)</td>
<td>&lt; 0.05</td>
<td></td>
</tr>
<tr>
<td>ΔVDalv (%)</td>
<td>–0.71</td>
<td>(–0.88) – (–0.4)</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>ΔVA (%)</td>
<td>0.71</td>
<td>0.4 – 0.88</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
<tr>
<td>ΔVCO₂ (%)</td>
<td>0.77</td>
<td>0.49 – 0.9</td>
<td>&lt; 0.001</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1: Analysis of ROC for change in VC parameters and effect of PEEP during OLV
(A: VCO₂: volume of exhaled carbon dioxide per breath; B: VDphys: physiological dead space; C: PaO₂-EtCO₂: arterial to end-tidal carbon dioxide difference; D: Vd/Vt: dead space to tidal volume ratio; E: VDalv: alveolar dead space; F: VA: alveolar ventilation)
References

16:30 h – Invited Lecture + Oral Session
Chairs: Pascal Colson, France; Rafael Badenes, Spain

Invited Lecture 6: Perioperative renal protection strategies in cardiac surgery

Marc Vives, MD, PhD, EDAIC
Toronto General Hospital, Toronto, Ontario, Canada

Acute Kidney Injury develops in 5% to 42% of patients who undergo cardiac surgery depending on the definition of AKI, and 1% to 4% of patients require dialysis. AKI requiring dialysis after cardiac surgery is associated with an increase of short and long-term mortality and morbidity, length of stay and cost. Even small increases in serum creatinine (≥ 26.5 μmol/L) postoperatively are associated with increased mortality. Given the significant morbidity and mortality risk associated with postoperative AKI, the prevention of renal dysfunction is of paramount importance.

Preoperative strategies
In the pre-operative period, the major goals include optimizing cardiac output, avoiding intravascular volume depletion, and continuing congestive heart failure treatment before surgery. Optimizing renal function in elective surgery for patients with reversible AKI should be considered. Pre-operative use (48 h before surgery) of diuretics has been associated with an increase risk of RRT in a retrospective study.

Patients may benefit from avoiding pre-operative anaemia, defined as haemoglobin < 12.5 mg/dL. A recent pilot study found that the administration of erythropoietin before surgery reduced the risk of AKI and improved postoperative renal function. A single-dose erythropoietin plus an iron supplement given the day before surgery might be renal protective. They found a significant reduction in AKI (24% vs 54%). It is unclear whether
the preserved postoperative renal function was due to a renoprotective effect of erythropoietin or reduced transfusion rates. Recent data suggest that transfusing PRBC preoperatively could be associated with a lower peri-operative free iron and transferrin saturation with a trend towards lower AKI rates after surgery [1]. Further studies are required to affirm the benefit of transfusing PRBC or optimizing haemoglobin pre-operatively in anaemic patients.

Exposure to radiocontrast agents should be avoided or minimized, along with time to allow for renal recovery whenever possible [2].

The pre-operative prophylactic use of RRT on patients with sCr > 2-2.5 mg/dL (177-221 μmol/L) has been shown to decrease morbidity and mortality in several trials. However, the results are difficult to interpret, as RRT directly influences the definition of AKI. Therefore, these results need to be replicated in further trials. Cost-effectiveness analysis of pre-operative prophylactic use of RRT should also be studied.

To date, studies optimizing peri-operative haemodynamics using fluids and/or inotropes have not been designed to examine renal outcomes. Some data suggested a significant reduction in length of hospital stay and in postoperative complications associated with optimization of stroke volume. Data from a prospective study on 268 patients presented at the 29th Autumn ACTA meeting in Newcastle showed a renal protection benefit from maximising stroke volume using LIDCO during the first 8 h postoperatively. There was no difference in the amount of fluids given (2.704 ml/kg vs 2.905 ml/kg), but in the timing these fluids were given. In the goal-directed therapy group fluid were given earlier without waiting for low blood pressure to appear. There was a significant decrease of AKI by postoperative day 3, defined as AKIN stage 1 (6.5% vs 19.9%, P 0.002) and also a significant decrease of RRT (3.3% vs 10.6%, P 0.021) and hospital LOS (6 vs 7 days, P 0.004). No difference was found regarding in-hospital mortality. Pre-operative intravenous hydration may reduce the incidence of AKI in patients with Chronic Kidney Disease (CKD) undergoing cardiac surgery. A small randomized trial, on 45 CKD moderate to severe patients with GFR < 45 ml/min, using an intravenous infusion of 0.45% normal saline at 1 ml/kg⁻¹/h⁻¹ for 12 h before surgery versus no hydration, showed some renal protection effects (AKI-D 27% vs 0%, P < 0.001). Even though results need to be validated by larger trials, so far, data suggest patients should be euvoalaemic and off diuretics before surgery to avoid AKI.

Intra-operative strategies

An association between intra-operative anaemia, blood transfusion and AKI has long been noted. However, there is evidence to suggest that low pre-operative and intra-operative haemoglobin levels are associated independently with CSA-AKI [3], but ironically, there is also evidence to suggest that intra-operative transfusion is independently associated with CSA-AKI. Some authors suggested that it is not the absolute level of haemoglobin that is important, but its change from the baseline.

The benefits of a tight glucose control strategy have not been replicated in multicentre studies, and the lack of benefit and increased potential harm was confirmed again in a recent meta-analysis. The large multicentre Nice Sugar study demonstrated no outcome benefit in tight glucose control compared with a regimen that targeted a blood sugar level of less than 180 mg/dl (9.9 mmol/L) and had an unacceptable incidence of hypoglycaemia.

As one of the main physiopathologic mechanisms of CSA-AKI is the ischaemia-reperfusion injury, remote ischaemic preconditioning (rIPC) has been proposed as a potential means to prevent it. rIPC may attenuate myocardial ischaemia-reperfusion injury in patients undergoing coronary bypass surgery. Remote ischaemic preconditioning (RIPC) is the concept that brief ischaemia followed by reperfusion in an organ can reduce subsequent ischaemia-reperfusion injury in
distant organs. Several clinical trials showed significant myocardial protective effect of remote ischaemic preconditioning by reducing postoperative cardiac enzymes. To date, the evidence is still controversial. More robust data will be given to us from several multicentre trials.

**Surgical strategies**

Off-pump coronary artery bypass graft (OPCABG) allows systemic pulsatile flow and no exposure to an extracorporeal circuit, thus reducing the inflammatory cytokine response. Most available data support a decreased risk of AKI associated with OPCABG procedures [4-6]. An interesting study from the CORONARY trial cohort looking at renal outcomes 1 year following surgery is planned for completion this year.

**Pharmacological renal protection**

Several pharmacologic and therapeutic strategies have been used in an attempt to decrease the incidence of CSA-AKI. Although some appeared promising in early studies, conclusive evidence to support their widespread use is still lacking.

**Fenoldopam**

Fenoldopam is a synthetic derivative of dopamine with DA1 receptor selectivity that increases blood flow to the kidneys. Its use during cardiac surgery has been suggested to have reno-protective effects. A meta-analysis of 13 randomized and case-matched studies on 1,059 patients undergoing cardiac surgery concluded that the use of fenoldopam significantly decreased AKI-D, ICU length of stay, and in-hospital mortality. The results of this analysis may be questioned, however, due to the heterogeneity of the trials, including an inconsistent definition of AKI and no clear criteria for RRT initiation. A trial on 80 patients undergoing complex cardiac surgery showed that patients who received fenoldopam were associated with a significant reduction of CSA-AKI compared to the control group (0% vs 10%, P 0.045). Because the number of the enrolled patients was small, a large, multicentre and appropriately powered trial is needed to confirm these promising results.

**Sodium bicarbonate**

Experimental data have shown that higher tubular pH could be protective in the presence of haemoglobinuria or myoglobinuria, especially through inhibition of hydroxyl radical generation and lipid peroxidation, which could be central in AKI. In an analogy with the beneficial effects of urine alkalinization after rhabdomyolysis, urine alkalinization after intravenous bicarbonate was thought to prevent CSA-AKI.

A trial on 100 patients, found a significant reduction (P < 0.043) in postoperative AKI, liberally defined as an increase of 25% from baseline creatinine within the first 5 postoperative days, as well as a significant decrease in urinary neutrophil gelatinase-associated lipocalin (NGAL), associated with the use of sodium bicarbonate infusion. However, no differences were found when a consensus-based definition of AKI (RIFLE or AKIN) was used. Furthermore, a multicentre double-blind RCT on 427 high risk patients for developing CSA-AKI showed no difference either in CSA-AKI (defined as an increase in creatinine of at least 25% from baseline to peak value within the first 5 postoperative days), or in duration of mechanical ventilation, or in ICU or hospital LOS and nor ICU-mortality or 90-days mortality [7]. In this study, a slightly larger dose of bicarbonate was used compared to the Haase, et al. [8] study (5.1 mmol/kg vs 4 mmol/kg in 24 h). Both studies used the same definition of CSA-AKI. Whether the difference in sodium bicarbonate dose used in both studies might have any impact on renal outcome might be further studied. The debate is still open, but data do not actually support routine use of bicarbonate for CSA-AKI prevention.

**Natriuretic peptide**

Natriuretic peptides are known to oppose the renin-angiotensin-aldosterone and arginine vasopressin systems through multi-
ple mechanisms. As a result they can induce natriuresis and vasodilatation to prevent hypervolaemia and oppose the vasoconstrictive response induced by hypovolaemia. Synthetic analogues of these proteins have been suggested as therapies to prevent renal failure following cardiac surgery. A multicentre trial on 303 patients with left ventricular dysfunction (LVEF < 40%) undergoing cardiac surgery with CPB found that peri-operative renal function was better in the nesiritide group (lower peak rise in serum creatinine, smaller decrease in eGFR, and greater 24 h urine output). These findings were even more pronounced in the subgroup with baseline renal insufficiency (sCr > 1.2 mg/dl: 106 μmol/L). Furthermore, length of hospital stay was shorter in the nesiritide group. In a recent Cochrane meta-analysis including 493 patients undergoing cardiovascular surgery from 8 randomized controlled trials there was no difference in mortality between the ANP and control groups: RR 0.73, 95% CI 0.37 to 1.43. ANP was associated with a significant reduction in the need for RRT (RR 0.35, 95% CI 0.18 to 0.70). Another recent meta-analysis, including 934 adult patients from 13 randomized controlled trials, showed that natriuretic peptide administration was associated with a reduction in acute renal failure requiring dialysis (OR 0.32 [0.15-0.66]) and a statistically non-significant trend towards a reduction in 30-day or in-hospital mortality (OR 0.59 [0.31-1.12]). Recently, there have been three trials showing renal protection benefit from using human ANP in on-pump CABG surgery in three different types of patient population. The different patient populations studied were the following: patients with pre-operative normal renal function [9], patients with pre-operative ventricular disfunction [10] and patients with pre-operative CKD [11]. The benefit of using hANP on the first two groups of patients was laboratory-based (creatinine and eGFR), whereas, the RCT on patients with pre-operative CKD showed a benefit regarding not only AKI, but also AKI requiring RRT. Therefore, CKD patients might be the group of patients who benefit most from using ANP peri-operatively. However, these results need to be confirmed in a larger, adequately powered, prospective multicenter study.

**Postoperative strategies**

The early use of RRT after cardiac surgery has repeatedly been associated with an increase in-hospital survival in patients with CSA-AKI [12, 13]. The early use of RRT may be an important strategy to increase survival in patients with CSA-AKI.

**Summary**

A number of pharmacological and non-pharmacological interventions have been employed to either prevent or treat AKI, with varying efficacy. Although some appeared promising in early studies, conclusive evidence to support their widespread use is still lacking. Currently, pharmacological interventions have been attempted with inconsistent results. This inconsistency is related to a number of factors. First, the pathophysiology of AKI following CPB is complex, and simple approaches to target single pathways are unlikely to succeed. Second, late pharmacological intervention (dictated by the detection of rises in serum creatinine) is likely to meet with failure. Third, patient populations that have been studied are often at low risk for renal dysfunction post-CPB, thus potentially masking small beneficial effects of therapies. Last, most clinical trials enroll a small number of subjects and are inadequately powered to detect small benefits. Therefore, although there are some promising strategies, further well-designed and adequately powered studies are still warranted.

**References**

2. Del Duca D, Iqbal S, Rahme E, et al. Renal failure after cardiac surgery: timing of car-


Invited Lecture 7:
New role for colloids and crystalloids?

Marco Ranucci, MD, FESC
Dept. of Cardiothoracic and Vascular Anesthesia and Intensive Care, IRCCS Policlinico San Donato, Milan, Italy

Background

All the major surgical operations challenge anaesthesiologists and intensivists with the problem of fluid replacement. Cardiac surgery introduces additional items to the problem, mainly related to the use of cardiopulmonary bypass (CPB) and to the haemostatic system alterations.

At present, there is a wide availability of different fluid replacement solutions, and this wide choice makes the scenario even more confused. Basically, the main fluid replacement solutions available include

1. Normal saline (0.9% NaCl)
2. Ringer lactate and Hartmann’s solutions
3. Plasma-Lyte
4. Sterofundin
5. Hypertonic crystalloid solutions (7.5% hypertonic saline)
6. Gelatins (35-40 g/L)
7. Starches (with different medium molecular weight, ranging from 130 to 670; different degrees of substitution, ranging from 0.4 to 0.75; and different concentrations, ranging from 60 to 100 g/L)
8. Human albumin (4-5%)

Quantity: restrictive or liberal strategies?

In non-cardiac surgery settings, recent data suggest a shift from liberal towards restrictive policies of fluid replacement. In the setting of cardiac surgery, the main problem is represented by the need to maintain a correct pre-load, however avoiding fluid overload. This introduces the need for a correct assessment of the individual fluid responsiveness that in cardiac patients is affected by a number of haemodynamic conditions, basically including the systolic and diastolic function of the left and right ventricles.

As a general rule, colloids are retained longer in the intravascular space than crystalloid solutions, with a better preservation of colloid osmotic pressure. However, hypertonic crystalloid solutions may induce a higher intravascular volume expansion due to their high osmolarity. This effect, however, seems to be time-limited (about 50 minutes).

Various fluid-responsiveness indices have been proposed to individualize fluid replacement volume in cardiac surgery. These include pressure-based parameters (CVP, MAP, PCWP), static volume parameters (EVLW, ITBV), dynamic parameters (SVV and PPV), and echo-derived parameters (left ventricle and right ventricle end-diastolic areas). Goal-directed therapies based on these parameters have been proposed; but the evidence in terms of better outcomes is still poor in the cardiac surgery setting.

Crystalloids or colloids?

A recent meta-analysis [1] of RCTs comparing crystalloid vs. colloid-based fluid replacement in critical patients demonstrated that the use of colloids vs. crystalloids for fluid resuscitation did not result in a lower mortality rate. Additionally, the use of hydroxyethyl starch might increase mortality. The authors concluded that given the higher cost of colloids and the absence of a clear benefit, there is little room available for this approach. It must be considered however that few studies dealing with cardiac surgery were included in this meta-analysis.

The main concern about the use of hydroxyethyl starch as a fluid replacement solution is based on the potential for kidney function damage. A recent study [2] highlighted that hydroxyethyl starch (HES 130/0.4) exerts a deleterious effect on proximal tubular cells in a dose-dependent manner and other studies have highlighted the deleterious effects of HES in the surgical setting [3] for cumulative doses > 33 ml/kg.

The cardiac surgery setting is particularly sensitive for postoperative acute renal failure; additionally, specific alterations of the haemostatic system should be considered in the choice of fluid replacement solutions. Various studies have demonstrated that HES use induces coagulation changes, basically related to decreased clot firmness. These effects are absent or less pronounced with gelatins or albumin. However, recent studies have confuted these findings, and the real clinical impact of decreased clot firmness is still to be determined. An important point is that quantity, rather than quality of fluid replacement may induce clinically relevant coagulation changes, mainly based on fibrinogen deficiency and dilution coagulopathy.

Albumin

In adult cardiac surgery, the use of 4-5% albumin is presently practically abandoned, mainly due to cost implications. However, it must be highlighted that the great majority of the studies comparing albumin with other solutions did not find any major negative effect of albumin. Additionally, albumin competes with fibrinogen when used in priming solutions, limiting fibrinogen deposition on foreign surfaces and consequent platelet adhesion.
In paediatric and particularly neonatal cardiac surgery, albumin is still one of the possible choices for priming solutions and fluid replacement, as an alternative to fresh frozen plasma.

**Conclusions**

The major volaemic changes induced by cardiac surgery are represented by the dilutional effects of CPB. Apart from the well-known deleterious effects of severe haemodilution in terms of oxygen availability, dilutional effects include deleterious changes in blood viscosity and dilution coagulopathy. In this setting, the major challenge for the anaesthesiologist is preserving the physiology of the circulating volume, by limiting haemodilution. Therefore, before addressing the problem of the quality of fluid replacement, its quantity should be carefully kept under control.

**References**

Heart surgery is necessary in 850-1,000/1,000,000 inhabitants and the proportion needing heart surgery increases with age dramatically. Heart surgery is associated with a definite risk of death. In the UK the average adjusted mortality rate was 3% as published regularly in the scvs website. The association between patient characteristics and procedural factors with risk of death has been recently updated in the new version of Euroscore. In the cohort analysed the highest decile of risk had an observed mortality of ...%. This mortality is much above the life-tables mortality.

Patients with a prolonged ICU stay have a very poor prognosis and consume a large part of the available ICU resources. The poor prognosis not only is associated with increased mortality for about one year but also with very poor quality of life. Many patients remain bed-ridden and their most important expectation from surgery regaining autonomy has not been achieved. It would be advantageous if this unnecessary burden on patients and their families could be prevented and if the limited resources available in health care could be used more efficiently.

In general the term futility is applied to health care that does not improve outcome. Futility is not an objective measure and thus differences in the understanding and even larger differences have been found in the way patients care is done once agreement about futility has been reached.

Many consider that once futility is present the treatment agreement aiming at improving health condition is not anymore fulfilled. The consequence would be that any further treatment is illegal. This is the situation where there is an issue to “say no”. The controversies are largest when stopping ongoing treatment would be the consequence.

There are three distinct stages where there is an option to “say no”:
– Before the intervention,
– During the intervention,
– After the intervention.

There is also a clear need to consider the view of surgeons, anesthesiologists and intensivists as well as the patient and society view.

The surgeon’s view matches technical feasibility and surgical risk with potential to meet patient’s expectations and acceptance of risk. The anesthesiologist’s view addresses primarily his technicalities like safe airway, physiologic reserve of the cardiorespiratory system, capacity of the coagulation system to maintain homeostasis. There is also a distinct view on the potential to optimize organ function before surgery. The necessary delay and the associated potential increased risk need to be weighed against the potential to decrease risk.

The dialog between physician and patient should clarify to which extent the individual patient is ready to share risk and whether the proposed benefit matches expectations.
Risk-averse or risk-ignoring patients are a particular challenge.

The society’s view largely depends on the individual country and the political allocation of resources to health care. Some health care systems have decided to limit access to certain costly interventions by criteria such as age. In most western countries there is a societal agreement that all members of the society should have equal access to health care. In fact triage is a reality and potentially also a necessity. Typically the budget of public funding is limited and resources are distributed in a more or less transparent way.

“Say no” before surgery

Before the intervention careful risk evaluation and transparent communication of potential improvement may allow the patient to make an informed decision. The risk that an individual is ready to accept will depend on many factors that are not medical. Our task is to provide a realistic estimation of the risk of perioperative death and complications that may affect quality of life. It is important to understand the patient’s will. The surgeon should “say no” if the patient’s expectations cannot be met. I think that when perioperative risk is 3 times above average for cardiac surgery this should be shared.

The anesthesiologist should “say no” if organ functions can be improved within a reasonable period of time and thus the perioperative risk can be clearly decreased.

“Say no” during surgery

During surgery the decision to stop the intervention is only possible as a shared decision. It will mostly be related to technical problems such as uncontrolled bleeding, interrupted brain perfusion due to dissection or impossibility to wean from cardio-pulmonary bypass. The latter is less frequent since temporary support systems such as veno-arterial ECMO became routinely available in many centres.

“Say no” after surgery

“Say no” after surgery is usually a challenge for the intensive care units. “Say no” in intensive care takes many different forms such as DNR (“do not resuscitate”, DNE (“do not escalate”, AND (“allow natural death”) but more and more actively stopping life maintaining treatment such as ECMO, artificial heart, ventilator is the final step when treatment has become futile. Despite a broad discussion and consensus on many aspects in the ethical community there is wide variation in acceptance and practice. The cultural and religious background has been extensively investigated and there is much better integration in daily practice in recent years. The discussion will certainly continue because ICU resources are often limited and because a large proportion of resources is dedicated to patients that have a poor outcome.

Futility may be easy in a few cases as proven brain death but often involves prognostication with its inherent uncertainty. Physiologic futility is only one aspect the much more important aspect is the patient’s individual wish. In certain cultures it is not accepted that end of life decisions are addressed whereas it becomes an obligation in others. In these cases the families become an important source of information.

General guidance about withholding or withdrawing, clearly states that this should be a shared decision of the caregivers involved such as intensivists, surgeons and the nursing team.

Table 1: Preoperative modifiable conditions

<table>
<thead>
<tr>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme hypertension, blood volume may be abnormal, large variations during surgery</td>
</tr>
<tr>
<td>Heart failure and pulmonary edema fluid retention can usually be decreased, the pulmonary fluid accumulation and decrease in compliance and thus higher work of breathing may be improved</td>
</tr>
<tr>
<td>Severe arrhythmia</td>
</tr>
<tr>
<td>Pulmonary infection</td>
</tr>
<tr>
<td>Decompensated diabetes</td>
</tr>
<tr>
<td>Severe electrolyte disturbance actual compensatory mechanisms may decompensate</td>
</tr>
<tr>
<td>Recent stroke</td>
</tr>
<tr>
<td>Acute renal and liver dysfunction</td>
</tr>
<tr>
<td>Coagulation factors that cannot be antagonised, not stabilised HIT</td>
</tr>
<tr>
<td>Malnutrition</td>
</tr>
</tbody>
</table>
Proper and timely information of relatives and documentation in patient chart must be standard of care.

In summary “say no” will always be part of medical care and will also be difficult because certainty is not the rule. Much improvement can be expected from proper communication with all involved including the families.

10:30 h – P19
Acute lung injury (ALI):
From bench to clinic
Chairs: Alain Vuylsteke, UK;
Rafael Badenes, Spain

P19-1
Basic mechanisms of acute lung injury

Professor Masao Takata MD, PhD, FRCA

Acute lung injury (ALI)/acute respiratory distress syndrome (ARDS) is a major cause of morbidity and mortality in critical care. ALI is characterised by severe disruption of the alveolar-capillary barrier leading to pulmonary oedema, as well as by intense pulmonary inflammation involving recruitment of leukocytes. The likelihood of survival is determined by the severity of lung injury, the extent of non-pulmonary organ dysfunction, pre-existing medical conditions, and supportive care. Mechanical ventilation is an essential tool to treat ARDS in the ICU, but unfortunately by itself produces or worsens ALI, a phenomenon called ventilator-induced lung injury (VILI). The introduction of lung protective ventilation to attenuate VILI, based on the understanding of applied physiology of ALI/VILI, has successfully reduced the mortality of ARDS. However, it is not possible to completely eliminate VILI even with small tidal volumes, and ARDS still carries a high mortality of > 30%.

In search of new therapies for ALI and VILI, investigators now focus on more fundamental mechanisms behind the physiology, e.g. inflammation, in preclinical models. In particular, the number of experimental studies using mice has dramatically increased since early 2000s, taking advantage of availability of genetically modified mice as well as considerable similarities between the mouse and human immune system. These studies have identified a plethora of pathways that are potentially relevant in the pathogenesis of ALI and VILI, and the number of these candidate inflammatory mediators is increasing every year. However, as ALI/ARDS is a complex syndrome with a broad clinical phenotype, it has been challenging to translate the results of preclinical studies to pharmacologic therapies.

This talk will summarise what we have learnt so far from such translational animal research, highlighting the inflammatory mechanisms of ALI and VILI. We shall discuss the present somewhat confused, ‘overcrowded’ situation of inflammation research in ALI, and consider the importance of careful evaluation of relevance of animal experiments in the literature before translating to human situations. We shall also discuss what strategies we need in order to choose appropriate targets, and as an example, review our own experimental studies regarding a pro-inflammatory cytokine ‘tumour necrosis factor’ (TNF) and its receptors, the results of which suggest the potential of selective inhibition of intra-alveolar TNF p55 receptor as a novel therapeutic strategy for ALI and VILI.

P19-2
Ischemia-reperfusion injury in lung transplantation

Nandor Marczin
London, UK
P19-3
Perioperative lung injuries

Marc Licker
Department of Anesthesiology, Pharmacology and Intensive Care, University Hospital of Geneva, rue Gabrielle-Perret-Gentil, Geneva, Switzerland

Currently, the incidence of postoperative pulmonary complications (PPC) far outnumbers cardiovascular complications [1], varying from 10% to 70%, depending on definition, study design, heterogeneity of patient population and type of procedure [2]. In thoracic surgery, the main causes of peri-operative deaths have now shifted from cardiovascular to infections and pulmonary complications [3, 4]. Pulmonary morbidity has also been associated with increasing health care costs and poor outcome as reflected by prolonged hospital stay, (re-)admission in intensive care units and reduced long-term survival [5, 6].

Transient and self-limiting impairments in gas exchange should be considered as part of the anaesthesia emergence period and as the physiological response to surgery. Most of the patients undergoing cardiothoracic or abdominal operations present some degree of hypoxaemia and diffuse micro-atelectasis that will barely impact on the postoperative clinical course. In contrast, pleural effusions, sustained bronchospasm, lobar atelectasis or hypoxaemia unresponsive to supplemental oxygen may forecast serious adverse events such as bronchopleural fistula, pneumonia, acute lung injury (ALI) or respiratory failure [7].

Predictive factors of PPCs entail patient-related factors (e.g. chronic obstructive pulmonary disease [COPD], advanced age, poor nutritional status, decreased exercise tolerance, heart failure) and intra-operative related factors (e.g. emergency surgery, upper abdominal and intra-thoracic procedures, duration of anaesthesia, presence of a nasogastric tube, ventilatory settings, fluid balance) [2, 8]. These procedure-related factors are much more amenable to modification than preexisting chronic diseases.

Ventilator-induced lung injuries (VILI)

During spontaneous ventilation, tidal volume ($V_T$) and transpulmonary pressure (Ptp) in healthy subjects vary within tight limits of 4 to 6 ml per kg of ideal body weight (IBW) and 4 to 8 mmHg, respectively. Surprisingly and for decades, anaesthetists have been taught to apply “unphysiological” large tidal volume (10 to 15 ml/kg) to prevent the development of atelectasis. To date, a growing body of knowledge indicates that mechanical ventilation induces alveolar injuries by repetitive opening and closing of unstable lung units owing to surfactant inactivation, upregulation of pro-inflammatory mediators, generation of reactive oxygen/nitrogen intermediates and excessive mechanical stress between atelelectatic areas and neighbouring ventilated areas [9].

In anaesthetized patients with healthy lungs, besides “high” $V_T$ and elevated inspiratory pressure, other risk factors for lung injuries have been identified [10, 11]. Fluid overhydration increases capillary hydrostatic pressure and promotes interstitial/alveolar oedema particularly when lymphatics are disrupted. Additionally, tissue trauma, ischaemia-reperfusion, blood transfusion and exposure to extracorporeal devices may all combine to trigger (or to amplify) a widespread inflammatory response with potential deleterious effects on the lungs [12].

Some individuals are prone to develop ALI, given their deficient lung defence and repair mechanisms (e.g., antioxidant, heat shock protein, p75 receptor for tumour necrosis factor alpha [TNF-$\alpha$]) that fail to counteract the inflammatory and oxidative responses to damaging insults [13]. Genetic disruption of the transcription factor Nrf2 (NF-E2 related factor 2) has been associated with overexpression of proinflammatory cytokines and increased risk of ALI due to hypoxia and high VT. Relevant gene variants or single nucleotide polymorphisms (SNPs) in ALI candidate genes have been tested for
differences in allelic frequency in cohort studies (Nrf2, ACE genotype) [14,15].

Interestingly, a recent survey among members of the UK Association of Cardiothoracic Anaesthetists revealed that only 40% of 132 respondents were using “low” VT (median 6 ml/kg, interquartile range 5-7 ml/kg) during one-lung ventilation [16].

**Lung Protective Approaches**

Based on experimental models of ALI/ARDS, the “open-lung” approach including the combination of low VT, titrated external PEEP and periodic recruitment manoeuvres, has been shown to minimize the bronchoalveolar strain while preserving the FRC and preventing the development of atelectasis [17,18]. In thoracic and non-thoracic surgery, preliminary data also support this concept, although well designed RCTs are still lacking [19,20].

The fraction of inspired oxygen (FIO₂) might be reduced to levels sufficient to keep SaO₂ > 96% (FIO₂ < 60%).

The use of volatile anaesthetic should be considered in patients with bronchospastic disease and may potentially confer additional protection to the lungs and other organs [21, 22].

The use of minimally invasive haemodynamic monitors is advocated to optimize oxygen transport while avoiding fluid overload [23].

In the postoperative period, noninvasive ventilation can be considered in high risk patients [24]. In all patients, voluntary deep breathing and early mobilization should be encouraged and will be facilitated if optimal analgesic techniques are provided without undue sedation and while cardiovascular homeostasis is maintained.

Newer technological modalities including extracorporeal membrane oxygenation (ECMO) and pumpless extracorporeal interventional lung assist (ILA) should also be considered, not only as rescue therapies in refractory respiratory failure but also in lesser severe ALI to minimize mechanical stress on the lung [25].

**References**


10. Dreyfuss D, Basset G, Soler P, Saumon G. High inflation pressure pulmonary edema. Respective effects of high airway pressure, high tidal volume, and positive end-expi-


P19-4
Current strategies for ICU management of ALI

Javier Belda
Valencia, Spain
Cardiac surgery can be complicated by postoperative cognitive decline (POCD), which affects quality of life and increases resource consumption [1]. POCD is thought to be the result of micro-embolic injury, cerebral hypoperfusion, the postoperative inflammatory response to cardiopulmonary bypass and major surgery, or a combination of these factors [1,2]. Because cardiac surgery is associated with postoperative cerebral edema and because POCD appears to be related to intensity of the postoperative inflammatory response [3,4], it was hypothesized that suppression of this response with an anti-inflammatory drug may improve cognitive outcome.

We conducted a study to evaluate the effect of a single intraoperative injection of dexamethasone (1 mg/kg) versus the effect of placebo (NaCl 0.9%) in 290 patients who underwent on-pump cardiac surgery, on the incidence of POCD. The project is part of the DExamethasone in Cardiac Surgery (DECS) trial, a multicenter randomized placebo controlled trial in 4494 adults undergoing cardiac surgery with cardiopulmonary bypass. The primary outcome (the effect of intraoperative dexamethasone on major adverse events in the first month after randomization) has been published recently [5].

The subjects in the present sub study were recruited in three Dutch heart centers and underwent a neuropsychological test battery before their surgery and at 1 and 15 month follow-up. The test battery included the Rey Auditory Verbal Learning Test, the Grooved Pegboard Test, the Trail Making Test Part A and B, the Digit Span and Corsi Block Tapping Test. The primary outcome measure was the incidence of cognitive decline at 1-month follow-up. Cognitive decline was defined as deterioration beyond the normal variation in cognitive performance observed within a control population of 50 volunteers with cardiac disease, not undergoing surgery.

After obtaining informed consent, 290 underwent baseline neuropsychological testing and were randomized. Cognitive 1-month follow-up was completed in 279 (96%) patients. The 15-month follow-up will be completed by February 2013. After determining the presence or absence of cognitive decline in each patient at both time-points, the dataset will be de-blinded. The results will be presented on the 28th Annual Meeting of the European Association of Cardio-thoracic Anaesthesiologists, June 2013.

This work was supported by grants 80-82310-98-08607 from the Netherlands Organization for Health Research and Development (ZonMw) and 2007B125 from the Dutch Heart Foundation, as well as the 2011 SCA Mid-Career Grant (awarded to DvD).

References
Off-pump valvular procedures. New technique or new fashion?

Joerg Ender
Chairman, Consultant, Department of Anaesthesiology and Intensive Care Medicine, Heartcenter, University of Leipzig, Germany

Since the first use of cardiopulmonary bypass (CPB) in 1953 for a patient with atrial septal defect, CPB has become standard especially for open heart procedures. Although profound improvements of the CPB have been achieved in the last 60 years, there are still severe side effects affecting coagulation, brain, kidney and the circulatory system that lead sometimes to bad outcome especially in the high risk group of our cardiac patients.

Therefore attempts have been made to avoid the use of CPB and to perform valve procedures under off-pump conditions. The breakthrough of these procedures was the first successful implantation of a bioprosthesis crimped over a catheter to treat severe aortic stenosis by Cribier et al [1]. Since that time several companies have developed a transcatheter aortic valve, either for transapical, femoral or aortic route implantation (TAVI).

The off-pump valvular procedures performed nowadays can be divided into procedures for stenotic valve diseases as TAVI, transcatheter pulmonary valve implantations (TPVI) [2], and transcatheter valve-in valve implantation for stenotic mitral valve bioprosthesis or failed mitral valve repair [3] and off-pump valvular procedures treating valvular regurgitation such as the MitralClip® [4], NeoChord® [5] and the Valtech Cardioband® [6].

Whereas the TAVI-TPVI- and MitralClip-procedures are mainly performed in high risk patient population, the NeoChord and Valtech Cardioband procedures are designed to replace conventional valve surgery, although not yet ready for clinical use.

For all these procedures no long term data exist due to the relatively new methods. For TAVI procedures the problem of paravalvular leakage and incidence of permanent pacemaker implantation as compared to conventional aortic valve replacement has to be solved before a more widespread use for low risk patients can be advocated [7]. In MitralClip procedures the amount of residual regurgitation compared to conventional mitral valve repair is an issue which has to be addressed in the future although there is an improvement of left ventricular function and quality of life in these patients [8].

All the new off-pump valvular procedures have led to a profound paradigm shift. Whereas the surgeons were accustomed to performing their procedures under direct sight, the interventionist (either cardiologist or cardiac surgeon) is now completely dependent on image guiding [9].

We, as anaesthesiologists, formerly performed intra-operative transoesophageal echocardiography for conventional cardiac surgery for decades, but now we should spare no efforts to be involved in the management and echocardiographic guidance for these new upcoming off-pump valvular procedures which are promising techniques and no fashion.

References
4. Fann JI, St Goar FG, Komtebedde J, et al. Beating heart catheter-based edge-to-edge mitral valve procedure in a porcine model:


The results will be presented at the EACTA 2013 Barcelona meeting.

16:30 h – P21
New technologies: Always helpful?

**Chairs:** Fabio Guarracino, Italy; G. Burkhard Mackensen, USA

**P21-1 Optimizing the patients for cardiac surgery: Any evidence?**

**Manfred D. Seeberger**
President of EACTA, Head of Cardiothoracic Anaesthesia, Department of Anaesthesia and Intensive Care Medicine, University Hospital Basel, Basel, Switzerland

It is a generally accepted concept that preoperative risk stratification and optimization of patients scheduled for major surgery may improve outcome [1]. In cardiac surgical patients, the EuroSCORE is one of the most commonly used scores for risk assessment [2].

It is obvious that patients at increased peri-operative risk only benefit from risk stratifications if risk factors identified can be modified, i.e., improved. A look at the risk factors used to calculate 30-day mortality by the EuroSCORE II [3] reveals that many of them cannot be changed or eliminated: Age, gender, renal impairment, extracardiac arteriopathy, poor mobility, previous cardiac surgery, chronic lung disease, active endocarditis, critical pre-operative state, diabetes on insulin, left ventricular function, NYHA functional classification, CCS class 4 angina, recent myocardial infarction, pulmonary hypertension, urgency of surgery, weight of the intervention and need for surgery on the thoracic aorta. Nevertheless, one may speculate that some of these risk factors are modifiable and can be improved if surgery can be postponed, e.g., the degree of renal impairment,
pulmonary status, quality of diabetes care, heart failure, unstable angina, or pulmonary hypertension. Also, the preconditions for successful surgery in patients with endocarditis may be improved if time allows adequate antibiotic pre-treatment. Unfortunately, there is very little scientific evidence on the effect of modifying risk factors on outcome.

Not all risk factors are listed in the EuroSCORE. One example is transfusion of blood and blood products which is complicated by increased morbidity and mortality [4]. Measures used to decrease the probability of transfusion include pre-operative optimization of haemoglobin levels by recombinant human erythropoietin [5, 6], severe blood conservation efforts [7, 8], and acute normovolaemic haemodilution [9]. Point-of-care monitoring has been found favourable for optimizing coagulation and thus decreasing transfusion [10, 11].

Another approach used to reduce morbidity and mortality in high-risk patients with coronary artery disease is avoidance of cardiopulmonary bypass by performing surgery off-pump. However, although off-pump coronary artery bypass surgery has been well established, recent evidence questions the general advantage of this method [12, 13].

Peri-operative management of drug therapy may also affect outcome. There are data in favour of peri-operative continuation of aspirin and statins treatments while continuation of dual antiplatelet therapy depends on the specific situation of the individual patient. Also, it seems wise to treat patients with unstable diabetes before elective surgery whereas very strict glucose control in the peri-operative period might be harmful [14]. Interestingly, a stop of smoking shortly before surgery increases the risk of pulmonary complications [15].

In some patients at high risk, a less invasive treatment option can be chosen, e.g., percutaneous coronary intervention vs. surgical coronary artery bypass grafting or transcatheter vs. surgical aortic valve replacement. However, not every patient will benefit from a less invasive approach for coronary revascularization [16], and the indications and contraindications for transcatheter aortic valve replacement still need to be defined.

Taken together, there are a number of potential steps that are being used for optimizing the patient prior to cardiac surgery. However, scientific evidence for their benefit is available only for some of them.

References

P21-2
Diastolic heart failure in anaesthesia and critical care

Fabio Guarracino
Pisa, Italy

P21-3
Mediastinitis after heart surgery: could we achieve a better outcome?

Emilio Bouza
Professor-Head of Department for Microbiology, Gregorio Marañón General Teaching Hospital. Professor of Microbiology at the Department of Medicine, Complutense University Faculty of Medicine, Madrid, Spain

Mediastinitis is an infrequent but severe infection that may follow major heart surgery (MHS). The incidence varies between 0.5 and 5 episodes per 100 MHS interventions and risk factors for this entity include pre, intra and postoperative risk factors. Among the most important pre-operative risk factors are obesity and uraemia. Intra-operative conditions that increase the risk of mediastinitis include the length of the operative procedure and postoperative risk factors of the need for transfusions and re-interventions. Patients with heart transplantation are considered at a higher risk of mediastinitis.

The main clinical manifestations of mediastinitis may appear later than a week after the intervention and include fever, occasionally of unknown origin, sternal wound instability, wound opening and evidence of bloodstream infection with positive blood cultures.

The main aetiologic agents are Gram positive bacteria, including staphylococcus aureus or coagulase negative staphylococcus, but Gram negatives may account for up to a third of the episodes and a low proportion may be caused by fungi. Candida is the main fungus causing mediastinitis but asper-
gillus and other filamentous fungi have also been causative in a limited number of cases.

A main issue regarding the pathogenesis of mediastinitis is its origin. The apparently obvious idea that postsurgical mediastinitis is always an intra-operatively acquired disease should be considered with caution. Microorganisms can be recovered in culture in a significant proportion of patients’ wound swabs at the end of the operative procedure. However most of those micro-organisms are not going to cause mediastinitis. By the contrary, micro-organisms causing the mediastinitis were not frequently present at the end of the surgical procedure.

Wide debridement and long term antimicrobial therapy are the essentials for the treatment of mediastinitis but many issues remain unanswered regarding the best surgical procedure, the type of postsurgical care of the wound and the need and moment for vacuum techniques. In the field of antimicrobial therapy, drugs of election, the need for combination therapy, the timing of treatment and other issues remain under discussion.

Postsurgical mediastinitis is a disease to be better avoided than a disease to be treated, and preventive measures are multiple and essential. The incidence of postsurgical mediastinitis is a good indicator of the quality of the multidisciplinary team caring for these patients.

Mortality has considerably decreased in the last decade but still is more than 10% in some recent series.

### Room 114

**08:30 h – P22**

**Transplantation: emerging concepts**

**Chairs:** Nandor Marcin, UK; Luis Suarez, Spain

**P22-1**

**Prompt brain death diagnosis in the potential donor. Implications for cardiothoracic organ function**

**Rafael Badenes**

*Department Anesthesiology and Surgical Intensive Care, Hospital Clínico Universitario de Valencia, Spain*

Brain death is a clinical diagnosis. Cardinal requirements for clinical determination of brain death include coma, absence of brain stem reflexes, and apnea [1]. Although confirmatory tests, also mentioned as ancillary tests, are not mandatory in most situations, additional testing may be necessary for declaration of brain death in patients in whom the results of specific components of clinical testing cannot be reliably evaluated. Furthermore, in many countries, including European, Central and South American, and Asian countries, confirmatory testing is required by law [2].

**Definition of Brain Death** [3]

a. Prerequisites.
   i. Establish irreversible and proximate cause of coma.
   ii. Exclude the presence of a CNS-depressant drug effect.
   iii. no recent administration or continued presence of neuromuscular blocking agents.
   iv. There should be no severe electrolyte, acidbase, or endocrine disturbance.
   v. Achieve normal core temperature.
   vi. Achieve normal systolic blood pressure (vasopressors are often required).

b. Neurologic assessment.
   i. Coma.
ii. Absence of brainstem reflexes.
iii. Atropine test. (inability to achieve a 10% increase in heart rate following the administration of 0.04 mg/kg iv atropine sulfate).
iv. Apnea (lack of spontaneous ventilation and final PaCO₂ ≥ 60 Torr or 7.98 KPa).
c. Ancillary test. Electroencephalography (EEG) or somatosensory evoked potentials (SSEP).

The process of brain death in a potential organ donor is well known to cause significant perturbations to hemodynamic stability. Raised intracranial pressure leads to brainstem herniation and bradycardia, which in turn leads to a catecholamine surge that causes tachycardia, hypertension, increased force of ventricular contraction, and raised cardiac output [4]. However, there are few studies of the impact of donor brain death on the transplanted heart in the recipient, and recent studies have yielded conflicting results.

The impact of brain death time on the performance and longevity of the donor heart in the recipient is of particular interest at the moment.

Our group hypothesises that prompt diagnosis of BD (neurologic assessment and ancillary test) is important to prevent deterioration of the organs [5] (mainly, heart and lungs).

References
damages the lungs affecting their long-term functionality. Finally, a form of chronic rejection called “bronchiolitis obliterans” (BO) inevitably and progressively affects graft survival over time. Despite significant advances in immunosuppressive therapies in the last decade, BO is essentially an unsolved problem in lung transplantation.

Despite being a decades-old concept, the preservation of lungs outside of the body in physiologic conditions – Ex vivo lung perfusion (EVLP) – has been revived in the last decade to the point of recently becoming a “hot topic” in lung transplantation. An EVLP system connects the lungs to an artificial tubing circuit through which a normothermic (37 °C) perfusion solution is continuously circulated. The lungs are also ventilated with protective parameters during EVLP. A set of sensors allow for real-time monitoring, ensuring that the grafts are maintained under physiological conditions and quantitatively assessing their function. After a few years’ experiences with “first-generation” static and complex systems, a novel portable EVLP device is now available. This system, called Organ Care System-Lung (OCS-Lung, Transmedics Inc.), concentrates all capabilities of previous devices in a compact and easier-to-use machine and truly opens the category of “third-generation” EVLPs.

OCS-lung consists of a single-use lung module with a sterile organ chamber, a perfusion circuit connected to the lung through the pulmonary artery, a ventilator and tubing to connect to the trachea and several pressure and flow sensors for monitoring. The lungs are perfused with a normothermic hyperoncotic red-cell enriched solution and the effluent perfusate is recovered from the left atrium, analysed and recirculated through a reservoir. This lung module is set up in a console equipped with electrical batteries, gas tanks for ventilation and gas exchange and a wireless monitor for data display and control. The OCS-lung is fully portable and can be transported by car, plane or any of the usual means of travel of retrieval teams, while maintaining physiological perfusion.

The change of paradigm of lung retrieval is substantial with this system. Instead of cold-preserving the lungs and rushing to the implanting hospital to minimize cold ischaemia, the OCS-lungs allows for normothermic perfusion right after retrieval and a safe transportation to the transplant centre until the recipient is ready for the implant. The consequence of this is that cold ischaemia is virtually eliminated and we hypothesize that this strategy could have a tremendously positive impact in lung function after reperfusion in the patient.

The first clinical transplantation after portable ex vivo perfusion with the OCS-lung system was successfully performed in Puerta de Hierro in 2011. Since then, the joint experience with the first 12 patients transplanted by the Hanover group and our own centre was published in The Lancet in 2012. This publication showed the safety and efficacy of the system, even with a group of high-risk unselected recipients.

Following this pilot experience, a multicentre international randomized trial was initiated to compare the standard cold-storage strategy to the normothermic portable preservation provided by the OCS-lung. The INSPIRE trial, to date the largest randomized trial in lung transplantation, has enrolled over 150 recipients of an planned goal of 246, from European, American and Australian centres. The preliminary results with 100 patients, presented at ISHLT 2013 in Montreal, show superiority or non-inferiority of the OCS-lung in the essential variables of patient and graft survival, incidence of PGD, morbidity and others. These results, if confirmed at the end of the trial, could constitute a substantial ground for changing the current lung preservation strategies, basically unchanged since the development of lung transplantation, and could also mean better long-term outcomes for lung recipients.

EVLP systems have also shown potential to not only preserve, but also improve the performance of certain suboptimal lungs using a strategy of protective hyperoncotic perfusion and protective ventilation. Moreover,
using EVLP on “doubtful” lungs, such as those from uncontrolled donors after cardiac death (DCDs) could ensure that transplanted and tested lungs will perform correctly in the recipient. These advantages could increase the number of available donor lungs, alleviating another of the unsolved problems of lung transplantation.

OCS-lung also has these potential capabilities of evaluation and recovery, with the added benefit of starting the process right after retrieval and continuing it during transportation, without the additional damage of cold ischaemia.

In our centre we have established a strategy of assessing lungs from our programme of uncontrolled DCDs with the OCS-lung prior to transplantation, with promising early results. The soon-to-start “EXPAND” international trial and registry will prospectively gather the data to confirm that OCS-lung is not only an excellent tool for improved preservation but also an effective means to recover damaged lungs, increase graft availability and benefit more recipients.

In the future, long-term perfusions (> 12 h-24 h) which we have already achieved with the OCS, could open the door for more advanced treatments of donor lungs such as treatment of infection or aspiration, gene therapy and immunomodulation, thus constituting a “portable repair centre” for lungs and increasing even more organ quality and performance.

---

**P22-3**

**Optimal Ventilation in postoperative lung transplant**

**Dr. Javier Garcia, M.D., Ph.D.**

Head of Department of Anaesthesia and Critical Care, Hospital Universitario Puerta del Hierro, Madrid, Spain

Adult lung transplantation has become an established technique for the treatment of end-stage pulmonary diseases. The mechanical ventilation strategies in the postoperative period of a lung transplant are crucial. There are several concerns and problems you must afford in the lung transplant during the postoperative period: ischemia-reperfusion injury, primary graft failure, bronchial anastomotic complications (stenosis, granulation tissue, and bronchial dehiscence), pulmonary hypertension associated with right ventricular failure, ALI/ARDS, etc. Early postoperative extubation might play the crucial role supported by a NIV in the weaning process. Protective ventilation base in reducing driving pressure, low tidal volume, permissive hypercapnia, and limited PIP low than 25-30 cmH₂O are crucial. There is a great concern about the use of recruit maneuvers in these patients to avoid bronchial dehiscence. May be one of the most difficult situations for mechanical ventilation you can find are patients with one lung transplantation with a primary graph failure and a severe emphysematous lung in the native lung. Due to all these disadvantages if a lung transplant patient develop a ARDS we need to use more often extracorporeal membrane oxygenation (ECMO) and other devices as passive membrane ventilator that allows for oxygen and carbon dioxide gas exchange than in non-transplant patients.
In the early days of perfusion, extracorporeal circulation was run by doctors and pump-technicians [1]. These perfusionist-pioneers were trained on the job or in the laboratory. Permanent disassembling and reassembling of initially re-usable and often in-house-built equipment provided an excellent basis for understanding of perfusion systems and training of pump technique. Later on technical development with disposable oxygenators and tubings and the advent of myocardial revascularization initiated an explosive increase in cardiac surgery. Simultaneously there was a need for better understanding of the pathophysiological mechanisms of hypothermia and perfusion (bleeding, inflammation and organ dysfunction) and hence the need for better theoretical education and systematical training of the perfusionist became evident. Various education and training programmes were developed in the U.S. (AmSECT founded 1964, Ohio State Univ programme 1969), Italy (Rome 1973, Verona 1977), the Netherlands (first National programme 1981), Belgium (Leuven 1986), Sweden (Gothenburg 1987), and Germany (Berlin 1988). However, there was a wide variation between the different programmes regarding entry requirements, curricula, and level of education (academic or non-academic) depending on differences in educational systems, cultural heritage and language [2, 3].

The European Board of Cardiovascular Perfusion (EBCP) was founded in 1991 in order to unite European perfusionists in their desire for equality of standards in both theoretical education and practical training as well as professional status [4]. A democratic organization was initiated with representatives from the perfusion societies of all European countries which, at that time, were members of the European Community or the European Free Trade Association. Supporting organizations of the EBCP included the European Association for Cardio-Thoracic Surgery (EACTS), the European Society for Cardio-Vascular Surgery (ESCVS) and the European Association for Cardio-Thoracic Anesthesiologists (EACTA).

The main objectives of the European Board of Cardiovascular Perfusion were to:
- Establish, monitor and maintain equality of standards in perfusion education and training.
- Set out Essentials and Guidelines by which training programmes could be accredited.
- Establish a common perfusionist certification programme and issue a European Certificate in Cardiovascular Perfusion (ECCP) and thereby permit greater mobility of labour with recognition of professional competence.
- Liaise with the European commission to legalize these objectives through the appropriate health department.

Over the years a number of documents have been published by the EBCP, including Essentials and Guidelines for Accreditation of Education and Training Programmes, the Examination Guide, Sample Questions for examination candidates, the EBCP Log book, and the Perfusion check-list.

Written examinations for the ECCP have been organized since 1996 under the auspices of the Board. Until then it was possible to obtain the certificate by a Grand-person clause. Written examinations later were completed by additional oral and practical examinations. Initially all examination candidates were obliged to sit the written examination of the EBCP, but as part of the ongoing harmonization process of perfusion education, candidates graduating from a perfusion school who has successfully re-applied for
accreditation, can apply for the ECCP without a separate EBCP exam.

A recertification programme was introduced in 1999 in order to ensure that clinical ECCP holders are employed as clinical perfusionists, perform a minimum number of extracorporeal circulations per year, and remain informed about clinical and scientific developments in the perfusion profession. All perfusionists who hold the ECCP are obliged to recertify at 3-year intervals. Since 2004 a certification registry is published on the EBCP homepage listing all ECCP holders whose certificates are currently valid, either through recent EBCP examination or recertification.

Starting in 2001 the EBCP also organizes the European Conference on Perfusion Education and Training. The objective of this annual event is to provide perfusionists and other health professionals with a forum to exchange ideas and to promote knowledge in the field of perfusion and related techniques.

Today, more than 2000 European Board certificates (ECCP) have been issued. Twenty-four European countries have delegates in the Board representing the majority of perfusionists throughout Europe. The European Board of Cardiovascular Perfusion is recognized by the European Commission as the professional organization representing cardiovascular perfusionists in Europe.

References
4. www.ebcp.org

P23-2
Experience in multidisciplinary simulation training in perfusion incidents

Dipl.-Med. Päd. Frank Merkle
German Heart Institute Berlin, Acting Director of the Academy for Perfusion, Perfusionist Instructor, Steinbeis Transfer-Institut Medicine and Allied Health, Berlin, Germany

Training and education for perfusion involves basic scientific knowledge, materials science and pathophysiology as well as profound knowledge on operative procedures and on the use of extracorporeal circulation for cardiac surgery. Team management and communication skills are necessary adjuncts.

At the Berlin Academy for Perfusion, a high fidelity perfusion simulator (Orpheus), installed at a dedicated Simulation Operation Room, is in use since March 2009. Perfusion students as well as students from other disciplines are trained in this realistic environment. Additionally, crisis-resource management courses will be offered in-house for anaesthesiologists, cardiac surgeons and perfusionists.

Perfusion students are subjected to different stages in Simulation. Initially, demonstration of perfusion-related technology and training of basic skills are offered. Thereafter, more complex perfusion scenarios are organized in order to train students for both routine and emergency situations.

The development of professional behaviour was studied on a group of 20 perfusion students. 4 teams with 5 participants each were subjected to a standard perfusion scenario. Team members were assigned to act as surgeon, anaesthesiologist, perfusionist, or to another team role. Key findings were that the team was able to arrange and rearrange relevant procedural information, but that unexpected situations led to problems with team leadership.

Training of the cardiac surgery team may be enhanced by the use of high fidelity simulation. Simulation is a useful tool for educat-
ing perfusionists, interdisciplinary team training and development of professional ethos and behaviour. It is hypothesized that patient outcome may be positively influenced by team training interventions in the future.

P23-3
Multidisciplinary combat against perfusion complications – guidelines, communication or checklists?

Alexander Wahba
Trondheim, Norway

12:00 h – P24
Paediatric anaesthesia:
New problems, old questions, new answers
Chairs: Ignacio Malagon, UK; Nuria Montferrer, Spain

P24-1
Coagulation and anticoagulation in paediatric cardiac patients

Philippe Pouard, MD
Head of Anaesthesia Paediatric, Cardiac Intensive Care and CPB Unit, Paediatric Cardiac Intensive Care, Anesthesia and Perfusion Unit, University Hospital Necker Enfants Malades, Paris V University, Paris, France

Haemostasis as a developmental system is changing through infancy and childhood and haemostatic management will depend on the age of the patient from the neonatal period to adolescence. Most of the haemostatic disorders are the consequences of neonatal physiology, CPB technique and haematocrit level, especially in case of anaemia or cyanosis. The characteristics of neonatal haemostasis include immaturity of the haemostatic system at birth, due to liver immaturity, increased clearance of the proteins, vitamin K deficiency associated with thrombopenia, platelets hyporeactivity, and low level of coagulation factors except V, XIII, VII and von Willebrand. In addition the circulating anticoagulants are decreased (AT, proteins C and S) except alpha 2 macroglobulin which is increased. Neonates are less sensitive to heparin than adults as shown by the lack of linear relationship between heparin level and antiXa level, by the increased forming of thrombin during CPB (TAT, F1 + 2).

The role of CPB in haemostatic disorders includes exposure to non biological surfaces, hypothermia, suction, dilution, components of the priming solution, consumption of coagulation factors, fibrinolysis and length of CPB.

The management of anticoagulation and haemostasis is essential during paediatric cardiac surgery and involves a lot of different techniques and requires the participation of all the team, anaesthesiologists, surgeons, perfusionists and specialized biologists. Management also includes pre-operative anaesthetic consultation to assess the family history and the haemostatic balance, the reduction of haemodilution by using a very small priming volume and ultrafiltration, components of the priming, decreased activation with specific coating, perfect surgical haemostasis, short time on bypass and adequate coagulation testing.

Anticoagulation within paediatric cardiac surgery is driven by the CPB technique, kind of repair and coagulation status of the patient. Uncontrolled bleeding inducing intractable blood loss are nowadays very rare and the use of specific treatment such as activated fact VII very unusual.

During paediatric cardiac surgery an adequate management of haemostasis can reduce the immediate risk of bleeding even in neonates and the delayed risk of thrombosis.
P24-2
Ethical issues around research in paediatric cardiac surgery

Paul Baines, MD, MRCP, FRCA
Wellcome Trust Clinical Ethics Fellow, PICU Consultant Alder Hey Hospital, Liverpool, UK

Research in paediatric cardiac surgery poses awkward ethical problems. These include problems general to research with children with added difficulties arising from the emotive nature of cardiac problems and the urgency of the situation. As well as this there may be incomplete knowledge of the other congenital abnormalities that the child may have.

Research is often presented as intrinsically bad. It is the sort of thing from which right minded people should protect children. When attending introductory research ethics lectures or Good Clinical Practice Courses for Research (GCP) in the UK, the presenter usually shows a slide of the Nuremberg War Crimes Trial (a photograph of the Nazi leaders but not the doctors’ trial). The presenters then go on to describe other reports describing studies where subjects have been harmed, some of which involved children, for example the Willowbrook studies of hepatitis. The general tone is that research is intrinsically harmful and needs to be carefully regulated to avoid excesses perpetrated by enthusiastic researchers interested only in their study. But the other side of the coin is that there are enormous benefits from research and science in medicine, from the smartphone in my pocket giving me access to the dramatic improvements in outcome from illnesses. As examples the survival following ALI in children has increased from 2% in the 1950s to 80-90% currently. An example from cardiac surgery is the longer term survival of children with congenital heart disease that had been fatal before the 1950s. For the improvements to continue, we will need to continue research.

Children (and women and especially pregnant women) have been protected from research with added safeguards because they are vulnerable. This has however created the problem that the number of research projects carried out in children (the evidence base) is sorely limited so that much of paediatric therapy has to be extrapolated from adult medicine. If children are vulnerable, then their vulnerability is compounded by the limited evidence base in paediatrics. Attempts have been made to encourage paediatric research but it is still lacking.

Two ways in which research and our treatment of children is conceptualised cause problems. The first is the primacy of the notion of consent, the second is the notion of the child’s best interests.

Consent

Children’s participation in research is modelled on adults. Consent is at the core of an adult’s participation in research. So, in the Nuremberg Code “The voluntary consent of the human subject is absolutely essential... the person involved should have legal capacity to give consent; should be so situated as to be able to exercise free power of choice, without the intervention of any element of force, fraud, deceit, duress, overreaching or other ulterior form of constraint or coercion...” [Trials 1947, p. 181] Though this is not the first reference to consent in research. Ironically amongst the first of requirements for informed consent in research comes from the Prussian Parliament. In 1900, the Minister for Religious, Educational and Medical Affairs directed “...all medical interventions for other than diagnostic, healing and immunisation procedures...are excluded under all circumstances if 1) the human subject is a minor or not competent due to other reasons 2) the human subject has not given his unambiguous consent.” [Nicholson p 156]. The Nuremberg code excludes children from research, absolutely in so far as the participant should have legal capacity to consent.

This was the absolutist position argued for by a prominent American theologian, Ram-
say. He further argued that parents should not consent to research because it treats a child as an adult, as a joint adventurer in a common cause. Research was only acceptable when directly of benefit to the child. Responses to Ramsay included the idea that we should treat children as they ought to behave and so in the case of research with consideration for others too. Ramsay’s conception was too individualistic. Other responses include the idea that children as a class should benefit, though not necessarily the child who participates.

Assent

As well as parental consent, emphasis is placed on the child’s assent. However, what is meant by assent is unclear (and is clearly different between research guidelines from different sources). Although the standard necessary to consent has been extensively considered there is little work on what assent means [Baines].

What this may mean is that modelling a child’s research participation on consent is fundamentally wrong. Children just can’t consent, they are not mini-adults. And the demand for consent (or assent) approaches children’s research participation in the wrong way. This just isn’t the way to treat children. Following O’Neill and Manson’s criticisms of consent, what is important are the norms of how we treat children, and the quality of the research [Manson & O’Neill]. If this is so, then parental permission is important, but is different from the consent that an adult provides on their own behalf.

Best interests

Another approach to justifying how children are treated is based on the child’s welfare. Usually when acting for children we will aim to act in the child’s best interests. Decisions are made for what will be best for them. However, in research what is best for the child may not be clear. If a new treatment is proposed for a child then whether or not it is better for the child is unknown. Enrollment of children in randomised controlled trials is unlikely to be in their interests (if interests are understood as what will benefit them medically) firstly as research depends on equipoise (at some level the clinicians are in agreement that either treatment is acceptable) and secondly that the child will be assigned a treatment at random and will not necessarily get that which is hoped to be best.

Much is made of the distinction between therapeutic research and non-therapeutic research. Therapeutic research holds the prospect of benefit for the individual child and so may be permissible when considering interests, but non-therapeutic research holds no clinical benefit to the child and so will expose the child to pain (of venepuncture perhaps) or risks (of radiation or drug exposure) but without the prospect of benefit. And so non-therapeutic research is often held to be unjustifiable when considering the child’s interests. However, the problem with therapeutic research (where a child is offered a new treatment) is that it may not be research in the true sense: it is therapy. And however impressive the outcome of series of children treated with a particular treatment, the gold standard remains a trial with random allocation.

Given these concerns it is unlikely that children’s research participation will be in the child’s best interests. However it is important to recognise that parents do not always act in a child’s interests. For example, parents have to balance the interests of their children one with another in the family alongside their own concerns. Furthermore parents are allowed to act in ways that harm their children, by smoking, and by refusing neonatal screening or vaccination of their child.

References


13:00 h – PBLD
Thoracic Problem Based Learned Discussions (PBLDs)
Chairs: Laszlo Szegedi, Belgium; Mª Jose Jimenez, Spain

PBLD-1
Mediastinal mass in the pregnant patient

Mª Jose Jimenez
Universitary Clinic Hospital, Barcelona, Spain

Anaesthetic management of anterior mediastinal masses is always a challenge for several reasons: airway compression, haemodynamic instability and possible emergency surgery. Moreover, this complex situation in a pregnant patient dramatically increases the risk of complications and must be approached by a multidisciplinary team.

There are several causes of mediastinal masses but the most frequent are thymoma, thyroid, teratoma and lymphoma. The main symptoms include cough, chest pain, dyspnoea, hoarseness, orthopnoea, dysphagia, superior vena cava (SVCS) syndrome and syncope. Different structures may be affected depending of the location of the tumour in the anterior, superior or middle mediastinum (superior vena cava, tracheal bifurcation, pulmonary arteries, aortic arch, atria and ventricles). In general, anterior mediastinal masses are responsible for the most severe and life threatening complications due to compression of the airways and vascular structures. All these problems will be exacerbating under general anaesthesia [1].

A pregnant patient with an anterior mediastinal mass, adds additional risk associated with the reduction of pulmonary capacity and the increase of blood volume, by the foetus. The risk of cardiovascular involvement is more likely to be present with tumours that have SVC compression. Moreover, pregnant patients present aortocaval compression obstruction of venous return from the lower extremities, which also increases the risk of cardiovascular collapse during general anaesthesia. Otherwise, the initial diagnosis could be particularly difficult, because the signs and symptoms in the early stage are similar to the common complaints during normal pregnancy [1, 2].

Clinical Case

We are going to analyse a hypothetical clinical case based on Kanellakos’s article [1] of a 30 year old woman, 30-weeks’ gestation, who was transferred to hospital because of respiratory distress.

The patient had previously been healthy during pregnancy but six weeks ago, she began to have increasing shortness of breath and a cough unresponsive to routine treatments. At admittance, she also had orthopnoea.

Chest X-ray, computed tomography (CT), cardiac magnetic resonance imaging (MRI) and echocardiography were performed, showing a large anterior mass occupying almost the entire right chest, displacing the trachea to the left with a 50% narrowing of the distal part. The left mainstem bronchus was compressed, showing a very narrow internal lumen and the right upper and middle lobes were compressed too. The superior vena cava was severely flattened but without signs of SVC syndrome. The right pulmonary artery had a significant compression. Minor left and right atrial compression without haemodynamic compromise was also present.

A benign thymoma was diagnosed by a percutaneous biopsy. Resectional surgery
was indicated as a treatment of choice. Until then, the patient was on steroid therapy, which improved respiratory status and orthopnoea, in order to optimize foetal maturity trying to reach 32 weeks. There was no clinical deterioration.

**Peri-operative Management**

The main objective should be to establish a pre-operative action plan, according to the case.

A multidisciplinary approach will be decided, by a team of anaesthesiologists (thoracic and obstetric), thoracic surgeons, obstetrician and neonatologists. An intensive care unit for the mother and infant should be made available. All members must be involved in the peri-operative setting plan.

The plan, if the patient reaches 32 weeks, would be:
- A regular C-section delivery with a titrated epidural given by an obstetric anaesthesiologist in a cardiothoracic surgery operating room with a cardiopulmonary bypass (CPB) backup available. In this operating theatre, full equipment of cardiothoracic surgery and anaesthesia should be provided on site, in case of cardiovascular collapse.
- The thoracic surgeons and anaesthesia team should also be ready.
- Obstetric nurses and neonatologists will be in charge of the newborn.
- An ICU bed would be available but, if unnecessary, the mother will be recovered in a step down unit and transferred to the thoracic ward the next day, if possible.
- Mediastinal mass resectional surgery will be approximately, one week after the C-section.

**Anaesthetic Management**

Firstly, a careful anaesthetic plan should be established.

A perfect knowledge of patient’s history and skilled examination of chest images and cardiovascular examination will be the most useful information to guide the anaesthetic management.

How to induce the patient should be the first question. Gradual induction anaesthesia with a continuous monitoring of gas exchange and haemodynamics assessment is strongly recommended.

The maintenance of spontaneous ventilation until the airway is considered secure will prevent airway collapse due to decreased muscle tone. Awake intubation in the sitting position before induction, should also be considered in high-risk patients where the supine position is not tolerated.

In case of intra-operative life threatening airway compression, either: repositioning of the patient to less symptomatic compression or rigid bronchoscopy and ventilation distal to the obstruction must be available.

Anaesthetic induction can be inhalational with a volatile agent such as sevoflurane or by intravenous titration of propofol and ketamine.

If a muscle relaxant is required, before its administration, manual ventilation is recommended to assure the tolerance of positive-pressure ventilation (PPV) should be done. This is because the introduction of PPV increases the pressure transmitted to the compressed vessels and airways, worsening the compression. Maintaining the preload in this scenario is critical [3].

Great care should also be taken to ensure proper endotracheal tube placement. In our case, a left double lumen tube, guided by a flexible fibreoptic bronchoscope (FBS) into the left main bronchus is chosen to bypass the tumour and prevent hyperinflation of the right lung [3,4].

The use of CBP to avoid cardiovascular collapse before induction has been reported and discussed in the literature. There is an agreement of opinion that instituting CBP in an emergency setting would be difficult. In these cases, proper pre-operative cardiovascular evaluation should be helpful for indicating CBP prior to induction. Central lines under ultrasound guidance should be placed; preferably the ifemoral venous and femoral arterial lines.
A summary of the anaesthetic considerations proposed by Kanellakos are listed below [1]:

- Airway compromise (compression of trachea or mainstem bronchus > 50%)
- Armoured endotracheal or double-lumen tubes
- Maintenance of spontaneous ventilation on induction
- Low cardiac output due to vascular compression
- SVC syndrome (including consideration of line placement)
- Pericardial effusion
- CT-scan evaluation (location of the tumour and degree of compression)
- Lateral or prone position to ameliorate instability
- Echocardiography to evaluate haemodynamic compromise
- Invasive monitors
- Massive blood loss
- CPB availability

References

PBLD-2
Tracheal dehiscence – management

Laszlo Szegedi
Brussels, Belgium

Tracheal dehiscence remains one of the most feared and fatal airway complications. There are just a few successfully treated cases described in the literature. After heart-lung transplantation a successful repair of tracheal dehiscence was reported, with an intercostal muscle flap [1]. However, cases of tracheal injury after double-lumen or single lumen tube placement are more current. Their early recognition might help towards rapid intervention and repair. This problem based learning discussion will focus on the anaesthetic management of tracheal and generally upper airway injury.

References

PBLD-3
The patient with severe heart disease requiring OLV for non cardiac surgery

Irene Rovira
Universitary Clinic Hospital, Barcelona, Spain

Session Learning Objective 1: Define severe heart disease and non-cardiac surgery requiring OLV.
Session Learning Objective 2: Describe the respiratory and haemodynamics effects of OLV and recognize the potential peri-operative consequences in severe heart disease.
Session Learning Objective 3: Discuss the anaesthetic management and monitoring approach in patients with severe heart disease during non-cardiac surgery.
Session Learning Objective 4: Discuss post-operative care in severe cardiac patients after non-cardiac surgery under OLV.

Severe heart disease

Patients with severe heart disease submitted to anaesthesia and surgery are at risk of cardiovascular decompensation and death. The risk could be even higher if the type of surgery required one lung ventilation (OLF).

Guidelines for evaluation and management of patients with severe heart disease undergoing non-cardiac surgery have been developed by the American College of Cardiology (ACC) and the American Heart Association (AHA) [1] and by the European Society of Cardiology (ESC) and endorsed by the European Society of Anaesthesiology (ESA) [2].

These practice guidelines reviewed and updated all the available clinical evidence for prediction, diagnosis, management and prevention of cardiac events in patients with severe heart disease undergoing non-cardiac surgery.

Clinical predictors of peri-operative cardiovascular risk regarding heart disease have been stratified in three categories. 1) Major: unstable angina pectoris, acute heart failure, significant cardiac arrhythmias, symptomatic valvular heart disease, recent myocardial infarction and residual myocardial ischaemia. 2) Intermediate: previous MI, mild angina pectoris, compensated chronic heart failure, insulin therapy or renal failure. 3) Minor: old age, ECG anomalies or absence of sinus rhythm, low functional capacity, history of stroke or uncontrolled systemic hypertension. For any of the major categories (unstable cardiac conditions) scheduled surgery must be postponed and for the others categories functional capacity must be assessed.

One of the best predictors of cardiac risk is functional capacity. Functional capacity is measured in metabolic equivalent (METS) and a low functional capacity (< 4 METs) is associated with an increased incidence of postoperative cardiac events. After thoracic surgery a poor functional capacity has been associated with an increased mortality [3]. Patients requiring OLV during surgery, usually have chronic obstructive lung disease, with an increased risk of peri-operative pulmonary complications, that can further impair cardiac function.

For prognosis, long-term mortality and cardiac events, some pre-operative biomarkers such as brain natriuretic peptide (BNP) and N-terminal pro-BNP (NT-proBNP) are of great value after major non-cardiac vascular surgery. No data is available for non-cardiac surgery requiring OLV. Nevertheless, according to guide lines, routine measurement of these biomarkers to identify cardiac events is not recommended.

Diagnosis of the magnitude of the three cardiac risk markers, the major determinants of adverse postoperative outcome, left ventricular dysfunction (LV), myocardial ischaemia, and heart valve alterations, must be performed in patients undergoing high-risk surgery. A meta-analysis [4] demonstrated that an LV ejection fraction of < 35% had a sensitivity of 50% and a specificity of 91% for prediction of peri-operative non-fatal MI or cardiac death after major vascular surgery. Again, there is no data in patients requiring surgery under OLV.

In addition, left heart disease may cause pulmonary hypertension (PH) which can be accentuated by PH due to lung disease and hypoxaemia. PH is associated with significant peri-operative morbidity and mortality. Moreover, patients with coronary stents are at an increased risk of peri-operative cardiac morbidity and mortality due to stent thrombosis. Finally, patients with severe heart disease may have a pacemaker or implantable cardioverter-defibrillator that requires correct management during surgery to avoid complications.

Regarding the prevention of cardiac events in patients with LV dysfunction undergoing major non-cardiac surgery, the use of angiotensin-converting enzyme inhibitors, beta-blockers, statins, and aspirin is independently associated with a reduced incidence of in-hospital mortality. Thus, it is recom-
mended that they be taken throughout the peri-operative period [6].

**Non cardiac surgery requiring OLV**

Non cardiac surgery requiring OLV refers to intrathoracic surgery (pulmonary surgery, thoracic aorta surgery, oesophageal surgery) and thoracic spine surgery. During this kind of surgery the collapse of one lung allows an adequate surgical exposure for performance of the surgery. There are many intrathoracic surgical procedures that require OLV: video-assisted thoracoscopic surgery (VATS), open lobectomy, pneumonectomy, repair of thoracic aortic aneurysm or bronchopleural fistula, unilateral lung cyst, oesophageal resection, single lung transplant, as well as non-surgical procedures such as bronchoalveolar lavage for alveolar proteinosis.

According to the above mentioned guidelines, cardiac risk for intrathoracic surgery is considered an intermediate-risk procedure, with a reported cardiac risk (myocardial infarction and cardiac death within 30 days after surgery) between 1% and 5%. However, patients with severe heart disease should be considered a high-risk for cardiac complications.

**Respiratory and haemodynamics effects of OLV and its consequences in severe heart disease**

During OLV a series of respiratory and haemodynamic changes are produced and despite compensatory physiological mechanisms. This can be harmful in patients with clinically significant heart disease.

Respiratory changes are in both pulmonary lung mechanics and pulmonary gas exchange. Switching from two lung ventilation to OLV produces an impairment of lung mechanics, shifting the pressure/volume loop to the right with high peak and plateau airway pressures and low lung compliance. The non-ventilated lung creates an obligatory intrapulmonary shunt with a decrease of both arterial oxygen tension (PaO₂) and oxygen saturation (SaO₂). Hypoxaemia, in severe heart disease patients can worse myocardial oxygen supply. Fortunately, pulmonary hypoxic vasoconstriction (HPV) and position (lateral decubitus or prone position) which cause a gravity redistribution of pulmonary blood flow and improve ventilation/perfusion mismatch are compensatory mechanisms to improve oxygenation during OLV. On the other hand, potential dynamic pulmonary hyperinflation must be taken into account during mechanical ventilation [6, 7].

Haemodynamic changes during OLV are due to the body position, an increase in intrathoracic pressure, a reduction of venous return to the heart, an increase in pulmonary vascular resistance due to HPV and consequent right ventricular afterload augmentation. On the other hand, an increase of cardiac output after opening the pleura may occur due to a decrease in peripheral vascular resistance during thoracic surgery probably due to a large turnover of catecholamines in the lungs [8]. All these cardiovascular changes can decompensate patients with clinically significant heart disease.

**Anaesthesia and monitoring in patients with severe heart disease requiring OLV for non cardiac surgery**

The anaesthetic management and intra-operative monitoring is of crucial importance in patients with severe heart disease. Most of the anaesthetic drugs cause vasodilation and reduces systemic arterial pressure, so it is important to support organ perfusion and function, independently of the kind of anaesthetic. There is no evidence of superiority of any specific anaesthetic agent in non-cardiac surgery, as has been demonstrated in cardiac surgery with inhalational anaesthetic agents. Accordingly, it seems reasonable to use these anaesthetic techniques in severe heart patients undergoing surgery under OLV with the same purpose. Mechanical ventilation must also be optimized in severe heart disease patients during both bilateral lung ventilation and OLV, in order to protect the lung (avoiding ventilator-induced acute lung injury) [9] and the heart (avoiding haemodynamic impairment and further heart failure).
Intraoperative monitoring is even more important than anesthetic technique in this high-risk patients in order to detect and treat as soon as possible any cardiac decompensation. Electrocardiogram with ST segment monitoring help to detect any myocardial ischaemia or cardiac arrhythmias. Invasive blood pressure and central venous pressure are mandatory, while the insertion of a pulmonary artery catheter is controversial because has not been proved to improve survival, however, is useful for continuous monitoring of preload, cardiac output (CO), systemic and pulmonary vascular resistances and mixed venous saturation.

Transoesophageal echocardiography (TOE) is a routine monitoring tool during cardiac surgery with established evidence of benefit, but in non-cardiac surgery there is less evidence to support its use [10,11]. However, in pulmonary resection and in lung transplantation patients, it allows optimization of preload, inotropic support and early detection of right ventricular dysfunction. In addition, TOE is recommended for the diagnosis of any acute and severe haemodynamic instability or life-threatening situation during or after any type of surgery. TTE give us more information than a pulmonary artery catheter:- left ventricle contractility (ejection fraction), old or new regional wall-motion abnormalities (chronic or acute ischaemia), valvular dysfunction, right ventricular failure, intracardiac shunts, cardiac tamponade or the presence of thrombi. If available, TOE could be used in patients with any significant heart disease when submitted to OLV surgery. The disadvantage is that TOE needs to be taught nor can it be used in oesophageal surgery.

Additional monitoring includes pulse oximetry, capnography and lung mechanics (continuous airways pressures, flows and volumes). Regional cerebral oxygen saturation (SrO2) has been used in thoracic surgery during OLV and low values seem to correlate with postoperative complications [12].

**Postoperative care after non-cardiac surgery under OLV in patients with severe heart disease**

Surgical patients with significant heart disease must be controlled and monitored in the postoperative period due to the risk of developing postoperative heart failure. The risk of cardiac decompensation is often due fluid overloading (fluids needed intra-operatively or third space fluid re-absorption), myocardial ischaemia, postoperative arrhythmias (particularly atrial fibrillation), worsening PH and right ventricle dysfunction. In addition, electrolytes or glucose alterations, hypoxae mia, infections or renal dysfunction have to be immediately detected and treated.

According to the recent ESC Guidelines on heart failure, pharmacological therapy must be optimized before surgery, principally beta-blockers, which are recommended in the peri-operative period in all high-risk patient. If a heart failure patient is not receiving beta-blockers, these should be initiated early enough before elective surgery.

Another key point is pain control. The postoperative analgesia of choice after thoracotomy is thoracic epidural analgesia (TEA) because it produces a significant improvement in pulmonary function. However, caution is required in heart disease patients receiving anticoagulants or antiplatelet drugs. Paravertebral analgesia or iv. multimodal analgesia are also effective [13].

**References**


14:30 h – P25
Paediatric anaesthesia:
“New problems, old questions, new answers”
Chairs: Ignacio Malagon, UK; Nuria Montferrer, Spain

P25-1
Cerebral oximetry in paediatric cardiac surgery; tool or fashion?

Dr Tim Murphy
Consultant paediatric cardiac anaesthetist, Freeman Hospital, Newcastle upon Tyne, UK

Tool – a device used to carry out a particular function
Fashion – a popular or the latest style of clothing, hair, decoration, or behaviour

Background
Progress is continually being made in the field of treatment for congenital cardiac defects. Surgical and anaesthetic techniques and peri-operative management have been refined. Increasing emphasis is now being placed not only on a satisfactory cardiological outcome after surgery, but also on other markers of satisfactory outcome, including neurological status. Although neurological injury is now less common than in earlier eras, steps are still being taken to minimise peri-operative neurological damage. It has been suggested that the use of NIRS may assist in achieving that goal, although there are important differences of opinion. This talk will attempt to address such differences and will conclude that, currently, the use of cerebral oximetry in paediatric cardiac surgery is still a little more fashion than tool.
A NIRS monitor might be defined as a ‘tool’ under the following circumstances:
1. The theory behind near infrared spectroscopic examination of tissues is robust, scientifically proven, acceptable and clinically relevant.
2. It is utilised peri-operatively in order to secure better neurological outcomes for our patients.
3. We can define, reliably, what a neurological outcome is and how it may change or progress over time.
4. We presume that we understand the timing and mechanism by which neurological injury occurs (circulatory arrest, low cardiac output, embolic phenomena etc) and therefore how it could be prevented.
5. There is a recognised, validated, widely utilised algorithm that permits the team to make defined changes in management strategy based on what information the NIRS monitor is providing, with the aim of preventing brain injury.
6. There is clinically convincing evidence that children managed with a NIRS monitor have superior neurological outcomes compared to children managed conventionally.
7. There is a relative absence of other, ‘complicating’ factors that might make it difficult to understand the relationship between NIRS use and neurological outcome.

Examination of the evidence
1. The theory behind NIRS monitoring is scientifically acceptable.
2. NIRS can be used on its own or as part of a multimodal neuromonitoring set up (together with EEG analysis and transcranial Doppler). Neuromonitoring is used to try to secure better neurological outcomes and prevent damage. It may be used as a surrogate for cardiac output/venous saturations; this is a different use.
3. It is more difficult to define neurological outcome: presence or absence of seizures during a defined period of time after return from theatres? New lesions as detectable on an MRI scan? Any abnormality of MRI (a significant proportion of CHD patients have abnormal brains before they go to theatre)? Information from comprehensive neurodevelopmental assessments at defined time points? There are other definitions.
4. There has to be some doubt about the precise timing and causation of some neurological insults.
5. Algorithms have been published, and they tend towards the same sort of interventions (transfuse, alter temperature, change pump flows, modify cardiac output with drugs and medical interventions, change ventilation management and FiO₂, check cannula positions etc) – but algorithms are probably not universally used or accepted.
6. There is some evidence, but it does not yet meet the standards set in large, adequately powered, randomised controlled trials.
7. There is a myriad of complicating factors: the injurious effects of bypass itself, blood gas management strategy, target haematocrit, use of antegrade cerebral perfusion, anaesthetic technique and drugs, cardiopulmonary bypass equipment and technique (and many others). This will probably make it difficult to define a NIRS-specific effect that allows for superior neurological outcomes.

References
Despite the tremendous decrease in morbidity and mortality after congenital cardiac surgery in recent years an important number (25%) of patients with congenital heart disease (CHD) still develop a low cardiac output syndrome (LCOS) in the immediate postoperative period. It is associated with longer mechanical ventilation and prolonged hospital stay and has been identified as the main cause of death in children after open heart surgery (OHS).

Since LCOS is a major contributing factor to morbidity and mortality, vasoactive drugs are routinely used to treat it. However, selecting drugs for children with LCOS is a challenging task for healthcare professionals. There are no specific guidelines on the postoperative management of children with LCOS. Furthermore dosing guidance is not available for over half of the available cardiovascular drugs.

The positive inotropic agents improve haemodynamics and symptoms by increasing intracellular cyclic adenosine monophosphate within the failing heart but have been associated with an increased risk of death and other cardiovascular events. A new class of inotrope has been studied more in adults than in children. Over the last few years there has been increasing interest in the pharmacological agents acting on the responsiveness of myofilaments to calcium, the so-called calcium sensitizers. These new agents enhance myocardial contraction with a unique mechanism of action that increases calcium sensitivity with lower intracellular calcium concentration requirements. One of these new agents is LEVOSIMENDAN.

Levosimendan, a calcium-sensitizing agent, binds to cardiac troponin C in a calcium-dependent process that leads to a change in the configuration of tropomyosin. This change leads to an exposure of actin and myosin that begets a more efficient cardiac contraction. This agent does not elicit an increase in myocardial intracellular calcium, therefore preserving diastolic relaxation. Also it opens adenosine-5’-triphosphate vascular potassium channels that cause hyperpolarisation and vascular relaxation. This leads to a decrease in systemic vascular resistance and promotes coronary vasodilation. Levosimendan is a pyridazone dinitrate derivative with linear pharmacokinetics. Steady-state concentrations are noted within 4-8 hr, and the elimination half life is 1-1.5 hr. The drug is excreted in both the urine and faeces. Two metabolites, OR-1855 and 1896 (active) are made through a reduction of intestinal flora and an acetylation/deacetylation process. These circulating metabolites peak 48-72 hr after a continuous infusion is initiated and have an elimination half life of 70-80 hr, thus likely accounting for the prolonged effect of the medication even after cessation of an infusion.

Recently, it had been proved that levosimendan has a direct inhibitory effect on platelet-derived growth factor-induced proliferation of pulmonary arterial smooth muscle cells. Possibly it exerts additional anti-inflammatory and anti-apoptotic effects. Such effects have been suggested in patients with severe heart failure because of a reduction of pro-inflammatory cytokine and decrease of serum levels of the apoptotic marker soluble FAS (sFAS) immediately after infusion. These effects were sustained for at least 7 days.
In clinical studies, levosimendan increased cardiac output and lowered cardiac filling pressures and was associated with reduced cardiac symptoms, risk of death, and hospitalization. Unlike other positive inotropic agents, the primary actions of levosimendan are independent of interactions with beta-adrenergic receptors.

It is well established in the treatment of acute heart failure with or without concomitant ischaemia. There are also encouraging preliminary results in patients undergoing cardiac surgery.

The haemodynamic effects of levosimendan support its use in acute and postoperative heart failure. Several moderate-size clinical trials in adults (LIDO, RUSSLAN, CASINO) have previously suggested that the drug might even improve the prognosis of patients with decompensated heart failure. These trials were carried out in patients with high filling pressures. Recently two large trials (SURVIVE and REVIVE) in patients who were hospitalized because of worsening heart failure have been finalized. The two trials showed that levosimendan improves the symptoms of heart failure, but does not improve survival.

Although levosimendan has been used safely in several case series and reports in infants and neonates, randomized clinical trials in this population are still lacking.

In paediatrics this drug may show promise in that its use is associated with efficient cardiac contraction and also enhanced lusitropy. As was noted in one randomized trial, levosimendan has favorable effects on myocardial oxygen demand. The drug also has the beneficial properties of decreasing systemic vascular resistance through vascular relaxation and also promotes coronary vasodilation. From a paediatric perspective, generally, a drug with a relatively long half life may be of concern. Levosimendan has active metabolites that are present for days even after the infusion has been discontinued. If no paediatric adverse effects are noted, this property may have benefit, noting a lasting positive inotropic effect. However, if concerns exist after study in large numbers of paediatric patients related to side effects, this prolonged half life then becomes a deterrent rather than a benefit.

Considering the inotropic proprieties and potent vasodilator effects on pulmonary vasculature, levosimendan may offer potential as peri-operative therapy for paediatric patients with congenital heart disease and low cardiac output or increased pulmonary artery pressures. Some reports demonstrated the safety and efficacy in terms of haemodynamics and left ventricular function of this new agent during the pre- or post-surgical phase in infants or children with congenital heart disease. Evidence concerning the use of it for the treatment of postoperative myocardial dysfunction is still limited.

Conclusions

Levosimendan has been found to be a safe and useful drug when given to the sickest children with acute heart failure. The pharmacokinetics of levosimendan underpin the prolonged beneficial haemodynamic effects that result from single dose infusion regime. It is an appealing and promising alternative or an intermittent adjunct to current therapies for heart failure. It has been recently tested as a bridge therapy for the peri-operative phase of cardiac surgery in both adult and paediatric patients. Levosimendan may only have an impact on selective subgroups of patients, which must be delineated further.

References

Incidence, Pathophysiology

The incidence of acute kidney injury (AKI) following cardiac surgery in infants is estimated be up to 36%, and is associated, depending on the severity of the injury, with a 5 to 9-fold increase in the risk of death [1].

Diagnosis

Several reports highlight the lack of reliability of early variations in serum creatinine to diagnose changes in kidney function in adults, and a decrease in creatinine seems to be the normal course following cardiac surgery in children, but correlation with renal function in children is lacking. The pathogenesis of cardiac surgery related AKI is complex, and it is largely assumed that the pathologic lesion is acute tubular necrosis [2]. Unlike in adults, no scoring system has been developed in infants to predict the risk of postoperative AKI, but the length of the cardiopulmonary bypass (CPB) is the most important risk factor identified. Of the several mechanisms which contribute to the tubular injury during CPB, ischaemia and reperfusion, oxidative stress due to the generation of free haemoglobin and iron through haemolysis [3], and inflammation are thought to be the most prominent. Reduced renal perfusion, as demonstrated by a renal oxygenation beyond 50% which lasted for more than 2 hours, was well correlated with postoperative renal dysfunction in infants in a single-centre study [4]. The autoregulation threshold of the renal blood flow in children with CPB is not known to date, but excursions of the mean arterial pressure below the lower limit of the cerebral blood flow autoregulation have been shown to be associated with the occurrence of AKI in adults with CPB [5]. It is now established that normothermic and hypothermic CPB are associated with a similar risk of renal impairment in children [6]. Both anaemia and transfusions have been shown to favour injury to the kidney in adults undergoing cardiac surgery. In neonates, the intra-operative haematocrit threshold was set at 30% to prevent neurologic injury [7]. No “renal” threshold has been identified in children yet, but large transfusions have been associated with a greater risk of AKI following cardiac surgery [8]. It is likely that the use of miniaturized CPB circuits, resulting in fewer transfusions and reduced systemic inflammatory reaction, be associated with a decrease in the incidence of AKI, but unlike in adults, there is no such evidence in children.

surgery [9, 10]. It is likely that the dilutional effect of the bypass prime results in a further decrease in postoperative creatinine in infants. An increase in creatinine is commonly seen beyond 48 h of surgery in patients with AKI. However, the development of acute tubular necrosis is heralded by the appearance of sensitive urinary biomarkers such as neutrophil gelatinase – associated lipocalin (NGAL), interleukin(IL)-18, liver fatty acid-binding protein (L-FABP), kidney injury molecule (KIM)-1 and cystatin C [11, 12] and such markers might help with the early diagnosis of AKI. Several may even help distinguish pre-renal from intrinsic AKI [13, 14], and predict recovery from AKI in patients with renal support [15]. However, validation of the novel biomarkers raises the question of the gold standard for the diagnosis of AKI, still based on an increase in creatinine, and it has been suggested using hard outcomes such as dialysis or death [16]. The most popular biomarker to date is urine NGAL, but the best time for collection and the most accurate threshold for the prediction of dialysis requirement appear to be age dependent. In infants with CPB, Parikh et al. [11] found urine NGAL concentrations beyond 72 ng/mL within 6 h of CPB commencement was significantly associated with at least 4-fold odds for severe AKI, as defined by receipt of dialysis or a doubling in sCr from baseline, and identified severe AKI with 42% sensitivity and 85% specificity. In a meta-analysis pooling together over 2500 cases across several settings, the threshold urine NGAL concentration of 278 ng/mL within 6 h of surgery identified AKI requiring dialysis with 76% sensitivity and 80% specificity [17].

**Prevention and treatment**

No specific therapies have emerged that can attenuate acute kidney injury or expedite recovery. One single-centre study demonstrated that high-dose fenoldopam, a short-acting dopamine-1 agonist which has been shown to increase blood flow to both the cortex and medulla, resulted in a decreased urine NGAL and cystatin C when infused in infants on bypass [18]. To date, treatment remains supportive. In adults with septic shock, there is evidence that increasing mean arterial pressure from 65 to 75 mmHg increases urine output, no benefit being observed beyond 75 mmHg [19]. The restoration of blood pressure is a desirable therapeutic goal when the kidney appears to lose autoregulation, particularly if a patients remains hypotensive and oliguric after adequate fluid resuscitation. The initiation of dialysis remains somewhat subjective, and the decision to start dialysis is strongly influenced by individual physician practice. However, initiation of dialysis within 48 h of CPB in infants with severe AKI has been shown to improve early and late survival [20]. Studies examining NGAL, cystatin-C, NAG, and KIM-1 among others have suggested these novel biomarkers have the potential to distinguish patients in whom dialysis will be needed, implying that these biomarkers may be integrated into clinical decision algorithms [21].

**Prognosis**

Evidence suggests that adults who have had acute kidney injury are at increased risk of subsequent chronic kidney disease [22]. No such data is available in children. Dimopoulou et al [23] demonstrated that the risk of death at long term was 5-fold higher in patients with grown-up congenital heart disease in whom the glomerular filtration rate was severely reduced, and 3-fold higher in those with a mild impairment. However, associations between the occurrence of chronic kidney injury and surgery have not been assessed, and to date, it is not known whether cardiac surgery during childhood is a risk factor for subsequent kidney injury.

**Conclusions**

AKI is a devastating complication following paediatric cardiac surgery, and, albeit treatment remains supportive to date, it is now admitted that early intervention improves survival. In keeping with such a purpose, the most recent developments have focused on the identification of new
biomarkers enabling early diagnosis and accurate prediction of the severity of AKI, and which are potentially useful tools for clinical decision algorithms.

References

16:30 h – P26
EACTA – ASIA Panel
Chairs: Manfred Seeberger, Switzerland; Peter Rosseel, The Netherlands

P26-1
Anaesthetic management and outcomes of Hybrid Procedures at the Cardiovascular Institute of the Fuwai Hospital

Weipeng Wang MD., Hui Xiong MD., Lihuan Li MD., Shengshou Hu MD
Cardiovascular Institute and Fuwai Hospital, National Center for Cardiovascular Diseases, Beijing, China

Fuwai Hospital is the largest cardiac surgery centre in the world in terms of cardiovascular surgery volume. As early as 1997, Professor Hu Shengshou and Professor Gao Runlin did the first hybrid case with minimally invasive video-assisted direct coronary artery bypass grafting and PCI to treat multi-vessel coronary artery disease in the operating room and the catheter laboratory. In June 2007, the first hybrid operating room was set up in Fuwai Hospital, and since then it has been the busiest operating room in the hospital. Now, there are more than 30 hybrid operating rooms established in different centres of China, such as: West China Hospital of Sichuan CHD University, Qingdao Children’s Hospital, Shanghai Chest Hospital, Fujian Union Hospital, the PLA General Hospital, etc. Hybrid procedures have been quickly popularized nationwide.

Hybrid cardiovascular surgery (HCVS) is defined as the combination of minimally invasive direct cardiovascular surgery and percutaneous intervention procedures indicated for patients at the same time, so it is also called a one-stop cardiovascular procedure. Three procedures are performed in the hybrid OR, including correction of congenital heart disease (CHD), coronary artery bypass graft surgery (CAD) and major vascular surgery (MVS). As an example, for hybrid coronary artery revascularization, the potential advantages of HCVS are the superior long-term patency of the surgical left internal mammary artery (LIMA) to left anterior descending artery (LAD) bypass graft. Potential risks of one-stop HCR are associated with the administration of potent antiplatelet drugs in patients undergoing this procedure and exposure to contrast dye, raising concerns about coagulopathy, increased transfusion requirements, and renal insufficiency.

This talk will introduce hybrid procedures and early outcomes in the Fuwai Hospital.

P26-2
Anaesthetic Management of Adult Congenital Heart Disease

Mlinoru Nomura, Shihoko Iwata, Yusuke Seino, & Kenji Doi
Tokyo Women’s Medical University, Tokyo, Japan

Most patients with congenital heart disease reach adulthood after intervention or reparative surgery. As complete correction is generally not possible, a patient population with great complexity and a particular challenge to medical management is arising and a regular follow-up is mandatory [1, 2].
The type of surgery also varied among institutes. In many institutes, however, operations for L-R shunt, valves, right ventricular outflow tract (RVOT) lesions, and Fontan revision could account for the majority of surgery for ACHD.

We should recognize that ACHD patients consist of 2 major groups, one of younger patients requiring re-operation following corrective surgery for complex lesions and the other of elderly patients with simple CHD in which ASD is representative. In the former patients, operations for valvular lesions, RVOT lesions and Fontan revision for moderate to complex CHD patients are typically involved. Therefore, we should be ready to anaesthetise these types of patients, that is, younger patients for re-operation for complex CHD and elderly patients with long-standing L-R shunt, in the field of ACHD.

Exercise tolerance testing can be one of the most useful examinations in identifying pre-operative patients at high risk of mortality or major complication. Myocardial perfusion imaging should be used for patients with high-risk pathophysiology of abnormal coronary perfusion to detect the presence and extent of myocardial damage. In addition, BNP can be valuable in detecting ventricular dysfunction and adjunctive in predicting a poor outcome after cardiac surgery. However no test will assure successful treatment of surgery in patients with ACHD.

In ACHD with severe complexity, especially single ventricle physiology however, the risks of bleeding, mortality, and morbidity were markedly increased and the ICU stay and hospitalization were markedly prolonged. The pre-operative examination, which can solely predict poor outcome after cardiac surgery for ACHD reliably, has yet to be established.

We will discuss risk-assessment of ACHD together with intra-operative diagnosis with TOE including 3D TOE analysis [3].

References
Invited Lecture 9: Low flow during ECC: Still good?

Jouko Jalonen
Professor of Anaesthesia, University of Turku, Turku, Finland

The required flow rate during cardiopulmonary bypass (CPB) depends obviously on the determinants of oxygen delivery and oxygen consumption, autoregulation of vascular beds in various organs and consequent blood flow distribution within the body. Excessive flow should be avoided due to consequent increased accumulation of fluid and tissue oedema and increased load of microemboli. In specific situations, however, it may be difficult to maintain desirable flow. What are the tolerable limits of low flow in those conditions?

Oxygen consumption (VO₂) in proportion to body weight changes from about 8 ml/kg·min⁻¹ in a newborn to approximately 4 ml/kg·min⁻¹ in an adult. In moderate hypothermia VO₂ decreases curvilinearly and is about 50% at 30 °C of the normothermic level. The decrease, however, may not be similar in all organs, and the ability to maintain adequate tissue oxygenation in falling temperatures depends on the adjustment of maintenance of autoregulation. This ability has been studied especially in the brain. Cerebral blood flow was maintained constant when CPB flow was adjusted between 1 and 2 L/min⁻¹/m² [1]. Also the autoregulation of the cerebral blood flow was maintained in hypothermia down to 20 °C if the unadjusted CO₂ tension was kept constant [2]. The autoregulation pressure threshold may be even lower in hypothermia than in normothermia.

Jonsson et al. found in a study on pigs that selective antegrade cerebral perfusion in 20 °C flow of at least 6 ml/kg·min⁻¹ did not increase lactate production in the brain whereas a temporary reduction of flow to 2 ml/kg·min⁻¹ did [3]. Using magnetic resonance spectroscopy they were able to show that this increase was also intracellular, and increased S100B levels further suggested brain cell injury. In another animal study a high flow of 18 ml/kg·min⁻¹, however, did not offer any advantages but induced an increase in intracranial pressure [4]. A study in cardiac surgical patients showed no signs of decreased cerebral oxygenation during hypothermic bypass with flow rates of 1.2 L/min⁻¹/m² when the perfusion pressure was maintained between 50 and 70 mmHg [5].

There is less information on changes in autoregulation in other tissues. In one study in humans at 28–30 °C, VO₂ increased linearly with increasing O₂ delivery, suggesting more recruited vascular beds [6]. In normothermic bypass flows less than 1.8–1.6 L/min⁻¹/m² are associated with increased lactate production. Consequently, flow rates of 2.2 L/min⁻¹/m² in temperatures of 28 °C or warmer in adults and 2.5 L/min⁻¹/m² in children [7]. In children cardiopulmonary bypass flow rate less than 100 ml/kg·min⁻¹ was associated with an odds ratio of 7.67 for postoperative hyperlactataemia [8]. On the other hand, cardiopulmonary bypass flow rate of 110 ml/kg·min⁻¹ was associated with higher positive net fluid balance and fluid extravasation rate than 80 ml/kg·min⁻¹ [9].

Not only flow but also pressure influences blood flow distribution during cardiopulmonary bypass. The perfusion pressure commonly drops at the start of bypass due to decreased haematocrit and viscosity. Hypothermia and increasing levels of circulating catecholamines gradually counteract these effects: viscosity at 25 °C and haematocrit 25% are about the same as viscosity at 37 °C and haematocrit 40%. There is evidence that lower perfusion pressures are associated with increased risk of postoperative neurological complications [10]. However, high perfusion pressure (90 mmHg) induced
hyperperfusion and increased intracranial pressure after hypothermic CPB in pigs [11].

In conclusion, the minimum tolerable low CPB flow has not been established and it is different in different patient populations. So far the commonly recommended conventional flow rates are probably the best guidelines that can be given. Advancements in monitoring of organ perfusion and oxygenation may offer additional safety if lower CPB flows is used in specific circumstances.

References

10:30 h – Invited Lecture + Oral Session
Chairs: Irene Rovira, Spain; Josefina Galan, Spain

Invited Lecture 10: Perioperative pain therapy: new concepts

Anna Flo
Leipzig, Germany

In spite of the advances in surgical therapy and anaesthetic management, treatment of acute pain remains inadequate with a substantial proportion of patients experiencing moderate-to-intense pain during the period immediately following surgery and also chronic postsurgical pain with a reported prevalence of 20 to 50%.

Adequate postoperative analgesia prevents unnecessary patient discomfort, inhibits stress response and enhances recovery of patients.

Most cardiac surgical procedures are still performed with a median sternotomy although the emerging minimal invasive pro-
Acute postoperative pain reflects the effects of complex injury occurred during surgery and transmitted to peripheral, spinal and cerebral levels, with the implication of chemical mediators of inflammation and sympathetic response. It is mostly secondary to tissue injury in the skin, subcutaneous tissue, bone, cartilage and parietal pleura. Intra-operative sternal retraction may cause rib fractures and brachial plexus injury which lead to postoperative non-incisional pain. Vein harvesting, internal mammary artery dissection and chest drainage tubes are other causes of postoperative pain.

Primary afferent fibres conduct impulses from peripheral nociceptive receptors stimulated from surgical tissue incision to the dorsal horn of the spinal cord and thereafter sensory information is relayed to the supraspinal structures including cortex. The pain transmission is modulated resulting in a reduction of pain threshold at the site of the lesion (primary hyperalgesia) and in the surrounding uninjured tissue (secondary hyperalgesia) as a result of a central sensitization at horn level. Prolonged central sensitization can lead to changes in neurons and in glia increasing excitatory and decreasing inhibitory mechanisms. An abnormal persistence of excitatory neuroplasticity is considered to be a major mechanism for development of postoperative persistent pain.

Persistent postoperative pain syndrome is defined as postoperative pain lasting at least 2 months after the procedure if other causes for pain such as incisional infection, sternal mal-union and intolerance to sternal wires can be excluded.

Aetiology of chronic pain is indefinite and several risk factors such as young age, female gender, anxiety and somatization, pre-existing pain, chronic pain treatment or elevated BMI as well as a genetic predisposition have been described. Severity of acute pain is considered as a strong predictor for long lasting pain. The most important surgical factor for development of the chronic pain is the site of incision with thoracotomy being a more powerful risk factor compared to sternotomy.

Opioids are used in large doses during anaesthesia and are the cornerstone of postoperative pain management. Their use can provide effective pain relief, but it may lead to undesirable side-effects such as sedation, respiratory depression, ileus and PONV which may be the explanation for insufficient opioid use in the treatment of postoperative pain. Studies have shown that opioids produce hyperalgesia, not only secondary to opioid withdrawal but also due to prolonged opioid exposure inducing a persistence of excitatory neuroplasticity. Whether the administration of large doses of opioids intra- and postoperatively plays a role in increasing the risk of early exaggerated postoperative pain or the development of postoperative chronic pain in the clinical setting, remains controversial. Opioids remain the basis of management of moderate to severe pain, but the simultaneous use of analgesics with different mechanisms of action has to be considered in clinical practice in order to provide a higher quality of pain control, reducing consumption of opioids and their adverse effects, providing an antihyperalgesic effect and potentially lowering the incidence of chronic pain development.

Among adjuvant strategies to complement opiate therapy are: thoracic epidural analgesia (TEA), intrathecal opiates, para-vertebral blocks, intercostal blocks, wound infiltration, NAIDs, acetominophen and anti-hyperalgesic medication.

TEA provides optimal pain relief during surgery and the first few days after surgery and perhaps improves postoperative outcomes but does not prevent the chronic post-surgical pain. The potential benefit of TEA in cardiac surgery is probably not worth enough because of the serious complication risk such as the development of neuroaxial haematoma.

Intrathecal morphine improves postoperative pain control but does not appear to blunt the stress response as effectively as
TEA and also possesses a risk of neuraxial haematoma.

Paravertebral block provides comparable pain relief to TEA with no neuroaxial complications.

Local anaesthetic infiltration and wound catheter infusion seems to be a rational approach to reduce afferent nociceptive input from the surgical injury, inhibiting local inflammatory responses and blocking central sensitization. The technique is simple and safe and provides potent, site specific analgesia.

NDAIDs and acetaminophen are useful adjunct therapies with analgesic and antihyperalgesic effects that allow a reduction in systemic opioid consumption and improve postoperative analgesia, although they should be used with caution in high risk patients.

A proposed management strategy against opioid induced hyperalgesia involves the use of antihyperalgesic medications such as NMDA receptor antagonists like ketamine, magnesium or NO, alfa-2 agonists such as clonidine or dexmedetomidine, voltage gated calcium channel blocker in the spinal cord such as gabapentin and pregabalin and cyclo-oxygenase inhibitors. The effect of this treatment on acute peri-operative pain can be imperceptible. It is still unknown if the early nociceptive hyperalgesic response is the cause of persistent pain and if its treatment will reduce the incidence of chronic postoperative pain. Their use remains controversial because of the contradictory clinical results.

Given the subjective nature of pain it would be rational to implement peri-operative educational and training programmes as part of pain therapy.

The knowledge of the pathophysiology of pain and the increasing evidence of an association between the level of acute pain and the risk of developing chronic pain should lead us to focus our analgesic intervention on multimodal techniques using a variety of drugs to overcome peripheral and central neuroplasticity as long as wound inflammation and hyperalgesia persist.

References