Deep sedation/procedural sedation for cardiac catheterization in children

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Abstract

Management of children and adolescents with congenital heart disease during cardiac catheterization is a challenge for the attending anaesthetist. According to other diagnostic procedures such as CT-scan and MRT, it is not always necessary to perform general anaesthesia with intubation. The aim of the anaesthesiologic management is to facilitate cardiac catheterization under physiological conditions in a spontaneously breathing, deeply sleeping patient, who is free of pain. In general, these goals are met by procedural sedation. In contrast, positive pressure ventilation with PEEP causes changes of the intrapulmonary pressure influencing intracardiac pressure and shunt volumes. Indications and contraindications for procedural sedation have to be kept in mind and profound knowledge of the individual heart disease is necessary. It has to be decided whether the individual patient is a candidate for procedural sedation or whether in rare cases general anaesthesia has to be performed.

Introduction

In contrast to heart catheterizations in adults which are often performed in the awake patient with local anaesthesia of the puncture site, this procedure is not indicated in children and adolescents. However, there is an increasing number of adult cardiac patients who want to profit from the comfort of anaesthesiologic management during diagnostic or interventional cardiac catheterization. Due to progresses in the field of non-invasive imaging procedures – transthoracic and transoesophageal echocardiography as well as cardiac computer tomography (CT) and magnet resonance imaging (MRT) – anatomic situation of the patient is usually well known. For this reason, in a lot of cases diagnostic cardiac catheterizations only have to be performed for preoperative evaluations to determine physiological pressure values and shunt volumes as well as oxygen saturation in the different sections of the circulation.

Scheduling of anaesthesiologic management

In general, cardiac catheterizations are elective interventions which can be readily planned in advance. Therefore, scheduling of the anaesthesiologic procedure as well as information of parents and patients require the same attention as in other elective interventions. Although in a lot of cases no intubation anaesthesia will be required and only procedural sedation [10] will be administered to the patient, the same anesthesia related contraindications apply as for any other intervention – especially with respect to the risk, which is already increased in the cardiac diseased patient. **This specifically applies for acute or post acute respiratory infection involving a period of three to four weeks of increased risk of pulmonary problems. In single cases we have to try hard to make our colleagues from other specialties (pediatric cardiologists, radiologists) aware of this problem.**

During scheduling of anaesthesia great attention has to be paid to the child/patient and his heart disease [15]. In most cases, the latest cardiological report

which should also include an echocardiography, yields sufficient information on the cardiac situation of the patient. Patient history, clinical examination as well as latest laboratory tests will all provide the necessary information to select an individualized anaesthesiologic procedure for each patient. Sometimes the underlying heart disease and surgical interventions which have already been performed to treat the defect, are very complicated and only allow a vague idea of the real cardiac and hemodynamic situation. In those cases anaesthetists should not refrain from asking the respective colleagues (pediatric cardiologist, intensive care specialist) for an up-to-date anaesthesia-related interpretation of the current medical results.

Below the sedation and anaesthetic procedure which is successfully applied in our institution will be presented. For basic anaesthesiological considerations with respect to the different heart defects the readers are referred to the current literature [5,8].

During premedication consultation data have to be collected on individual standard values of each patient including the following single parameters:

Ability to meet physical strain: Children have to be assessed for resting dyspnoe. Parents and children should report on the child's usual ability regarding daily activities. The questions have to be precise and adequate for the respective age of the child. A general question like "Is the physical ability of your child within the normal range?" will usually yield positive answers because parents often cannot provide an objective evaluation on what is regarded as normal physical ability.

Heart rate and blood pressure: If possible, both parameters should be measured in a resting state and under normal physical activity (child is playing games or walking around). In case of stenosis of the major vessels or in case of central shunts, measurements should be performed at all four limbs.

Peripheral oxygen saturation with room air: This parameter should also be measured in resting (baby is sleeping) and under stress (child is crying during a clinical examination), especially in patients with cyanotic heart disease.
In cyanotic heart disease it is also of value to know whether the patient shows positive reaction to application of oxygen or whether saturation values only slightly depend on inspiratory O_2 concentration, like in patients suffering from marked pulmonary stenoses.

Blood gas analysis: In patients with cyanotic defects blood gas analysis should be evaluated before performing anaesthesia.

Laboratory tests: These tests always include blood counts, electrolytes, coagulation parameters, parameters of liver and kidneys as well as determination of drug levels (antiepileptics, digoxin).

Control of pacemaker: It is imperative to control any such device before performing procedural sedation or anaesthesia.

Selection of anaesthetic procedure: In principal, for cardiac catheterization, like for any other intervention, anaesthetic procedure [16,17] should be determined depending on the following factors:
– empty stomach (fasting)
– age of the patient
– professional experience of the anaesthetist
– severity of underlying disease.

Due to the fact that in general any anaesthetic procedure for cardiac catheterization in children will only be performed by experienced pediatric anaesthetists, severity of the underlying heart disease plays a decisive role. Therefore, the following procedure is applied in our institution:

0 – 3 months: intubation anaesthesia
3 – 12 months: in contrast to children without any cardiopulmonary pathology, indication for intubation anaesthesia will be more frequent with respect to the severity of the underlying heart disease, especially due to the fact that sufficient ventilation has to be guaranteed during interventions being performed with room air.
> 12 months: deep sedation, in general

Duration of examination is a further limitation to the concept of deep sedation. When examinations or interventions are scheduled to exceed two hours, intubation anaesthesia will have to be performed in general.

Duration of fasting: For deep sedation/procedural sedation, the same fasting instructions apply as for general anaesthesia.

6 hours: solid foods, dairy products, adapted and semi-adapted baby food
4 hours: breast milk
2 hours: clear fluids (tea, diluted juices, clear water)

Pre-procedure patient information, patient consent: Thorough information on the planned anaesthetic procedure is provided to the parents and/or patients. However, planned deep sedation/procedural sedation may end up in general anaesthesia if cardiological and/or anaesthesiological problems arise. Parents always have to be made aware of this possibility and informed consent has to be obtained accordingly. Due to the fact that, as a rule, blood products are always ready for use in pediatric cardiac catheterization, informed consent of the parents for general administration of blood products also has to be obtained; parents also have to be informed that intensive care treatment may be necessary after catheterization.

Venous access: Unless already available, venous access is perfomed in the hospital ward the day before intervention. Before starting venous punction Emla® patch should be applied in time. In babies and young children fasting times can be bridged by administering infusions. Older children with less complicated heart defects are allowed to ingest clear fluids up to two hours prior to intervention. In case of complicated heart defects infusion will be administered to optimize intravascular volume and cardiac preload.

Long-term medication: All long-term medication which has to be continued p.o., should be administered on the morning of the planned intervention with some tea latest two hours before performing anaesthesia.

Administration of antibiotics: From the point of view of the cardiologist, endocarditis prophylaxis which is frequently required for surgical interventions, is not indicated in purely diagnostic catheterizations. In interventional cardiac catheterization the administration of antibiotics is prescribed by the cardiologist. For antibiotic prophylaxis during puncture, a total of three doses is administered to the patient, the first dose is given on the ward before premedication. Cefuroxim (33 mg/kg max. 1,5 g as single dose) is administered in general.

Preparation of anaesthetic equipment: Due to the fact that cardiac catheterizations are performed in rooms which may be distant from the operation theatres while at the same time subjects are often classified as high risk patients, anaesthetic equipment has to be checked very carefully. This also implies that all emergency medications have to be diluated according to the patient's special requirements and injections be ready for use. Along with an experienced pediatric anaesthetist cardiac catheterization also requires an equally experienced anaesthetic nurse.

Premedication: To reduce stress, adequate premedication has to be administered to the patients on the ward and, if possible, children should be accompanied by their parents when they are transferred to the pre-op room.

– Midazolam (for dosing scheme see Tab.1)

As soon as premedication has been administered, patients are monitored by pulsoxymetry.

Table 1. Midazolam for premedication

Weight	Dosage	Administration
≤ 30 kg	0.5 mg/kg (max. 15 mg)	p.o.
		rectally
> 30 kg	7.5 mg tablet	p.o.
	0.1 – 0.2 mg/kg	i.v.

Induction and maintenance of anaesthesia

As a prime principle in performing deep sedation or anaesthesia in patients with congenital heart disease, individual standard values of each patient have to be maintained within a range of ± 20%.

Procedure for deep sedation/procedural sedation

In case patients are still anxious or even crying in the pre-op room,

– Midazolam 0,1 – 0,2 mg/kg

may be administered. Furthermore in patients with unstable circulation

– S-ketamin 1 – 2 mg/kg

may be administered before starting transfer manipulations to achieve stabilization of circulation [6].

In case no midazolam has been administered in the pre-op room, it will be administered as a first drug at the operation table. As stated above, S-ketamin may be additionally administered, because adequate pre-oxygenation can be achieved in patients with application of midazolam/S-ketamin sedation, monitoring (ECG, pulsoxymetry) can be started and first blood pressure values can be easily obtained. Due to the fact that cardiac catheterization is not associated with heavy pains and furthermore puncture site is infiltrated with a local anaesthetic by the cardiologist, application of a long acting basic analgesic has proved efficient:

– Piritramid 0,1 – 0,15 mg/kg

Thereafter fractionated

– Propofol 1 – 3 mg/kg [1]

is administered to obtain a Ramsay score of 6 during spontaneous breathing [4,13]. This means that oropharyngeal suctioning or placement of gastric tube is tolerated without any reaction. Single suctioning of fasting secretions has proved efficient especially in babies and young children as well as after long fasting periods and in case patients did not take advantage of the possibility to ingest clear fluids up to two hours prior to anaesthesia.

Table 2: Ramsay score

Score	Description
0	awake, orientated
1	agitated, anxious
2	awake, cooperative
3	sleeping, but cooperative
4	deep sedation, quick reaction to pain stimuli
5	deep sedation, slow reaction to pain stimuli
6	deep sedation, no reaction to pain stimuli

Deep sedation [7] is maintained using

– Propofol infusion (5 – 6 mg/kg/h)

In case of excessive saliva production

– Glycopyrrolat 5 µg/kg is administered

Furthermore a peripherally acting analgesic drug is administered:
– Ibuprofen 10 mg/kg rectally or
– Diclofenac 1 mg/kg rectally or
– Diclofenac 1 mg/kg p. o. together with premedication (is preferred by older children and adults)

Respiratory monitoring

Once adequate depth of sedation is achieved, oropharyngeal airway is inserted and a lateral flow CO_2 measurement is placed into it [2,11]. This setting [12] provides a sufficient respiratory monitoring (Fig 1, Fig. 2).

Furthermore, during catheterization O_2 is administered via mask (Fig. 3, Fig. 4) depending on the cardiological situation. A lot of cardiac catheterizations, however, require application of air, as already explained in the chapter Introduction.

Due to the fact that compressing the puncture site often takes a lot of time, it has proved useful not to stop propofol administration at the end of the examination, but to make sure that compression dressing is applied while the child is still well sedated. In babies and young children it is generally preferable to administer

– Midazolam 0,1 mg/kg

prior to patient transfer to allow the young patients to awake in their own bed with their mother next to them. The patients have to achieve a Ramsay score of 4 or less prior to be transferred. However, monitoring of

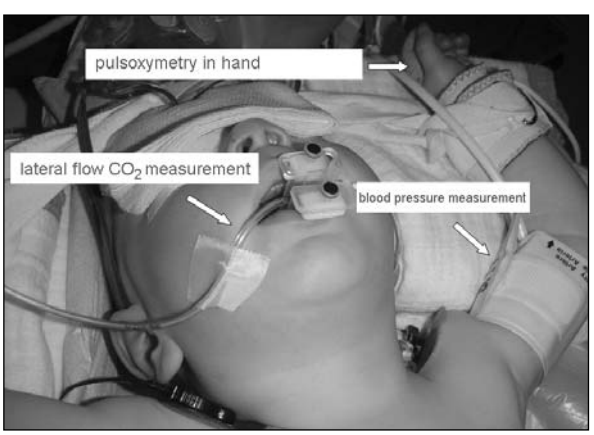

Figure 1. Respiratory monitoring via lateral flow CO_2 measurement in the oropharyngeal tube

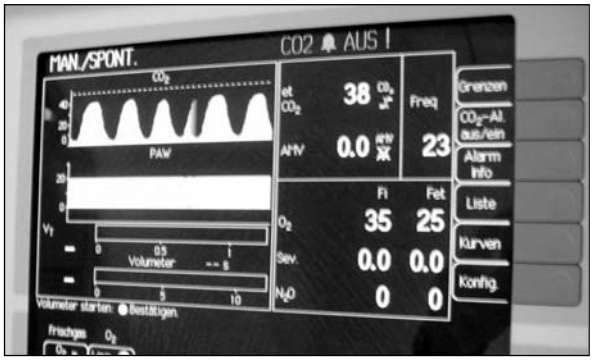

Figure 2. Screenshot: spontaneous breathing during deep sedation

Figure 3. Placement of patient with arms above the patient's head

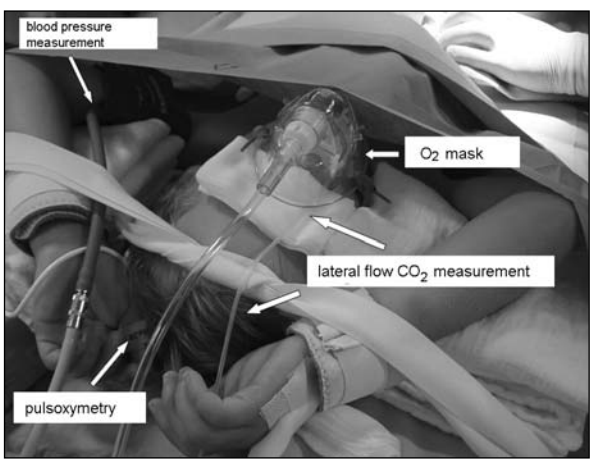

Figure 4. Placement of patient connected to monitoring devices

the patient and physician-escorted transfer to the recovery room or to the ward has to be guaranteed.

As an example for an interventional cardiac catheterization, the following figures present a stent implantation with underlying aortic isthmus stenosis performed under deep sedation (Fig. 5, Fig. 6)

Alternative sedation scheme

There are some cardiac catheterization patients who may not be suited to undergo propofol sedation. Espe-

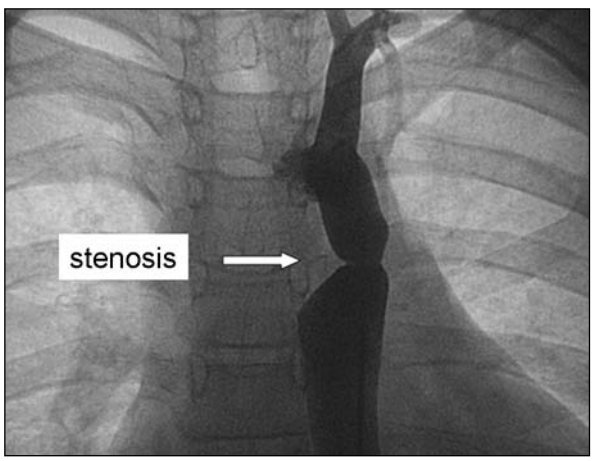

Figure 5. Aortic isthmus stenosis: angiography prior to stent implantation

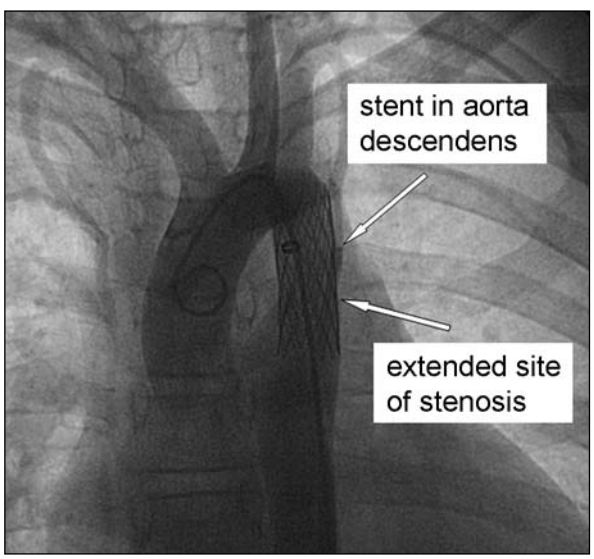

Figure 6. Aortic isthmus stenosis after stent implantation

cially in patients with right/left shunt, even slight propofol-induced reduction in peripheral resistance may cause increased shunt volume leading to impaired oxygenation. In these cases midazolam/S-ketamin sedation can be performed as an alternative [9]

– Midazolam 0,2 mg/kg
– S-ketamin 1 – 2 mg/kg
– Glycopyrrolat 5 µg/kg

followed by continuous infusion of

– Midazolam 0,1 – 0,15mg/kg/h and
– S-ketamin 1 – 2mg/kg/h

Intubation anaesthesia

In rare cases, patients are transferred from intensive care unit, who are already intubated and ventilated. In all other patients indication for intubation is decided upon the above mentioned considerations. Premedication is performed according to the routine scheme, midazolam/S-ketamin sedation is also applied for transfer manipulations and pre-oxygenation. Induction of anaesthesia is performed as follows:
– Fentanyl 1 – 2 µg/kg
– Propofol 2 – 5 mg/kg or
– Etomidate 0,15 – 0,3 mg/kg (in case of circulatory instability)
– Rocuronium 0,6 mg/kg or
– Cis-Atracurium 0,15 – 0,2 mg/kg

Especially in children with congenital heart disease, all medications should be administered slowly and anaesthetics should be titrated to anaesthesia depth as required. Furthermore, before application of the muscle relaxant it has to be checked whether manual ventilation of the patient would be feasible.

Maintenance of anaesthesia
– Sevoflurane [14]
– Piritramid 0,1 mg/kg
– Peripheral analgesic (Ibuprofen, Diclofenac)

In uncomplicated situations, especially in diagnostic examinations, patients should be extubated after application of the compression dressing, if possible. These patients also have to achieve a Ramsay score of 4 or less before they can be transferred to the recovery room. They have to be fully monitored and escorted by a physician. If patients cannot be extubated quickly after the end of examination or whenever intensive care monitoring is requested in the initial period after cardiac catheterization, patients will be transferred to the intensive care unit.

We present two examples where indication for intubation anaesthesia has been made (Fig. 7, Fig. 8).

Conclusion

In the hands of an experienced anaesthetist, deep sedation/procedural sedation is a good and safe procedure

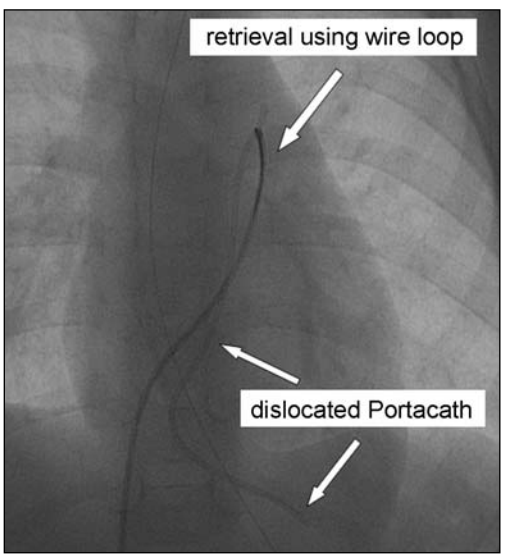

Figure 7. Emergency intervention, non-fasting patient: Retrieval of a dislocated Portacath which has partly moved to the right ventricle and partly to the main pulmonary artery

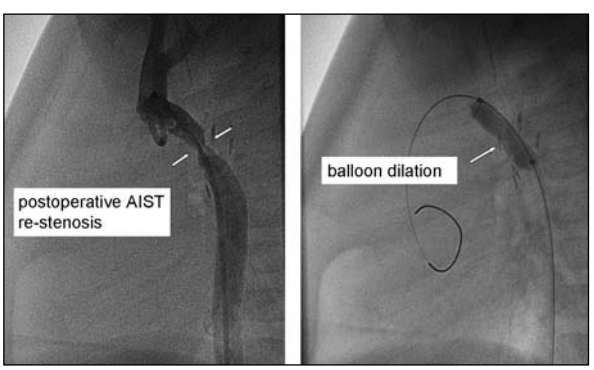

Figure 8. Balloon dilation of a postoperative aortic isthmus re-stenosis in a baby

to perform diagnostic as well as interventional cardiac catheterizations. As a precondition, profound knowledge of the pathophysiology and hemodynamics of the underlying heart disease is mandatory which is also the basis for selecting the adaquate anaesthetic procedure. In this special field, good interdisciplinary cooperation is an especially important factor. This is particularly true for managing complications [3] requiring experience and expertise from the anaesthetist as well as from the cardiologist.

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