Pediatric Anesthesia

Pediatric Anesthesia ISSN 1155-5645

PRO–CON DEBATE

Pro–con debate: intravenous vs inhalation induction of anesthesia in children

THE CASE FOR INTRAVENOUS INDUCTION
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THE CASE FOR INHALATION INDUCTION
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Introduction

Induction of anesthesia in a child can often be a relaxed event, but this is not always the case. The selection of approach and technique has some basis in scientific evidence and published data, but in reality the procedure is more complex. Induction of anesthesia is not simply a technical exercise. It involves a variety of rapid individual evaluations and judgements relating to both child and parent, the situation and to some extent the experience and preferences of the individual anesthetic team on a particular day.

It is clear from the outset that one mode of induction may be indicated over the other in particular clinical situations, but that in more general terms, it is not a case of one or the other. Most pediatric anesthetists use both induction methods at different times but usually have a preference. The articles below therefore reflect the personal opinions of two experienced pediatric anesthetists who have kindly agreed to put a case for each method. They have addressed the science where possible but also have given personalized accounts which will stimulate individual reflection on practice and rationale.

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Section Editor: Andrew Wolf

Accepted 16 November 2010

doi: 10.1111/j.1460-9592.2010.03488.x

In support of intravenous induction of anesthesia

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For many children, the induction of anesthesia can be highly stressful and current estimations, indicate that more than 60% of children suffer anxiety in the preoperative period (1). The reasons of this are complex: first, children are afraid of being separated from their parents and home environment and this is compounded by unfamiliar routines, new strange people, frightening equipment such as anesthetic machine and surgical instruments which all contribute to the process of building high levels of anxiety.

Not surprisingly then, the method of induction can play a crucial role in generation of perioperative anxiety. Pediatric anesthesiologists make a choice between two recommended methods: inhalational or intravenous. Traditionally, the inhalational method of induction of anesthesia is thought to be less harmful for children (2–4). In many textbooks of pediatric anesthesia, the potential fear of a needle among pediatric patients is stressed. But it is clear to experienced anesthesiologists working with children that children are not only afraid of a needle but also a mask. Usually, children struggle to accept the presence of any foreign body on their face and they start to express their dissatisfaction immediately after placing the mask close to their face. This then becomes even less acceptable if the mask is then kept against their face despite their protests. Volatile agents have an unfamiliar and often pungent smell causing even the most well-prepared child to lose composure when the concentration of anesthetic gas is increased.

While much attention has been given to the issue of needle phobia in children (2), the problem of mask phobia also exists. This can be particularly troublesome in children requiring multiple procedures under anesthesia who may develop an aversion or even true phobia to the odor or feel of the mask. This phenomenon was described in an article by Przybylo *et al.* (5) in which they presented eight children demonstrating a real mask fear that developed even after one exposition to inhalational induction of anesthesia.

The pediatric anesthetist should base his choice of induction method on several criteria. The ideal induction should be painless, smooth, quick, and friendly for patient and medical staff alike and easily accepted by the child. The induction technique should be safe and not cause circulatory or respiratory instability, nor should it be associated with postoperative complications such as emergence delirium or postoperative behavioral disturbance. Other patient factors may affect the choice of induction method and this may include the patient with a difficult airway (volatile), full stomach (intravenous), absence of available veins (volatile), etc.

There are, of course, potentially negative aspects to the choice of intravenous induction. These include: necessity of vein catheterization (which can be painful), pain during injection even when the skin has been effectively anaesthetized (propofol, methohexital), and the risk of bradycardia and hypotension after intravenous administration. However, many of these negative aspects of intravenous method of induction can be minimized or avoided. The risk of pain on cannulation can be reduced by using a topical anesthesic. Applying EMLA cream (eutectic mixture of prilocaine and lidocaine), 1 h or more before planned venepuncture should eliminate pain of cannulation. It is not an ideal agent because of the time necessary for the cream to provide effective analgesia and the vasoconstriction associated with EMLA which can make vein access more difficult. Sometimes, especially in day stay surgery, there is not enough time between a patient's arrivals at the department for the drug to have become effective before the start of the planned procedure. Other local anesthetic drug preparations such as Ametop cream and LAT gel (the mixture of lignocaine, adrenaline, and tetracaine) are now available with a faster onset of action. Ametop is highly effective in that the incubation time to effective topical anesthesia that allows painless cannulation is shorter (30 mins–1 h) than EMLA and it does not cause vasoconstriction (6). However, Ametop can cause local hyperemia that occasionally may be severe and cases of anaphylaxis have been recorded. LAT gel also shows promise: it is widely used in emergency departments as a part of management of wounds in children and effectively anesthetizes a child's face or scalp before suturing an uncomplicated laceration within 30 min (7,8). Applying this mixture for reducing pain connected with vein cannulation in situations when very rapid topical anesthesia of the skin is required seems logical.

Even when topical anesthesia has been effective, it is important to remember that removing the pain of cannulation will not necessarily eliminate the anticipated fear of pain related to cannulation or the more general issue of the scared child. Despite all efforts and an effective topical block, vein cannulation can still be traumatic for child and carers if the level of anxiety is still very high. Worse still, is the child returning for a repeat anesthetic when the promised 'painless cannulation' has not been painless at the first anesthetic because of ineffective topical local anesthesia. Such children may have developed an understandable lack of trust to the anesthetic claim of pain-free induction and result in a very uncooperative and traumatized child. This makes it essential to optimize topical anesthesia practise and ensure the best possible chance of it working if the child has been persuaded to accept an intravenous induction.

Bradycardia and hypotension are common side effects of many induction agents (both intravenous and inhalational). This characteristic is particularly relevant to intravenous induction routes because drugs are usually injected relatively rapidly unlike the more incremental and reversible process of inhalation induction. However, by careful titration of the induction agents and patience in the case of low cardiac output states, intravenous induction can be achieved in even the sickest patients. Ketamine is a particularly useful drug in this regard because its sympathomimetic action helps to maintain heart rate and blood pressure (9).

Infusion of some intravenous anesthetic drugs can be painful. It is especially characteristic of propofol infusion. Using a small dose of fentanyl just before propofol, adding lidocaine to the syringe with propofol, can be very effective. In the opinion of the author the most sufficient method of reducing pain of infusion is a small dose of lidocaine infused just before propofol (up to 1 ml of 1% solution – 0.05–0.1 $mg \cdot kg^{-1}$), followed by gentle squeezing a child's limb just above the point when a vein catheter is inserted (9). However, no individual method can guarantee perfect pain-free drug injection.

Inhalational induction of anesthesia is painless and it is the main reason why it remains a popular induction method of choice for many pediatric anaesthesiologists. Nevertheless, as mentioned above, it is can be associated with great fear by the child (1,10). The time

of inhalational induction is longer than intravenous methods and this can add to prolonged and aggravate distress.

With the loss of availability of halothane, the choice of anesthetic agents suitable for gaseous induction is limited, and sevoflurane has become the almost universal choice despite its association with postoperative emergence agitation. This effect is self-limiting but can last for 10–20 min. It is more common in preschool children and can be poorly tolerated by their parents despite preparing them for this eventuality before surgery. Parents can be very worried by this behavior, with concerns that their child has never behaved in such a disturbing fashion before and even questioned the presence of neurological damage (11,12). It has also been shown that the use of sevoflurane is connected with increase in behavioral changes in postoperative period such as fear of dark, difficulty in getting the child to bed, desire of sleeping with parents (13,14).

Bal *et al.* (14) have studied behavioral changes after surgery using three methods of induction of anesthesia; sevoflurane, propofol, and a mixed method of induction with sevoflurane followed by a small subhypnotic dose of propofol (1 $mg \cdot kg^{-1}$). In their study, 20% of children from the sevoflurane and the mixed group had a postoperative nightmare or fear at night while those in the propofol group had a significantly lower incidence. However, no differences were shown between groups in respect to anxiety at induction and at other measurement times although the level of anxiety at induction was high in all groups. In contrast, a more recently published study by Aguilera *et al.* (15) showed that the level of anxiety at the moment of intravenous induction was higher than during inhalational induction. They also reported a trend toward greater postoperative behavioral disturbances in the inhalational group similar to Bal's results, but these differences did not teach statistical significance.

An additional concern with sevoflurane induction is the observation that concentrations higher than 5 vol% used for induction of anesthesia cause epileptiform EEG activity in young children and are higher when combined with hyperventilation (16).

Intravenous or inhalation induction: an individualized choice

Selection of a single universal method of induction and proving its benefits over another method for all circumstances is unfeasible. Each circumstance and child are different requiring an intelligent tailored approach to induction of anesthesia. Below is a brief personal guide that can aid the choice of technique (Table 1).

Table 1 Personal indications for intravenous or volatile agent induction of anaesthesia

Personal Indications for intravenous induction	all medical situations require a rapid sequence of induction, eg full stomach, gastroesophageal reflux, emergency anesthesia a child with a high risk of malignant hyperthermia a child manifesting a fear of mask a mentally impaired child with high level of fear a child for neurosurgical procedures with high risk of CNS ischemia (necessity of neuroprotection) (17,18) a child with behavioral disturbances a child with epilepsy a child who entered operating theatre with an already has effective and secure vein access a child who has chosen this method of induction
Personal Indications for inhalation induction	child's preference, particularly in those who have had multiple procedures and anesthetics a child with a real needle phobia a child with difficult airways a child with difficult vein access after failed attempts at vein cannulation. The decision to abandon after one or two attempts will depend on the local sites that have been already anaesthetized and the child's demeanor after the first failed attempt

Methods of reduction in preoperative anxiety and postoperative behavioral disturbances

According to one of the oldest studies published more than 50 years ago in 1953, by Eckenhoff, (19) there is a direct link between 'unsatisfactory' anesthetic induction and negative personality changes in postoperative period. This highlights the importance of the general psychological comfort of a child in preoperative period and the consequences of a difficult induction. This 'level of comfort' in the child depends on many factors which translate into feelings of confidence or anxiety. Every element is important, including the method of induction and the risk of creating fear within the child is attendant with both intravenous and inhalation induction. Constructing a strategy to reducing the level of preoperative anxiety is, in the authors' view, more important than the problem of choosing the method of induction of anesthesia and should be in the center of interest of pediatric anaesthesiologists.

Pharmacological methods

Pharmacological premedication plays a great role in reducing the level of anxiety in children. Midazolam, short acting benzodiazepine, is extremely popular in pediatric anesthesia. Its anxiolytic properties and

amnesic effect (retrograde amnesia) are particularly useful in pediatric population. But there are two concerns connected with midazolam premedication: side effects and recovery time. Most studies have proved the safety of this drug for premedication: no circulatory and respiratory problems have been reported. However, in some children, the paradoxical reactions of increase in excitation and even dysphoria have been observed in some children (20,21). In contrast, the studies by Kain have reported reduced anxiety in children during induction of anesthesia and reduced negative behaviors after surgery, an effect that has also been demonstrated in earlier studies (22–25).

Clonidine has become popular in recent years as a premedicant drug for pediatric anesthesia. Its sedative effects mediated by α2 receptors on presynaptic neurons are very effective in reducing anxiety. It decreases anesthetic requirements in patients undergoing different types of surgery with sedation comparable to midazolam. According to current studies, children given α2 agonists have less perioperative sympathetic stimulation and less postoperative pain that those given midazolam (26,27).

Nonpharmacological interventions

Parental presence. Parental presence at anesthetic induction remains controversial. Some of the literature suggests limited benefit of parental presence at induction for all children. In a recently published Cochrane Review about nonpharmacological interventions for assisting the induction of anesthesia in children, 5 of 8 published studies did not show any difference in anxiety or cooperation of children on entering the induction area or during induction (22,28–31). Recent studies have suggested that premedication with midazolam is much more effective than parental presence in reducing anxiety in children but that the combination of premedication and parental presence was more effective than parental presence alone (22,30,32).

The level of anxiety of the parents has a significant impact on the child (28). According to Kain *et al*., (33) a child with an anxious parent is more likely to have persistent behavioral problems lasting to 6 months after operation than a child with a calm parent, while a previous study showed that presence of parents with low anxiety trait decreases the anxiety level of children at induction (28). Leaving aside the published studies, probably the most important benefit of parental presence at induction is the fact of family participation in a major life event and this may be crucial from the psychological point of view. If a parent's presence is passive, it is helpful neither for a child nor for medical staff. But parents who provide positive distraction for the child during induction can be very positive.

The use of clowns in the presurgery and induction areas has been used to allay anxiety and fear during induction (34–37). However, health professionals taking part in an Italian experiment indicated that while children themselves benefited from clowns presence, this did delay procedures and interfere in the relations between the child and the medical personnel (36). Other techniques include the use of distraction with computers and videos (38), hypnosis (39), music (40), or a low stimulus environment presurgery (41) to aid demeanor during induction. Showing parents a short video demonstrating a pediatric mask induction also had a positive influence on postoperative behavioral score of their children (42,43), but there are no equivalent studies preparing the child for painless intravenous induction.

Inhalational induction of anesthesia is THE BEST!

Dr Helen Holtby

There are a few absolute contraindications to the use of inhalational agents for induction of general anesthesia, most notably malignant hyperthermia, probably muscular dystrophy (44), and the absence of appropriate delivery systems, but otherwise sevoflurane is the closest thing to the ideal induction agent for children. I would suggest that a full stomach is a relative contraindication, but in certain circumstances, inhalation induction has been used and continues to be regarded as a reasonable approach (45). A classic example of such a dilemma is the often debated case of how to induce anesthesia in an obese toddler with an open eye injury, no intravenous access, and a full stomach: the actual risk of aspiration in children is about 0.1%, but very few children have serious sequelae and the incremental risk for emergency procedures appears to be small (46).

Key arguments in favor of inhalational induction

- Painless.
- Can be given by increments.
- Reversible.
- Invaluable in the patient with a marginal airway.
- Relies less on manual dexterity than intravenous techniques.
- Avoids the psychological trauma associated with the fear of needles.

In the modern era, the only practical agent for inhalational induction of anesthesia is sevoflurane. It is safe, dosing is incremental; it is rapid, generally pleasant, involves no manual dexterity, and is utterly painless.

In a perfect world, it would not cause *any* adverse reactions but they are certainly relatively infrequent. The most recent Peri-operative Cardiac Arrest registry findings support the assertion that sevoflurane is safe, certainly in comparison with halothane (47). If it did not smell, the first thing the manufacturers would do, for safety reasons if no other, is add a scent. I believe many of the criticisms and much of the concerns relating to induction of anesthesia are actually a result of the entire hospital experience and represent a degree of transference from adults to children. All preoperative upset tends to be described as 'anxiety'. This not to deny that there are children who are specifically anxious about induction of anesthesia, but many children are generically anxious about new situations, strangers, parental stress, and changes in routine. Hospitalization provides all the stimuli. Some children who are 'frequent flyers' report disliking the sensation of losing consciousness (whether by inhalation or intravenous route) and I have had children ask for medicine to be given either more slowly or more quickly to alleviate this. The problem of emergence delirium is vexing, but not a reason to avoid the technique. I would consider alternatives in the rare patient with a persistent history of emergence delirium. However, having encountered one such patient, (postheart transplant) who had multiple episodes despite a plethora of different techniques, (oral, intravenous, and inhalational induction), the noteworthy observations were that he had absolutely no recollection of any part of the delirium and that the problem went away after one day and so far has not returned. The etiology and the strategies for managing this phenomenon remain somewhat obscure (48). It is possible that this represents a dissociative state. Meta-analysis does support the concept that sevoflurane is associated with a higher risk of emergence delirium but emphasizes it is a multifactorial problem and rare enough to need large numbers to reach significant conclusions (49). The odds ratio for sevoflurane compared to halothane is 2.2. All intravenous agents show a lower incidence, but interestingly, midazolam premedication does not appear to prevent it according to the recent meta-analysis (50).

The neonate and very young child generally have no preconceived notions about anesthesia or surgery, other than the absence of breakfast, which can make them very irritable. More liberal fasting guidelines make the whole experience a good deal more pleasant and decrease the likelihood of a stormy induction regardless of the chosen technique. However, even very young infants can become predictably upset when laid down on a table and undressed by people in operating room attire if they have been previously hospitalized: this is a frequent prelude to venipuncture or other painful episodes. It is therefore preferable to induce them sitting up, or in a lap. Younger children may also be less likely to be adequately sedated with midazolam premedication (51). Once the child is of an age to recognize familiar people, and thus also strangers, then the whole experience is fraught with anxiety: in any hospitalization there is a constant parade of strangers, all of whom are bursting with empathy, and wanting to interact. This may well not be helpful.

The child is in an unfamiliar environment and exposed to many new experiences, including wearing weird clothes, doing strange things, and often being sleep deprived. Under these conditions, it is surprising that any child maintains their equilibrium. Young children are most attuned to the mood of their primary caregivers, so parental anxiety is integral to the experience of the child. The best strategies for managing this remain elusive despite enthusiastic efforts on the part of many clinical investigators (52,53).

My initial training involved intravenous inductions as the preferred mode. Since the introduction of sevoflurane, my practice has completely changed. The major indication for intravenous induction in 2010 is either a patients' preference or an *in situ* catheter. Occasionally, there are medical reasons. I do my best to ascertain patients' preference in the majority of patients who might have an opinion. In Ontario, the ability to consent is defined by competence, not by age, and the principle of informed consent mandates the discussion of the risks and benefits of any treatment plan, and the alternatives. Occasionally, a patients' preference may be over-ruled. For example a much-pierced and tattooed 80 kg, 16 year old told me she wanted a mask because 'I don't like needles?!'. She rapidly realized the reason for my laughter, and we agreed that perhaps an intravenous induction would be acceptable. If she had been vasoconstricted, tearful, and adamant, I would have conceded to the request; sometimes management decisions are based on convenience but they should mostly be based on kindness.

Advantages of inhalational induction

It is painless

An inhalational induction is guaranteed to be painless. It might be smelly, but it will never hurt. You can therefore look the 6, 7, and 8+ year old in the eye and guarantee them no pokes and no pain, which is something no anesthesiologist of conscience can do for an intravenous induction with propofol. This is despite topical anesthesia on the skin, and subcutaneous or

intravenous lignocaine. It is possible to do a painless induction with an in situ intravenous catheter using thiopentone and fentanyl, but there are disadvantages to such an approach, including delayed emergence and 'hangover' from the use of barbiturates. I believe that it is important to avoid euphemisms and over-optimistic explanations, especially for children who need multiple anesthetics, because the loss of trust is devastating.

It requires no particular technical skill

No particular degree of manual dexterity is required to do an inhalational induction, and very little restraint of the child is required, in comparison with an intravenous induction. This is not to suggest that no skill is needed, but the ability to manage the airway with a bag and mask is such an integral part of anesthetic practice that it has to be taken for granted. The child can be sitting up, lying down, or on a parents' lap. I can hold the mask or a nurse can, or a parent can, or the child can. The only goal is to get 3 or 4 breaths of 8%, and then the child can be moved onto the OR table, laid down, and restrained only if they become excited, and not everyone does. The excitement phase can be an issue in larger patients.

There is no need for compliance

Cooperation of the patient is in fact optional for inhalation inductions, and I offer the following anecdote as evidence. The technique below is not recommended for routine practice, but in the case below was preferable to all-out combat, especially for a child with a lifelong illness.

Clare (name changed) was described by her mother with great affection as the 'naughtiest girl in Ontario' and had complex congenital heart disease. She was 3 years old and booked for a Fontan operation. Vascular access was known to be difficult. Her cardiac catheterization had proceeded with considerable parental restraint after she spat out her premedication. When she came to the operating room for her Fontan, having had 'special acetaminophen' (with midazolam, which was once again partly expectorated) she was tearful, combative, and still in her street clothes, with her 'blankie' over her head. I induced anesthesia by sitting her on the OR table with her mother holding her and putting sevoflurane in 100% O_2 under the edge of the blanket. The depth of sedation was gauged by the fact that she stopped kicking and allowed placement of a pulse oximeter probe on a protruding toe, followed by the fact that she did not prevent us uncovering her. The remainder of the induction proceeded in a more conventional fashion.

The drug is given incrementally

Any dose of intravenous drug is at best an informed estimate and a physiological experiment. Once the dose is in, it cannot be retrieved. Sevoflurane has the advantage of always being given in incremental doses, and the effects can be observed, and the dose adjusted as necessary, relatively rapidly. While the speed of emergence can be a nuisance with respect to bronchoscopy and is occasionally an issue with respect to awareness, it is an important safety precaution in difficult airways, hypovolemic, or hemodynamically unstable patients. Historically, the use of halothane has been advocated for management of the bleeding tonsil, because blood flow to the brain is relatively higher in hypovolemic patients, thus there is a rapid rise in cerebral partial pressure. There is paradoxically less likelihood of cardiovascular compromise, and relative overdose for this reason. It can also be used in subMAC concentrations for 'conscious sedation' or to supplement narcotic/local anesthetic/nitrous oxide for procedures such as chest tube insertion in frail children.

It is the standard of care for airway management

The use of inhaled agents for the management of difficult airways is an entrenched part of both adult and pediatric practice and has never been superseded by intravenous drugs, for the following reasons: it is less likely to be accompanied by tears or increased airway secretions. Apnea is predictable and avoidable. It can be used as a single agent with an experienced anesthesiologist and ENT surgeon. (It is not ideal with trainees.) Rapid emergence can be life saving if the airway becomes difficult to manage with a bag and mask. Sevoflurane can be given in 92% oxygen, which also affords a margin of safety.

There are psychological benefits

The use of inhalational agents for induction affords an opportunity for a child to help with the proceedings; they can hold the mask themselves, watch the bag move, and make 'mountains' on the monitor screen with the end tidal CO2 trace. It is very difficult to offer the same experience inserting an intravenous catheter.

There are several approaches to overcome the issue of smell, including single-breath techniques, 'flavors', games, and suggestibility. Holding the mask over the

child's mouth rather than both the mouth and nose, diminishes the intensity of the smell. Rational observation would conclude that the smell of sevoflurane is in fact no more unpleasant then the artificial smell of bubblegum flavoring, or the average school child's locker! It is the context that provides the negative connotation. I will often ask the child what the mask smells of: usually starting with a fruit salad (does it smell of apples?, bananas?, pineapple? etc.,) and progressing on to nonsense. Small boys seem to find the idea of a reasonably respectable grownup asking if the mask smells of 'old socks, winter boots or farts' disproportionately entertaining!

It is important to keep events moving and a steady stream of distraction in the form of conversation and stories is useful for many children, and it probably helps parents as well (54). A sometimes overlooked factor is to offer choices to enable some control in the process to be devolved to the child. However, making a choice can be stressful for some children. A conversation may end up with a plan that has local anesthetic cream applied to the hands, a parent in attendance and a suggestion that we will try the mask, and if you really do not like it then we can give you medicine in your hand.

Practical observations

Induction of general anesthesia is a seminal (perhaps surreal!) moment for a child undergoing surgery and has been identified as a major risk factor for behavioral changes in day care surgery. It is therefore important to make all reasonable efforts to make the experience as decent as possible.

The first decision to be made (in the interests of efficiency) is whether the child is fit to proceed, swiftly followed by an assessment of the need for oral sedation. Every child should be spoken to directly; a simple 'hello' will ascertain those who are shy. The preschool child who refuses to acknowledge you may well turn out to be very upset, as 2 and 3 year olds are very concrete in their thinking. (If I cannot see you, then you are not there and this is not happening). Older children who will not speak or adolescents who do not answer direct questions are also a population who may be upset or act out. It is an interesting exercise to keep a personal score: a child who starts out calm, but is upset before they are unconscious represents a failure on our part; either of judgement or of process, or of pharmacology!

When talking to small children, it is a good idea to frame questions so that any answer is acceptable to you, e.g., Do not ask if they 'would like to have a special sleep,' as this puts you into a difficult position if the child says 'no'! However, a choice such as orange flavor vs bubblegum, sitting up or lying down, etc., or a story while they go to sleep means that that there is no unacceptable response. It has been suggested that distraction is more useful than empathy for many children, and so stories, especially about flying, balloons, being on swings are useful. Techniques for self-hypnosis, e.g., where is your favorite place, think of your favorite activity, can also be useful. Sometimes, older children do well with challenges (recite the alphabet backwards- make sure you can do it!) or jokes. Children over 6, who are cooperative and are able to hold their breath can be successful with single-breath techniques (55). Other more involved scenarios using therapeutic clowns, play therapists, magic tricks have also been described (36).

The preschool child who exhibits stranger anxiety should be premedicated unless the parents refuse, even if parents are accompanying the child (24). It is possible for pediatric anesthesiologists to predict anxiety with a reasonable degree of accuracy and therefore individualize the use of premedication (56). Useful parents accompanying a child can be given the role of story teller, but often parents are speechless so it is necessary to give the parents an alternative role such as hand holding, hugs (which can be a surrogate form of restraint while providing comfort). It is also important to limit the number of people talking to the child, or handling them. From the perspective of the small child, being laid down on an OR table, 2 or 3 or 4 people (at least one of whom is a stranger) talking, sometimes simultaneously, putting monitors on, etc., has to be very overwhelming. It is a wonder that any of them appear to go through the experience *without* any external signs of distress.

More outgoing children may do well without pharmacological interventions, and 'frequent flyers' should be given an opportunity to express their own opinion. The advice of parents should be sought, although it should be noted that parents are not necessarily very accurate at predicting the response of first time patients. However, many parents of children with chronic illnesses are very good resources for routines that are helpful for their child.

Small children are use to having people's hands around their faces, being fed and washed, having their noses wiped, etc., and will often tolerate a cupped hand, if they object to direct placement of the mask on their face. It may be helpful to show the child the mask beforehand and demonstrate it on one's own face (without any vapor on!) before bringing it to theirs. Movements around a child's face should be

gentle, and reasonably slow; crying is often a first response to being startled in the very young.

My personal preference is to have a small amount of vapor in the circuit (< 1%) so that there is an opportunity for the smell to become ignored and then turn the concentration straight up to 8%, with relatively high flows while talking, playing games and using maximum distraction. A pulse oximeter probe is the only mandatory monitor at this stage. I do not generally try to get a tight mask fit until the child is unaware as I suspect that it contributes to the sense of being smothered. As soon as the child is unaware, the remaining monitors go on and an IV is started. I warn parents that the child may move and become excited, but it is brief.

In the child who appears or is known to have difficult intravenous access, I would argue that it is safer to manage the airway until an LMA or endotracheal tube can be placed and then ventilate the child with pressure support while intravenous access is obtained. The possibility of less than ideal airway management while attempts are made for intravenous access is the worst of all possible worlds.

In summary, the use of an inhalation drug for induction of anesthesia is ubiquitous in pediatric anesthesia for good reason. It is safe, technically straightforward, and generally more pleasant than intravenous induction, because of the avoidance of awake venipuncture. Sevoflurane is useful for both sedation and general anesthesia, and while there is an increased likelihood of emergence delirium, it is not exclusive to this agent and can be managed. It is less expensive than propofol, does not sting or burn, and ordinarily does not cause apnea, or unpredictable bradycardia. In children in whom vascular access is an issue, the vasodilation is very helpful.

Questions to the Authors

1. Inhalation induction with sevoflurane is commonly used in patients with known epilepsy despite the concerns of the effects of sevoflurane on the EEG. Are there any circumstances when you would choose not use sevoflurane for a gaseous induction?

MZ: I would never choose sevoflurane for induction in a child who has already been anaesthetized with sevoflurane and manifested agitation and 'strange' behavior during and after recovery. In addition I would not use volatile agents in a child with high risk of malignant hyperthermia.

HH: This is an area where I have little expertise. However, I would avoid the drug if the parents of a known epileptic were concerned or if there was a repeated history of seizure on induction in an epileptic child. I have not encountered this. I might also consider adding nitrous to reduce sevoflurane exposure with the hope this could suppress spike and wave patterns.

2. If you had an infant requiring surgery for a pyloromyotomy that had been adequately resuscitated, but whose IV had tissued just before surgery, how would you choose to anaesthetize the infant and why would you choose that method?

MZ: For this particular case I would choose induction of anesthesia via rectal ketamine. The child will be anaesthetized within 10–15 min or at least a deep sedation will be reached. This will then provide an opportunity to identify and cannulate a vein in a relatively still child. While with this approach could theoretically introduce a risk of regurgitation and aspiration, this can be reduced without stress to the infant by aspiration on the indwelling naso-gastric tube. In this condition gaseous induction would then be an alternative to i.v. induction, if no vein is available.

HH: In a well child that has been adequately resuscitated, it is likely that alternative intravenous sites will be available that can be used. In this case, I would restart the iv and do a rapid sequence induction. If the baby was little (ie < 4 kg) and there was no obvious site for intravenous cannulation, I would think about awake intubation. I would pass an oro/nasogastric tube and attempt to remove as much gastric reduce as possible. Alternatively, I would be prepared to perform an inhalation induction and intubate the infant, with the suction on and by the bedside. I would NOT do an awake cutdown. I might also consider placing an intraosseous needle for the case.

3. You are faced with an infant who has a major symptomatic ventricular septal defect who has been treated with captopril, diuretics and fluid restriction. The child needs urgent surgery but there is no intravenous cannula and no obvious veins due to previous cannula attempts plus treatment for cardiac failure. How would you induce anesthesia and why would you choose this method?

MZ: Sevoflurane induction in a fluid restricted child on captopril carries with it a significant risk of severe hypotension. The potential risk of sevoflurane induction will need to be carefully considered. Again, my personal

approach would be to consider induction with rectal ketamine. Low dose sevoflurane could then be used in a combined technique with rectal ketamine to reduce the risks of hypotension and give a reasonable chance for a smooth and uneventful induction.

HH: I would choose careful inhalation induction, insert a laryngeal mask airway (LMA) and provide pressure support ventilation until vascular access is established. If the LMA is not providing a secure and adequate airway, then I would place an ETT at an appropriate depth of anesthesia, and then go looking for an iv or a central line leaving the baby to trigger and control depth of anesthesia. This is one of the few situations where I would use nitrous oxide precardiopulmonary bypass until iv access has been secured.

References

1 Aydin T, Sahin L, Algin C *et al*. Do not mask the mask: use it as a premedicant. *Pediatr Anesth* 2008; **18**: 107–112.

2 Hamilton JG. Needle phobia: a neglected diagnosis. *J Fam Pract* 1995; **41**: 169–175.

3 Hamer Hodges RJ. Induction of anaesthesia in young children. *Lancet* 1960; **1**: 82–87.

4 Lerman J, Jöhr M. Pro-con Debate. Inhalational anesthesia vs total intravenous anesthesia (TIVA) for pediatric anesthesia. *Pediatr Anesth* 2009; **19**: 521–534.

5 Przybylo HJ, Tarbell SE, Stevenson GW. Mask fear in children presenting for anesthesia: aversion, phobia or both? *Pediatr Anesth* 2005; **15**: 366–370.

6 O'Brien L, Taddio A, Lyszkiewicz DA *et al*. A critical review of the topical anesthetic amethocaine (Ametop) for pediatric pain. *Paediatr Drugs* 2005; **7**: 41–54.

7 Kemp C. LET gel effective for pain relief. *AAP News* 1999; **15**: 2.

8 O'Connor G, Mullarkey C. Topical anaesthesia in children: reducing the need for specialty referral. *Eur J Emerg Med* 2010; **17**: 97–100.

9 Aitkenhead AR. Intravenous anaesthetic agents. In: Aitkenhead AR, Smith G, Rowbotham DJ, eds. Textbook of Anaesthesia, 5th edn. Churchill Livingstone: London, 2007: 34–51

10 Fukumoto M, Arima H, Ito S *et al*. Distorted perception of smell by voaltile agents facilitated inhalational induction of anesthesia. *Pediatr Anesth* 2005; **15**: 98–101.

11 Jöhr M. Postanaesthesia excitation. *Paediatr Anaesth* 2002; **12**: 293–295.

12 Mayer J, Bolt J, Rohm KD *et al*. Desflurane anesthesia after sevoflurane inhaled induction reduces severity of emergence agitation in children undergoing minor ear-nose-throat burgery compared with sevoflurane induction and maintenance. *Anesth Analg* 2006; **102**: 400–404.

13 Watson A, Visram A. Children's preoperative anxiety and postoperative behaviour. *Pediatr Anaesth* 2003; **13**: 188–204.

14 Bal N, Saricaoglu F, Uzun S *et al*. Perioperative anxiety and postoperative behavioural disturbances in children: comparison between induction techniques. *Eur J Anaesthesiol* 2006; **23**: 470–475.

15 Aguilera I, Patel D, Meakin G *et al*. Perioperative anxiety and postoperative behavioural disturbances in children undergoing intravenous or inhalation induction of anaesthesia. *Pediatr Anaesth* 2003; **13**: 501–507.

16 Akeson J, Didriksson I. Convulsions on anaesthetic induction with sevoflurane in young children. *Acta Anaesthesiol Scand* 2004; **48**: 405–407.

17 Karsli C, Luginbuehl I, Farrar M *et al*. Propofol decreases cerebral blood flow velocity in anesthetized children. *Can J Anaesth* 2002; **49**: 64–72.

18 Engelhard K, Werner C, Eberspacher E *et al*. Influence of propofol on neuronal damage and apoptotic factors after incomplete cerebral ischemia and reperfusion in rats: a long-term observation. *Anesthesiology* 2004; **101**: 912–917.

19 Eckenhoff JE. Relationship of anesthetic to postoperative personality changes in children. *Am J Dis Child* 1953; **86**: 587–591.

20 Ullyot SC. Paediatric premedication. *Can J Anaesth* 1999; **39**: 533–536.

21 Mc Millan CO, Spahr-Schopfer IA, Sikich N *et al*. Premedication of children with oral midazolam. *Can J Anaesth* 1992; **39**: 545–550.

22 Kain ZN, Mayes LC, Wang SM. Parental presence during induction of anesthesia versus sedative premedication: which intervention is more effective? *Anesthesiology* 1998; **89**: 1147–1156.

23 Mc Graw T, Kendrick A. Oral midazolam premedication and postoperative behavior in children. *Paediatr Anaesth* 1998; **8**: 117–121.

24 Kain ZN, Mayes LC, Wang SM *et al*. Parental presence and a sedative premedication for children undergoing surgery. *Anesthesiology* 2000; **92**: 939–946.

25 Kain ZN, Caldwell-Andrews AA, Krivutza DM *et al*. Trends in the practice of parental presence during induction of anesthesia and the use of preoperative sedative premedication in the United States, 1995–2002; results of a follow up national survey. *Anesth Analg* 2004; **98**: 1252–1259.

26 Schmidt A, Vallinetti E. Effect of preanesthetic administration of midazolam, clonidine and dexmedetomidine on postoperative pain and anxiety in children. *Pediatr Anesth* 2007; **17**: 667–674.

27 Yuen V, Hui T, Irvin M *et al*. A comparison of intranasal dexmedetomidine and oral midazolam for premedication in pediatric anesthesia: a double blinded randomized controlled trial. *Anesth Analg* 2008; **106**: 1715–1721.

28 Bevan JC, Johnston C, Haig MJ *et al*. Preoperative parental anxiety predicts behavioral and emotional responses to induction of anesthesia in children. *Can J Anaesth* 1990; **37**: 177–182.

29 Kain ZN, Mayes L, Carmico L *et al*. Parental presence during induction of anesthesia: a randomized controlled trial. *Anesthesiology* 1996; **84**: 1060–1067.

30 Kain ZN, Caldwell-Andrews AA, Mayes LC *et al*. Family-centered preparation for surgery improves preoperative outcomes in children: a randomized controlled trial. *Anesthesiology* 2007; **106**: 65–74.

31 Palermo TM, Tripi PA, Burgess F. Parental presence during anesthesia induction for outpatient surgery in infants. *Paediatr Anaesth* 2000; **10**: 487–491.

32 Kain ZN, Caldwell-Andrews AA, Mayes LC *et al*. Parental presence during induction of anesthesia: physiological effects on parents. *Anaesthesiology* 2003; **98**: 58–64.

33 Kain ZN, Mayes LC, Caldwell-Andrews AA *et al*. Predicting which children benefit most from parental presence during induction of anesthesia. *Pediatr Anesth* 2006; **16**: 627–634.

34 Berk LS, Felten DL, Tan SA *et al*. Modulation of neuroimmune parameters during the eustress of humor-associated mirthful laughter. *Altern Ther Health Med* 2001; **7**: 62–76.

35 Fry WF. The physiologic effects of humor, mirth and laughter. *JAMA* 1992; **267**: 1857–1858.

36 Vagnoli L, Caprilli S, Robiglio A. Clown doctors as a treatment for preoperative

anxiety in children: a randomized prospective study. *Pediatrics* 2005; **116**: e563–e567.
37 Golan G, Tighe P, Dobija N *et al*. Clowns for the prevention anxiety in children: a randomized controlled trial. *Pediatr Anesth* 2009; **19**: 262–266.
38 Patel A, Schieble T, Davidson M *et al*. Distraction with a hand–held video game reduces pediatric preoperative anxiety. *Pediatr Anesth* 2006; **16**: 1019–1026.
39 Calipel S, Lucas-Polomeni MM. Premedication in children: hypnosis versus midazolam. *Pediatr Anesth* 2005; **15**: 275–281.
40 Kain ZN, Caldwell-Andrews AA, Krivutza DM *et al*. Interactive music therapy as a treatment for preoperative anxiety in children: a randomized controlled trial. *Anesth Analg* 2004; **98**: 1260–1266.
41 Kain ZN, Wang SM, Mayes LC *et al*. Sensory stimuli and anxiety in children undergoing surgery: a randomized, controlled trial. *Anesth Analg* 2001; **92**: 897–903.
42 Zuwala R, Barber KR. Reducing anxiety in parents before and during pediatric anesthesia induction. *AANA J* 2001; **69**: 21–25.
43 McEwen A, Moorth C, Quantock C *et al*. The effect of videotaped preoperative information on parental anxiety during anesthesia induction for elective pediatric procedures. *Pediatr Anesth* 2007; **17**: 534–539.
44 Hayes J, Veykemans F, Bissonnette B. Duchenne muscular dystrophy: an old anesthesia problem revisited. *Pediatr Anesth* 2008; **18**: 100–106.
45 Brady M, Kinn S, Ness V *et al*. Preoperative fasting for preventing perioperative complications in children. *Cochrane Database Syst Rev* 2009; CD005285.
46 Borland LM, Sereika SM, Woelfel SK *et al*. Pulmonary aspiration in pediatric patients during general anesthesia:incidence and outcome. *J Clin Anesth* 1998; **10**: 95–102.
47 Bhananker SM, Ramamoorthy C, Geiduschek JM *et al*. Anesthesia-related cardiac arrest in children: update from the Pediatric Perioperative Cardiac Arrest Registry. *Anesth Analg* 2007; **105**: 344–350.
48 Vlajkovic GP, Sindjelic RP. Emergence delirium in children: many questions, few answers. *Anesth Analg* 2007; **104**: 84–91.
49 Kuratani N, Oi Y. Greater incidence of emergence agitation in children after sevoflurane anesthesia as compared with halothane. A meta-analysis of randomized controlled trials. *Anesthesiology* 2008; **109**: 225–232.
50 Dahmani S, Stany I, Brasher C *et al*. Pharmacological prevention of sevoflurane- and desflurane-related emergence agitation in children: a meta-analysis of published studies. *Br J Anaesth* 2010; **104**: 216–223. Epub 2010 Jan 3.
51 Kain ZN, MacLaren J, McClain BC *et al*. Effects of age and emotionality on the effectiveness of midazolam administered preoperatively to children. *Anesthesiology* 2007; **107**: 545–552.
52 Yip P, Middleton P, Cyna AM *et al*. Non-pharmacological interventions for assisting the induction of anaesthesia in children. *Cochrane Database Syst Rev* 2009; CD006447.
53 Chundamala J, Wright JG, Kemp SM An evidence-based review of parental presence during anesthesia induction and parent/child anxiety. *Can J Anaesth* 2009;**56**:57–70. Epub 2008 Dec 20
54 MacLaren JC, Torrey C, Blount R *et al*. Healthcare provider and parent behavior and children's coping and distress at anesthesia induction. *Anesthesiology* 2009; **111**: 1290–1296.
55 Agnor RC, Sikich N, Lerman J. Single-breath vital capacity rapid inhalation induction in children: 8% sevoflurane versus 5% halothane. *Anesthesiology* 1998; **89**: 379–384.
56 MacLaren JE, Thompson C, Weinberg M *et al*. Prediction of preoperative anxiety in children: who is most accurate? *Anesth Analg* 2009; **108**: 1777–1782.