Review Article

Non-operating room anaesthesia in children

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ABSTRACT

Administration of sedation and/or anaesthesia to patients undergoing painful or uncomfortable procedures at off-site locations is referred to as non-operating room anaesthesia (NORA). Sedating/anaesthetising children in an unfamiliar environment, with the lack of support staff, nonavailability of choice of medication and equipment is often challenging. Studies have shown an increased risk of airway-related adverse events, complications, and even death outside the operating room locations. It is crucial to be familiar with the anatomical and physiological variations in children, well versed with the difficult airway algorithm and call for help early. The most common event in NORA claims was inadequate oxygenation/ventilation, which are preventable with vigilant monitoring. English language articles were searched in Pubmed, Google Scholar, and Academic using 'sedation in children', 'remote location anaesthesia', 'peadiatric sedation', and 'nonoperating room anaesthesia' as the mesh words. Full text of the relevant articles was obtained and this review article was synthesised. The article outlines various safety guidelines, sedation techniques, drugs used for sedation, environmental concerns, procedure-specific risks, and complications associated with NORA in children.

Key words: Non-operating room anaesthesia, paediatric, procedural sedation, sedation

INTRODUCTION

Administration of sedation/anaesthesia to patients undergoing painful or uncomfortable procedures at off-site locations is referred to as non-operating room anaesthesia (NORA).[1] Frequent patient visits, multiple comorbidities, the advent of interventional procedures, and growing sensitivity to pain have increased the need for sedation or anaesthesia in ancillary areas outside the operating room. Clinicians who are unfamiliar with NORA typically underestimate the higher risk involved in undergoing procedural sedation at ancillary areas, involving new and advanced technological equipment. The anatomical and physiological variations in infants and children, and the unfamiliar and non-conventional environment of NORA pose challenges to the anaesthetic management.

Cravero JP *et al.* reported incidence and outcomes related to propofol sedation in over 49,000 paediatric patients.[2] This landmark study collected detailed data of various outcomes. Although no deaths occurred, cardiopulmonary resuscitation (CPR) was required twice, and there were four cases of pulmonary aspiration. Airway-related complications were more prominent and affected one out of 65 sedations. One in 70 cases required interventions to rescue the airway. Although these data suggest that paediatric NORA by well-trained personnel is rarely accompanied by mortality and major morbidity, caution is warranted as airway complications did occur, particularly with the use of propofol. Presence of skilled anaesthesiologists capable of airway rescue can avert catastrophic outcomes. Despite the presence of an anaesthesiologist during NORA, the rate of morbidity and mortality increases if ancillary personnel in the radiology or endoscopy suite are unfamiliar with the requirements of anaesthesia. Hence, the anaesthesiologist must also ensure that the participating staff are adequately trained to assist in NORA as well as CPR.[3]

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Sedation is also performed at stand-alone clinics, a dentist's office and other venues by practitioners who are not anaesthesiology specialists. Table 1 describes the American Society of Anesthesiology (ASA) Task Force guidelines for non-anaesthesiologists, to perform sedation/analgesia while minimizing the associated risks.[4]

Sedation/anaesthesia techniques and drugs used in NORA

The depth of sedation to be targeted and the drugs used depend upon the procedure performed, the degree of pain anticipated, allowable patient movement, duration of the procedure, and other patient factors such as last oral intake, comorbidities (e.g., upper respiratory infection), prior sedation experience, and urgency of the procedure. An ideal sedative agent should have a rapid onset, rapid clearance, minimal side-effects, and should be easy to titrate. As a single ideal agent is not available, NORA is often conducted with a combination of agents to provide analgesia, amnesia, and hypnosis with an aim to achieve rapid and complete recovery at the end of the procedure.

Assessing and achieving the right depth of sedation is of utmost importance. While several scales are available to assess the quality and safety of sedation practice in children, the ASA classification of sedation (based on the responsiveness of the patient, patency of the airway, adequacy of spontaneous ventilation, and cardiovascular function) is followed most frequently by clinicians.[5] Cravero *et al.* have developed and validated a six-point scale called the Pediatric Sedation State Scale (PSSS) which is a measure of quality and effectiveness of procedural sedation in children.[6] The PSSS measures factors such as movement, stress, pain, respiratory depression, blood pressure, and heart rate.

All children scheduled for procedures under sedation should undergo a thorough clinical evaluation and must be graded as per the ASA physical status. The standard fasting guidelines must be followed (6 hr for solids and non-human milk, 4 hr for breast milk, and 2 hr for 'clear liquids'), and a written informed consent must be obtained from the guardians. High-risk paediatric patients (ASA 3 and 4) and children with special needs or airway abnormalities are required to consult anaesthesiologists with subspecialty certification in paediatric anaesthesiology who dedicate at least 25% of their clinical practice to neonates and children. Such patients should receive sedation at a centre with an organised paediatric sedation service.[7] General anaesthesia with tracheal intubation (GETA) may be necessary for patients undergoing magnetic resonance imaging (MRI) or interventional neurologic cases with head trauma who need end-tidal CO_2 control or airway protection, or in sick children admitted in the intensive care unit. Controlled ventilation is preferred in infants and ex-premies prone to bradycardia and apnoea. No clear evidence exists to recommend sedation over anaesthesia or vice versa for procedures in which both techniques are effective and safe. It is appropriate to consider all the implications of a given technique for a given procedure in a given child prior to conducting NORA.

Sedation/Anaesthesia for non-painful procedures

Imaging tests (e.g., non-interventional computed tomography (CT) or MRI) are the most common nonpainful procedures for which children undergo sedation. CT is rapid and less sensitive to patient movement than MRI and may be carried out without sedation. Other non-painful procedures such as echocardiography, electroencephalogram, genital examination, or routine physical examination of special children may also require NORA or sedation.

Table 1: ASA guidelines for non-anaesthesiologists administering sedation and/or analgesia

Individual administering sedation/analgesia	Should understand the pharmacology of agents administered, and be well versed with antagonists for opioids and benzodiazepines
Individual monitoring the patient	Should be present throughout the procedure
	Should be able to recognise complications early
	During deep sedation, this individual should have no other responsibility other than monitoring the patient
	During moderate sedation, this individual may assist with minor tasks, once analgesia and vital signs have been stabilised.
At least one individual capable of establishing an airway and administering positive pressure ventilation	Should be present in the procedure room
Individual with advanced life support skills	Should be immediately available (within 5 min) during moderate sedation
	Should be in the procedure room during deep sedation
Additional assistance	Should be easily available

The ability of a child to cooperate for a procedure depends on the chronologic age, cognitive, and emotional development. Non-pharmacologic interventions such as distraction, simulation, play preparation, video/audio technologies, positive reinforcement, and relaxation should be employed for all children undergoing procedures. This may decrease the amount of sedation required or prevent the need for sedation altogether especially if the procedure is non-painful. For healthy infants and children (ASA 1 or 2) with an intravenous (IV) access in place, bolus doses of propofol or dexmedetomidine are more effective when compared to IV short-acting barbiturates (e.g., Thiopentone) or midazolam.[8,9] A Cochrane analysis compared IV midazolam to other IV medications, and it concluded that although IV midazolam produced lesser sedation and anxiolysis, the benefits of anterograde amnesia were noted.[10] IV ketamine is also commonly used for sedation during imaging; however, when used as the sole agent, it may be associated with movement in some children.[11] IV route of drug administration is always preferred; however, when an IV line has not been placed, intramuscular ketamine, oral or intranasal (IN) midazolam, and IN dexmedetomidine can be used. Midazolam atomiser (now available in India) aids nasal mucosal absorption, gives a better comfort, and reduces sneezing and cough when compared to direct instillation.[12] IN dexmedetomidine (2.5 mcg/kg) is superior to oral midazolam for producing satisfactory sedation with a similar onset of action and time to discharge.[13] Per rectal midazolam may be administered; however, it is not reliable. Sedation with the continuous infusion of propofol or dexmedetomidine may be used. The onset of sedation is longer with dexmedetomidine than with propofol.[14] Dexmedetomidine may be preferred in children with sleep apnoea.[15] Oral or rectal short-acting barbiturates are efficacious; however, the long duration of sedation produced for a relative short imaging time is unnecessary. The potential for delayed adverse events, including prolonged sleepiness, airway obstruction, and ataxia limits their use.[16] Chloral hydrate is believed to have carcinogenic potential (although the risk of cancer from a single dose is inconclusive) and is no longer recommended for sedation.

Sedation/Anaesthesia for minimally painful short procedures

Some common examples include peripheral IV-line placement, urethral catheterization, small laceration repair, or nasogastric tube placement. In healthy children (ASA 1 or 2) inhaled nitrous oxide (N_2O); oral, sublingual, or IN midazolam; or IN dexmedetomidine are commonly preferred. In a cooperative child, N_2O may be preferred to midazolam, as it has shorter recovery time and lesser adverse effects.[17,18] IN dexmedetomidine has a safety profile similar to midazolam for minimally painful procedures.[19,20]

Sedation/Anaesthesia for moderately or severely painful procedures

Common examples include: fracture reduction, bone marrow aspiration, and burns dressing. For painful procedures of short duration, ketamine alone or ketamine with propofol or fentanyl with propofol provides good sedation efficacy and is found to be superior to regimens that combine opioids (typically fentanyl) with midazolam or etomidate.[21,22] Airway reflexes are usually preserved with ketamine; however, the risk of laryngospasm cannot be ruled out. Vomiting and agitation during emergence are more frequent following ketamine sedation. Avoidance of high dosing (≥2.5 mg/kg initial dose or total dose ≥5 mg/kg) and prophylactic ondansetron may decrease their frequency.[23]

Remifentanil with propofol has been used for anaesthesia and deep sedation in children. However, evidence is lacking regarding the safety of this regimen in NORA.[24] N_2O alone for these procedures is a challenge due to the lack of patient cooperation. It often requires a need for restraint and is hence not recommended. Dosages of commonly used drugs for sedation in children are given in Table 2.[25]

Organization of anaesthesia services at NORA

In some institutions, NORA services are organised at an off-site anaesthesia unit. These units have the advantage of providing all anaesthesia-related care at one location. These units provide for pre-anaesthesia check (PAC), induction, procedure location, and a recovery area equipped with the required personnel and equipment. Children may be transported to remote locations (such as MRI) from the unit. NORA can also be organised at the site of procedural care (in radiology departments or gastrointestinal suites) when the requirement is for a multitude of children, on a regular basis, in a given location. Formation of specialty teams consisting of paediatric anaesthesiologists, nursing, technical, and administrative personnel who are familiar with NORA leads to consistency of the equipment and personnel thus enhancing safety, efficiency, and patient/parent satisfaction.

Table 2: Drug dosages for sedation in children

Drug	Age	Route	Dose
Midazolam	6 months to 5 years	IV	0.05 to 0.1 mg/kg (max 6 mg)
	5 years to 12 years	IV	0.025 to 0.05 mg/kg (max 10 mg)
		IM	0.1 to 0.15 mg/kg
		Per rectal	1 mg/kg
		Sublingual	0.5 to 0.75 mg/kg
		Intranasal	0.2 to 0.3 mg/kg (max 10 mg/kg)
	<32 weeks neonates	IV infusion	0.03 mg/kg/hr
	>32 weeks neonates	IV infusion	0.06 mg/kg/hr
		IV infusion	0.06 to 0.12 mg/kg/hr
Pentobarbital		IV	1 to 3 mg/kg
		IM	2 to 6 mg/kg
Propofol		IV	2.5 to 3.5 mg/kg
		IV infusion	125-150 mcg/kg/min
Ketamine		IV (sedation)	0.5 to 2 mg/kg
		IV (analgesic)	0.1 mg/kg
		IV infusion (analgesic)	0.1 to 0.3 mg/kg/hr
Etomidate		IV	0.1 to 0.3 mg/kg
Dexmedetomidine		IV infusion	1 to 2 mcg/kg over 10 min, then 0.5 to 1 mcg/kg/hr
	<1 year	IV infusion	1 to 2 mcg/kg over 10 min, then 0.5 to 1.5 mcg/kg/hr

Challenges in NORA

Environment and equipment-related concerns in NORA

Most radiology suites and catheterization labs are commonly situated in the basement of hospitals and are not easily accessible. Communication through mobile phones is also not possible due to the thick walls built for radiation protection. Hence, when anaesthesia is administered in such areas it is also termed as remote location anaesthesia. The unfamiliar environment, lack of support staff, non-availability of choice of medication, and equipment are the challenges often posed. The minimal requirements at NORA locations given by ASA are outlined in Table 3.[26]

Studies and audits have shown an increased risk of airway-related events, death, and complications outside the operating room.[27-29] Airway management outside the operating room often requires mastery of not only the anatomically difficult airway but also the physiologically and situationally difficult airway. Brindley *et al.* offer a mnemonic 'PREPARE'(P: pre-oxygenate/position; R: reset/resist; E: examine/explicit; P: have plan a and plan b; A: adjust/attention; R: remain/review; E: exit/explore) that combines technical and non-technical insights during airway management at NORA to improve team communication and cohesion thereby increasing the safety of NORA.[30] When inhalation agents are used in NORA, gas-scavenging systems must be installed to prevent air contamination and exposure to health care personnel. Use of cuffed endotracheal tubes can minimise gas leak and decrease pollution.

Table 3: Guidelines by ASA for minimal requirements at non-operating room locations

Reliable source of oxygen with backup
Suction apparatus
Waste gas scavenging unit
Standard monitoring
Electrical outlet
Adequate illumination of patient and anaesthesia work station
Staff trained to support the anaesthesiologist
Emergency cart - self-inflating bag, emergency drugs, anaesthesia drugs, defibrillator
Reliable source of communication to call for help
All applicable building and safety codes
Post anaesthesia/procedure care unit

Monitoring is a challenge in MRI suites due to the absolute need to exclude ferromagnetic objects. There may be interference/malfunction of equipment caused by the changing magnetic fields. There is also the possibility of heat generation within monitoring wires as a result of electromagnetic conduction. The MRI compatible equipment required routinely are listed in Table 4.

Every institution must ensure that the procedurist in collaboration with the dedicated anaesthesiologist develops standardised protocols for NORA based on the environment, equipment available, complexity of the procedure, and patient characteristics in order to improve the safety of NORA.

Procedure specific concerns in NORA

A) *NORA for neuro interventional radiology*

Neuro-interventional radiology includes the treatment of a central nervous system (CNS)

Table 4: MRI compatible equipment required routinely

Equipment	Description
ECG	High impedance graphite electrodes and leads (thermal injury has been reported)
Blood pressure	Oscillometer with nonferrous gauge
Respiratory gas analyser	Side stream sampling with long sampling line
Pulse oximeter	Non-ferromagnetic with fiberoptic signals
Laryngoscope	Plastic scopes with paper or aluminium covered lithium cells
Temperature probe	Skin temperature sensing strips with radiofrequency filters
Stylet	Copper model to be used
Endotracheal tube	Spring within the cuff valve may distort images; nonmagnetic version needs to be used. Metal reinforced tubes & metal connectors need to be avoided
Laryngeal Mask Airway	Spring within the cuff valve may distort images; reinforced LMA (Proseal) LMA cannot be used
Infusion Pumps	Not permitted inside the MRI suite. Extensions are needed
Self-inflating bag	Need to be valve less with no ferromagnetic parts
Suction apparatus	Wall mounted with a 10-meter tubing
Anaesthesia workstation	Nonmagnetic machine, aluminum cylinders required (e.g., Aestiva-5 MRI workstation from Datex Ohmeda)
Defibrillator	Not permitted into the MRI suite. Resuscitation usually carried out outside magnetic field

disease using endovascular access for the purpose of delivering therapeutic agents, including both drugs and devices to the CNS. Most common procedures include embolization of cerebral and dural arteriovenous malformations, coiling of cerebral aneurysms, thrombolysis, and balloon dilatation of vessels[1,31]

NORA may be a challenge as these patients warrant adequate resuscitation, maintenance of cerebral perfusion pressure, and control of intracranial pressure. General anaesthesia (GA) with controlled ventilation is usually preferred. Preparedness to tackle haemodynamic instability and immediate call for help should be available. Adequate steps to ensure normothermia should be taken. Haemorrhage, thromboembolic phenomenon, coil occlusion, and cerebral vasospasm are the major complications encountered, and this can further worsen hypotension and compromise haemodynamics.

B) *NORA for interventional cardiology*

Common cardiac interventional procedures performed include placement of occlusion devices for congenital heart diseases like atrial/ventricular septal defects and patent ductus arteriosus, balloon dilatation/valvuloplasty for pulmonary and mitral stenosis, electrophysiological studies, embolization of collaterals, and permanent pacemaker insertion. NORA at the cardiac catheterization lab must be preceded by a thorough PAC eliciting a history of cyanosis, shortness of breath, signs/symptoms of congestive cardiac failure, history of previous surgical or cardiological interventions, h/o anticoagulant therapy, and other cardiac medications[1,32]

GA/sedation must be titrated depending on the degree of cardiac dysfunction and the cardiac defect. Adequate perfusion of systemic and pulmonary circulation, filling pressures, heart rate, and coronary perfusion pressures need to be maintained. Invasive monitoring and blood gas analysis may be needed. GETA may be required if transesophageal echocardiography (TEE) is planned, as most children may not tolerate the TEE probe under sedation.

C) *NORA at the interventional GI suite*

Diagnostic endoscopy may be done under moderate sedation. However, advanced endoscopic procedures such as dilatation and stenting of stricture esophagus, endoscopic retrograde cholangiopancreatography (ERCP), treatment of esophageal varices, peroral endoscopic myotomy may require deep sedation or GA. Patients with achalasia cardia, gastroesophageal reflux are at high risk of aspiration and must be intubated to protect against aspiration

ERCP is an uncomfortable procedure requiring deep sedation or GA. Patient cooperation is an imperative factor for the success of the procedure and to avoid intra-operative complications such as duodenal perforations. Deep sedation may compromise the airway and desaturation can occur. Prone position may further limit timely airway intervention. GA with target-controlled infusion has shown shorter extubation time, better respiratory and haemodynamic stability, and better satisfaction of the procedurist. Contrast-related risk such as nephrotoxicity, idiosyncratic reactions, and anaphylactic/anaphylactoid reactions may occur in radio interventional procedures.

Radiation hazard to health care personnel

Exposure to radiation is an occupational hazard to anaesthesiologists who anaesthetise children undergoing procedures like CT scan, PET Scan, ERCP, cardiac, or neurologic interventional procedures and radiotherapy for cancer. The main source of radiation is scattered radiation. It is recommended that radiation exposure should be 'as low as reasonably achievable' (ALARA), and hence an attempt to reduce modifiable factors such as duration of exposure and distance from the patient should be made whenever possible.[33] While anaesthesiologists have little control over the duration of the procedure, distance from the source should be maintained as the intensity of the radiation beam is attenuated according to the inverse square law ($1/d^2$). Patient care often mandates the anaesthesiologists to be in the vicinity especially during sedation for interventional procedures as any sudden patient movement can prove to be dangerous.

Personal protection with wrap around lead aprons, thyroid collars, lead eye glasses, and lead gloves can reduce exposure by 90%. Staff regularly exposed to radiation should wear personal dosimeter. Two dosimeters – one outside the shielded garment at collar level, second at waist level inside shielded garment – are recommended, assigned to monitor over a period of 3 months. In total, 20 milli-sievert is the maximum exposure per year allowable.

Radiation protection during Positron Emission Tomography (PET) scan

The physics behind PET scan differs greatly from other imaging modalities. The patient receives a radioactive isotope, fluorodeoxyglucose (FDG) and is then placed under a scanner. The isotope used results in the patient becoming a radioactive source and their bodies emit a high dose of radiation.[34] Shielding with lead aprons are not effective in positron radiation. It can prove to be detrimental due to the entrapment of radioactive particles underneath the apron.

Most children under the age of 6 years require anaesthesia services to prevent movement during these procedures. However, many children, undergoing a PET-CT or PET-MRI are often unwell for a considerable amount of time and are most likely to have undergone radiological imaging previously. The sense of familiarity with the location, equipment, and staff may already exist. Good communication and parental presence in the scan room can alleviate anxiety and help an uncooperative child to complete the scan without the need for sedation.

When sedation/anaesthesia is required for children undergoing such procedures; patient contact is inevitable during the application of monitors, induction, and airway intervention. Health care personnel can reduce radiation exposure based on the use of distance, shielding, and minimization of time spent in hot areas.[34] The patient injection process is considered to have the greatest potential for high staff exposure. Shielded dispensing units, syringe shields, and carriers need to be used. Staff preparing and administering unsealed FDG doses may receive a significant dose especially to their fingers. Although a dosimeter placed at the fingertip would be ideal to calculate radiation exposure accurately, it may be impractical/inconvenient for the worker.

If it is mandatory for the anaesthesiologist/staff to be in the scan room with the patient, standing at two identified positions, at the end of the bed or to the side of the gantry, may help to reduce exposure. Children should be counselled and encouraged to empty their bladder post procedure and get on and off beds independently whenever practical/clinically safe. After FDG injections, the child should be monitored and communicated to through a closed-circuit television camera and two-way intercom system when possible. This will reduce contact time and increase distance from the patient. Individuals escorting the child after PET scan should ideally keep a distance of >0.5 meters during the first 2 hr after the injection. The patient should stay away from other children and pregnant women for at least 6 hr.

Challenges in NORA have been summarised in Tables 5 and 6.

Complications in NORA

A. *Respiratory complications*

   Respiratory depression is more frequent during NORA. Non-vigilance, inappropriate anaesthetic technique, non-anaesthesia staff handling a complex medical cases, esophageal intubation during resuscitation, and unexplained bradycardia were noted to be associated with respiratory complications[35]

Table 5: Age-specific anaesthetic concerns			
Neonate	**Infant**	**Child**	**Adolescent**
Difficult intravenous access Difficult Airway Associated congenital anomalies to be ruled out Check Nil per oral status Hypothermia Hypoglycaemia Perioperative apnoea Bronchospasm Laryngospasm Airway obstruction	Seperation anxiety Difficult intravenous access Check Nil per oral status Hypothermia Hypoglycaemia Bronchospasm Laryngospasm Airway obstruction	Seperation anxiety Check Nil per oral status Emergence delirium Bronchospasm Laryngospasm Airway obstruction	Fear and anxiety of the procedure

Table 6: Procedure-related risk in NORA			
Location	**Procedure**	**Procedure specific concern**	**Environment and equipment related concern**
Endoscopy Suite	Esophagogastroduodenoscopy	Aspiration risk	Not familiar with work place,
	Sigmodoscopy Colonoscopy	Bowel perforation and Bleeding	Non availability of drugs/appropriately sized equipment, unfavourable equipment layout,
	Endoscopic retrograde cholangiopancreatography	Aspiration Risk, Bowel perforation, sepsis	Radiation hazard to health care personnel
	Bronchoscopy Foreign body airway removal Endobronchial stenting Endobronchial biopsy/cauterization Balloon Dilatation	Airway obstruction, Bronchospasm, Laryngospasm, Trauma and bleeding, Hypoxia, Airway fire	
	Magnetic resonance cholangio pancreatography		Absolute need to exclude ferromagnetic objects/equipment. Need to shift patient out of the MRI scanner room for resuscitation
Imaging suite	Non interventional CT/Contrast CT	Contrast/Dye related risk such as nephrotoxicity, idiosyncratic reactions, anaphylactic/anaphylactoid reactions	Not familiar with workplace, Non availability of drugs/appropriately sized equipment, unfavourable equipment layout, Radiation hazard to health care personnel
	MRI/MRI with contrast		Absolute need to exclude ferromagnetic objects/equipment. Need to shift patient out of the MRI scanner room for resuscitation
	PET Scan		Radiation hazard to health care personnel
Catheterization laboratory	CT Angiography Digital subtraction Angiography Embolization of cerebral and dural arteriovenous malformations Coiling of cerebral aneurysms thrombolysis and balloon dilatation of vessels Occlusion devices for congenital heart diseases like atrial/ventricular septal defects and patent ductus arteriosus Balloon dilatation/valvuloplasty for pulmonary and mitral stenosis Embolization of collaterals Permanent pacemaker insertion	Contrast related risk such as nephrotoxicity, idiosyncratic reactions, anaphylactic/anaphylactoid reactions, Radiation hazard, Thromboembolic phenomenon, Haemodynamic instability, Bleeding	Not familiar with workplace, Non availability of drugs/appropriately sized equipment, unfavourable equipment layout, Radiation hazard to health care personnel
ER, Ward, Minor OT	Intravenous line insertion Urethral catheterization Nasogastric tube insertion Wound dressing Burns dressing Minor suturing Examination under anaesthesia Biopsies EEG ECG		Non availability of drugs/appropriately sized equipment, unfavourable equipment layout, Parental presence/pressure

It is said that about 10% of anaesthesiologists have no backup plan for unanticipated difficult intubation. It is crucial to be familiar with the difficult airway algorithm and call for help early. The most common event in NORA claims was inadequate oxygenation/ventilation which is preventable with vigilant monitoring, using pulse oximetry and capnography.[35]

B. *Hypothermia*

Lower temperatures are maintained in diagnostic suites to prevent equipment overheating. Children are vulnerable to hypothermia, and although bleeding is uncommon in the setting of NORA, even mild hypothermia is known to increase surgical blood loss, and thereby increases the risk of transfusion. Hypothermia also delays recovery and increases oxygen consumption. Active warming measures such as body and fluid warmers need to be used.

C. *Aspiration, postoperative nausea, and vomiting (PONV)*

All patients undergoing elective procedures need to be fasted according to the standard guidelines. Administration of sedatives and anaesthetic agents can blunt airway reflexes and predispose to aspiration. PONV is one of the most common reasons for unplanned hospitalization. It is treatable and preventable. At risk patients should be identified and prophylactically medicated.

D. *Hypovolaemia and hypoglycaemia*

Prolonged fasting can predispose to dehydration, hypovolaemia, and hypoglycaemia. Maintenance of a sufficient volume status before the procedure by pre-hydration and a slow injection of intravenous drugs can prevent adverse haemodynamic events.

Post-procedure care

A designated area for post-anaesthesia care, with equipment for emergency resuscitation should be available. The post-sedation period requires monitoring of oxygen saturation and blood pressure at the minimum and strict surveillance similar to that after GA. It is imperative that the adequate staff is available to monitor the child with vigilance till the discharge criteria (Modified Aldrete score) have been met.

CONCLUSION

With technological advances in medicine and the increased proficiency of procedurists, anaesthesia providers are more frequently asked to provide complete, anaesthetic care outside the traditional operating room setting. The numbers and the complexity of such cases are increasing exponentially over time. The key to efficient and safe NORA practice in children relies on good PAC, thorough understanding of the anatomical and physiological variations in children, knowledge of the unique pharmacokinetics and pharmacodynamics of individual sedation agents, understanding the requirements of the procedure, and efficient team communication between the anaesthesiologist and non-operating room personnel.

SUMMARY

The anatomical and physiological variations in infants and children, the unfamiliar and non-conventional environment of NORA, pose challenges to anaesthetic management. Safety guidelines provided by ASA task force must strictly be adhered to by non-anaesthesiologists providing sedation, to allow patients with the benefits of sedation/analgesia while minimizing the associated risks. Individuals administering sedation/analgesia should understand the pharmacology of agents administered, and be well versed with antagonists for opioids and benzodiazepines. The targeted depth of sedation and the drugs used depend upon the procedure performed, the anticipated degree of pain, allowable patient movement, duration of procedure, and other patient factors – last oral intake, urgency of the procedure, prior sedation experience, and comorbidities (e.g., upper respiratory infection). Individual institutions should develop guidelines to support the safe practice of paediatric sedation. In hospitals where paediatric NORA is a routine, a designated NORA team or sedation service can provide efficient, effective, and safe anaesthesia. All participating staff must be adequately trained to assist in NORA as well as in CPR.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Gross WL. Non-operating room anaesthesia. In: Miller RD, editor. Miller's Anaesthesia. 8th ed. Philadelphia: Elsevier; 2015. p. 2646-73.
2. Cravero JP, Beach ML, Blike GT, Gallagher SM, Hertzog JH. Pediatric Sedation Research Consortium. The incidence and

nature of adverse events during pediatric sedation/anaesthesia with propofol for procedures outside the operating room: A report from the Pediatric Sedation Research Consortium. Anesth Analg 2009;108:795-804.
3. Youn AM, Ko YK, Kim YH. Anaesthesia and sedation outside of the operating room. Korean J Anesthesiol 2015;68:323-31.
4. American Society of Anaesthesiologists Task Force on Sedation and Analgesia by Non-Anaesthesiologists. Practice guidelines for sedation and analgesia by non-anaesthesiologists. Anesthesiology 2002;96:1004-17.
5. An Updated Report by the American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. Practice Guidelines for Sedation and Analgesia by Non-Anesthesiologists. Anesthesiology 2002;96:1004-17.
6. Cravero JP, Askins N, Sriswasdi P, Tsze DS, Zurakowski D, Sinnott S. Validation of the pediatric sedation state scale. Pediatrics 2017;139:e20162897.
7. Tobias J, Agarwal R, Anderson C, Bannister C, Hardy C, Honkanen A, *et al.* Critical elements for the pediatric perioperative anaesthesia environment. Pediatrics 2015;136;1200-5.
8. Srinivasan M, Turmelle M, Depalma LM, Mao J, Carlson DW. Procedural sedation for diagnostic imaging in children by pediatric hospitalists using propofol: Analysis of the nature, frequency, and predictors of adverse events and interventions. J Pediatr 2012;160:801-6.
9. Macias CG, Chumpitazi CE. Sedation and anaesthesia for CT: Emerging issues for providing high-quality care. Pediatr Radiol 2011;41:517-22.
10. Conway A, Rolley J, Sutherland JR. Midazolam for sedation before procedures. Cochrane Database Syst Rev 2016;20:CD009491.
11. Grunwell JR, Travers C, McCracken CE, Scherrer PD, Stormorken AG, Chumpitazi CE, *et al.* Procedural sedation outside of the operating room using ketamine in 22,645 children: A report from the Pediatric Sedation Research Consortium. Pediatr Crit Care Med 2016;17:1109-16.
12. Chiaretti A, Barone G, Rigante D, Ruggiero A, Pierri F, Barbi E, *et al.* Intranasal lidocaine and midazolam for procedural sedation in children. Arch Dis Child 2011;96:160-3.
13. Ghai B, Jain K, Saxena AK, Bhatia N, Sodhi KS. Comparison of oral midazolam with intranasal dexmedetomidine premedication for children undergoing CT imaging: A randomized, double-blind, and controlled study. Paediatr Anaesth 2017;27:37-44.
14. Heard C, Burrows F, Johnson K, Joshi P, Houck J, Lerman J. A comparison of dexmedetomidine-midazolam with propofol for maintenance of anaesthesia in children undergoing magnetic resonance imaging. Anesth Analg 2008;107:1832-9.
15. Mahmoud M, Gunter J, Donnelly LF, Wang Y, Nick TG, Sadhasivam S. A comparison of dexmedetomidine with propofol for magnetic resonance imaging sleep studies in children. Anesth Analg 2009;109:745-53.
16. Tobias JD, Leder M. Procedural sedation: A review of sedative agents, monitoring, and management of complications. Saudi J Anaesth 2011;5:395-410.
17. Zier JL, Liu M. Safety of high-concentration nitrous oxide by nasal mask for pediatric procedural sedation: Experience with 7802 cases. Pediatr Emerg Care 2011;27:1107-12.
18. Ekbom K, Kalman S, Jakobsson J, Marcus C. Efficient intravenous access without distress: A double-blind randomized study of midazolam and nitrous oxide in children and adolescents. Arch Pediatr Adolesc Med 2011;165:785-91.
19. Surendar MN, Pandey RK, Saksena AK, Kumar R, Chandra G. A comparative evaluation of intranasal dexmedetomidine, midazolam and ketamine for their sedative and analgesic properties: A triple blind randomized study. J Clin Pediatr Dent 2014;38:255-61.
20. Sheta SA, Al-Sarheed MA, Abdelhalim AA. Intranasal dexmedetomidine vs midazolam for premedication in children undergoing complete dental rehabilitation: A double-blinded randomized controlled trial. Paediatr Anaesth 2014;24:181-9.
21. Godambe SA, Elliot V, Matheny D, Pershad J. Comparison of propofol/fentanyl versus ketamine/midazolam for brief orthopedic procedural sedation in a pediatric emergency department. Pediatrics 2003;112:116-23.
22. Migita RT, Klein EJ, Garrison MM. Sedation and analgesia for pediatric fracture reduction in the emergency department: A systematic review. Arch Pediatr Adolesc Med 2006;160:46-51.
23. Langston WT, Wathen JE, Roback MG, Bajaj L. Effect of ondansetron on the incidence of vomiting associated with ketamine sedation in children: A double-blind, randomized, placebo-controlled trial. Ann Emerg Med 2008;52:30-4.
24. Sammartino M, Garra R, Sbaraglia F, De Riso M, Continolo N. Remifentanil in children. Paediatr Anaesth 2010;20:246-55.
25. Blasiole B, Davis PJ. Intravenous agents. In: Davis PJ, Cladis FP, editors. Smith's Anaesthesia for infants and children. 9th ed. Philadelphia Elsevier Mosby; 2011. p. 186-99.
26. Statement on Nonoperating Room Anesthetizing Locations Committee of Origin: Standards and Practice Parameters (Approved by the ASA House of Delegates on October 19, 1994, last amended on October 16, 2013, and reaffirmed on October 17, 2018).
27. Cook T, Behringer EC, Benger J. Airway management outside the operating room: Hazaedous and incompletely studied. Curr Opin Anaesthesiol 2012;25:461-9.
28. Cook TM, Woodall N, Frerk C. Fourth National Audit Project. Major complications of airway management in the UK: Results of the Fourth National Audit Project of the Royal College of Anaesthesiologists and the Difficult Airway Society. Part 1: Anaesthesia. Br J Anaesth 2011;106:617-31.
29. Berkow LC. Anesthetic management and human factors in the intraoperative MRI environment. Curr Opin Anaesthesiol 2016;29:563-7.
30. Brindley PG, Beed M, Law JA, Hung O, Levitan R, Murphy MF, *et al.* Airway management outside the operating room: How to better prepare. Can J Anaesth 2017;64:530-9.
31. Varma MK, Price K, Jayakrishnan V, Manickam B, Kessell G. Anaesthetic considerations for interventional neuroradiology. Br J Anaesth 2007;99:75-85.
32. Reddy K, Jaggar S, Gillbe C. The Anaesthesiologist and the cardiac catherisation laboratory. Anaesthesia 2006;61:1175-86.
33. Ismail S, Khan F, Sultan N, Naqvi M. Radiation exposure to Anaesthesiologists during interventional radiology. Anaesthesia 2010;65:54-60.
34. Alenezi A, Soliman K. Trends in radiation protection of positron emission tomography/computed tomography imaging. Ann ICRP 2015;44:259-75.
35. Robbertze R, Posner KL, Domino KB. Closed claims review of anaesthesia for procedures outside the operating room. Curr Opin Anaesthesiol 2006;19:436-42.