NON-OPERATING ROOM ANAESTHESIA IN PAEDIATRIC PATIENTS- AN OVERVIEW

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ABSTRACT

BACKGROUND

Although, anaesthesiologists may feel free to provide anaesthesia care in an infrastructural-rich scenario of operating room they are coming out from that secured environment to cater their services to ever-expanding diagnostic and interventional domain. It is quite challenging to provide anaesthesia care in this arena where environment, equipment and staff are often not sufficient from logistic point of view. The peculiarities of environment, limitations regarding human resource, equipment and ancillary facilities should be borne in mind. Certainly, the safety for the paediatric patients increases when anaesthesiologists are involved for anaesthesia care. However, conventional anaesthesiologists should acquire practical experience from seniors and experts in this field to tackle these situations. Training under supervision, being armoured with proper equipment and drugs, along with adequate backup facilities are of paramount important matters. In this narrative review, mostly consensus views have been presented about how to provide safe anaesthesia care for this special population. Some grey areas are there about which evidence is growing.

KEYWORDS

Analgesia, Anaesthesia, Child, Humans, Pain Management.

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BACKGROUND

Recently, there is an exponential growth of interventional medicine. A multitude of complex diagnostic and therapeutic procedures involving bulky and complex equipment are being performed outside of Operating Room (OR). This preserves OR resource for usual surgical procedures. Shifting and accommodating this equipment in the theatre is difficult technically. Any frightening or unpleasant procedure and/or painful interventions requiring maximum toleration or immobility are indications for sedation-analgesia or anaesthesia. Children represent a special group of patients, who usually lack the emotional maturity and mental resolve to cooperate and are more likely to require moderate to deep sedation or anaesthesia.[1] This has compelled anaesthesiologist to leave the secured place of operating room to cater their services in an unfamiliar territory. Death of 3 children in a single dental office has led the American Academy of Pediatrics (AAP)/American Academy of Pediatric Dentistry (AAPD) to publish their series of guidelines in 1985 onwards for monitoring and management of paediatric patients during and after sedation for a procedure. With the revision of that document, Joint Commission on Accreditation of Healthcare Organisations, the American Society of Anesthesiologists (ASA), the AAP and the AAPD gradually unified the terminologies to define sedation spectrum and the expected physiologic responses.[2-5]

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MATERIALS AND METHODS

Literature search was done using relevant keywords such as 'procedural sedation,' 'sedo-analgesia,' 'paediatric,' etc. using search engine 'Google' and only the free full-texts of mostly review articles, meta-analysis and some original articles available from US National Library of Medicine (Pubmed) were considered. Articles available in the form of abstracts were excluded. A consensus view is presented here. Some grey areas are present, for which evidence is growing. Readers will be able to acquire preliminary knowledge to provide sedo-analgesia and anaesthesia care for paediatric patients. Also, the readers will acquire some knowledge about the existing standards of preparation and monitoring to minimise adverse events during such care.

What is Effective Anaesthesia Care

An effective anaesthesia care should be optimally successful and comfortable in terms of achieving the required degree of sedation, analgesia, immobility and cooperation. It should decrease or at best eliminate anxiety, discomfort and post-traumatic disorder.[2] The ASA has described different levels of sedation including general anaesthesia, as 'the sedation continuum.'[3] The criteria for monitoring and supervision by medical teams have been recommended for different procedures, which require different depth of sedation and analgesia (Anxiolysis; minimal, moderate and deep sedation; dissociative anaesthesia and general anaesthesia). Responsiveness, airway, spontaneous respiration and cardiovascular function all are more or less preserved and favourable up to the 'moderate sedation.' It is practically impossible to demarcate, where deep sedation ends and general anaesthesia begins. Change of sedation level, i.e. the 'sedation drift' can occur rapidly in paediatric patients.[6] Loss of airway control and oxygen desaturation occurs rapidly in children. Safety can be achieved with vigilance. A tendency exists among the health care providers to administer less analgesic and sedatives than actually is required. Children's

pain and distress matters; it should be treated adequately, not only for the children but also for the family and society. Often, they are undertreated for their pain-, the so called 'oligo-analgesia.'[7] Lack of knowledge and lack of guidelines in pain management can contribute to inadequate treatment of pain. Moreover, assessing pain in children is also a difficult task unless properly trained. Often pain and anxiety are not always appreciated properly by an attending nurse or physician. Hence, improvement of knowledge among the care providers and revision of guidelines may increase the administration of analgesia.[8,9]

The anaesthesia care provider should follow the 'right drug at the right time' approach making prudent use of the pharmacodynamic and pharmacokinetic properties of an individual drug or drug combination. Otherwise, there will be a failure of proper anaesthesia care (Procedural sedation) either due to use of a right drug given at wrong time, such that the peak effect occurs after the painful procedure is completed or the use of wrong or inappropriate drug given at right time. Here, wrong drug means the drug lacking the required sedative or analgesic component for the intended procedure.[10]

What are the Different Clinical Scenarios

According to the nature of establishment and availability of resources (Geographical), different environments can exist outside the OR-

A. In-hospital situations: (a) Large, complex equipment (CT, MRI, nuclear medicine scanning, cardiac catheter laboratories, external beam radiation therapy) that cannot be transported to; (b) Procedures of accident and emergency department, Gastrointestinal (GI) endoscopy, flexible bronchoscopy, interventional radiology, etc. which can be moved out of OR to spare the OR resources for surgery.
B. Remote places or office-based procedures (e.g. dermal laser treatment, procedures in dental clinic).
C. Intra- and inter-hospital transfer during critical illness.
D. Extrication of persons or amputation of limb in accidents, disasters and other austere environments.

The procedure may vary according to the degree of invasiveness and magnitude of distress.[3] Non-invasive (Non-painful) procedures does not require insertion of a device through the skin or a body orifice. For example, MRI, CT, procedures in the field of nuclear medicine, assessment of evoked potential, etc. Invasive (Painful) procedures require insertion of a device through the skin or body orifice, such as oncology and surgical office procedures. Examples are-lumbar punctures, bone marrow aspirates/biopsies, etc. Distressful (in-between the invasive and non-invasive) procedure results in mental or physical suffering or anguish.[10] The innate capability of different patients to tolerate the pain varies. Varying degrees of pain, distress and complexity can exist in different combination, making specific categorisation of any procedure difficult. Hence, it is difficult to prescribe any anaesthetic protocol to cover a particular procedure. Assessment of patients, facilities available in that set up for rescuing the patient from any undue level of anaesthesia, human resources available for help- all would influence the ultimate decision for choosing a particular recipe of drugs for anaesthesia care. Learning by experience under supervision from an experienced person is one accepted age-old modality.

Environment (Equipment and Staff)

In an unplanned procedure, the anaesthesiologist is often called after the intervention has started and the patient is found to be uncooperative. It is safer to accept the patient from the very beginning than to attend in the middle of the procedure as a rescuer. Staff, commonly trained in their own specialty may not be familiar with the requirements for safe anaesthesia and usually unable to provide the necessary assistance without a prior proper plan or airway assessment; and the situation may be hazardous. Unfamiliar environment, poor communication between staff of other specialties leading to failure in recognising each other's requirement. Patient preparation and recovery facilities are often not at par with preoperative protocols. The suite may not have been designed with anaesthetic requirements. Anaesthetic apparatus often competes with procedural equipment for space, compromising access to the patient. Anaesthetic equipment and monitoring devices are often the oldest. The machine may neither be in regular use nor be under regular maintenance contract. Breathing systems and monitors with long extension tubes are necessary. Often, a spanner to open cylinders and a means of illumination other than the laryngoscope are not available. Equipment checklist may be remembered with an acronym 'SOAPME.' S: Suction, O: Oxygen, A: Airway, P: Pharmacy, M: Monitors, E: Equipment.[10]

Points to be Ensured for Safe Anaesthesia Outside the OR

(i) Reliable oxygen source with backup, (ii) A functioning suction equipment, (iii) Scavenging system for inhaled anaesthetics, (iv) Basic monitoring equipment and self-inflating resuscitator bag of appropriate size that can administer at least 90% oxygen, (v) Safe electrical outlets, (vi) Adequate illumination for patient and anaesthetic equipment with battery backup, (vii) Sufficient space for the anaesthesia provider, (viii) Emergency cart (containing a defibrillator with age-appropriate paddles and resuscitative drugs and equipment), (ix) A reliable two-way communication, (x) Applicable building codes and facility standards, (xi) Adequately trained staff for immediate assistance and (xii) Necessary post anaesthesia care ensuring safe transport of the patient.[11]

Patient-Related Factors

Immature respiratory centre, unstable airways and smaller FRC predispose this special population to apnoea and hypoxia during anaesthesia care and also in the post-anaesthesia period. An extended observation period of up to 72 hours is required, especially in premature infants up to a post-conceptual age of 60 weeks.[12,13] Special care (experienced team, intubation, hospital admission, etc.) is needed in the following situations: (i) Neonates (especially, if premature or ex-premature), (ii) Emergency cases where adequate starvation is not possible, (iii) Children with cardiovascular disease, respiratory function impairment, compromised hepatic and/or renal function, history of gastro-oesophageal reflux, mitochondrial or metabolic disease, neuromuscular diseases and craniofacial malformations.[14]

Who will Provide Anaesthesia Care

Safe administration of anaesthesia cannot be carried out single-handedly; competent and exclusive assistance is necessary at all times.[15,16] The 'ten golden rules for safe anaesthesia' also puts importance about trained assistant.[17] Unfortunately, this is violated, at least in some settings of developing country. Non-anaesthesiologists trained to rescue patients from deep sedation can perform minimal-to-moderate sedation. However, deep sedation service should be done only by adequately trained anaesthesia personnel. Cote has summarised the issue prudently by writing: "When caring for children, particularly when they have to remain quiet for any length of time, one must induce pharmacological coma; - let us be honest and call deep sedation exactly what it is and take proper care of these deeply sedated patients."[18] The care provider team should contain a physician and a nurse who have undergone structured training in sedo-analgesia and airway management in paediatrics. All members should have BLS skills. At least one member must have APLS skills and upgrading regularly. Both must carry out the anaesthetic care exclusively.

Preanaesthetic Assessment

Adequate history should be achieved about the present illness, current and previous medication, developmental and immunisation status, allergies and co-morbid conditions (Cardiopulmonary, hepatic and renal diseases). Examination of airways to identify potential difficulties with mask ventilation or intubation, ASA physical status classification, risk assessment, communication with the parent or guardian about the nature of the procedure should be done. Child's anxiety and cooperation is affected by age, past medical experience and the level of parental anxiety. Red flags are for the neonates, especially the premature and ex-premature, children with different systemic disorders and the emergency cases need special care.

Fasting

For minimal sedation, fasting is not needed owing to preserved protective pharyngeal reflexes. Standard fasting guideline (Rule of '2-4-6') should be followed for elective procedures requiring moderate or deep sedation.[2,5,11] In emergent situations (without an empty stomach), deep sedation should be avoided as much as possible; clinical judgment is required to delay or for alternate plan (Consideration of alternative procedure, intubation by expert anaesthesiologist, etc.).[15,19]

Selection of Anaesthesia Care and Drug Regimen

The challenges faced by the anaesthesiologist is greatly influenced by complex interaction between patient profile, extent of procedure and available environment (Equipment and staff).[20] The suitable spectrum of 'sedation continuum' and analgesia depends upon intensity of pain, required immobility and the complexity of procedure. Children often need higher doses per kg body weight, but suffer respiratory depression and airway obstruction quicker than adults. However, the achieved level of sedo-analgesia can vary according to the patient's sensitivity and co-morbid condition.[1,6]

Broadly, the choices of anaesthetic techniques are: Monitored Anaesthesia Care (MAC), sedation/analgesia and General Anaesthesia (GA). Mostly, moderate-to-deep sedation with analgesia is required. When appropriate, supplementation with local/topical anaesthesia (LA) can be adopted. But the actual level achieved can vary according to patient's sensitivity, the pre-existing distress, past experience, developmental status and drug profile.[2,15] It is clear that the anaesthetic technique may lie anywhere of the spectrum from MAC to GA with airway control. Question arises whether MAC is safer than GA. The answer is uncertain. The percentage of death and permanent brain injury in MAC is similar to that of GA. Deep sedation can be riskier than the GA with control of airway.[13,20]

The drugs utilised can be sedatives-anxiolytics like midazolam, nitrous oxide; sedative-hypnotics such as chloral hydrate, barbiturates and central alpha-2 adrenergic agonist, sedative-analgesics, e.g.- opioid agonists and ketamine. Non-invasive procedures can be managed with sedative-anxiolytics or sedative-hypnotics in case of requirement of strict immobility. Invasive procedures are best managed with combinations of sedative-hypnotics and analgesics. Distressful procedures require control of varying degrees of anxiety.[10,15,19]

The optimal degree of sedation/analgesia need individualisation and is tailored according to the procedure. Some general principles should be borne in mind-

- The duration of drugs' effect should match the duration of procedure. Titration of drugs to the desired effect by administering repeated small doses is better than giving a single bolus. Intravenous (IV) route should be preferred to Intramuscular (IM), oral and rectal, as the absorption is often erratic with the latter. Antagonists should be available.
- Opioids provide pain relief, but provide adequate sedation only at high dosages which increases the risk of adverse effects. Benzodiazepines alone produce anxiolysis, amnesia, no analgesia and rarely apnoea. The shortest-acting benzodiazepines have durations of action considerably longer than the shortest-acting opioids. Benzodiazepines markedly potentiate opioid-induced respiratory depression. If used in combination opioid should be given first, its sedative effect should be assessed carefully and then benzodiazepines should be administered. Ketamine provides excellent analgesia, but alter the signs of anaesthetic depth. Moreover, it can cause airway obstruction and pulmonary aspiration. Hence, it should be avoided in procedures of upper airway and GI endoscopies. Dexmedetomidine has been evaluated as a sedative that does not cause significant respiratory depression.
- Midazolam and propofol as sedatives may be combined with ketamine or an opioid for painful procedures. Propofol with fentanyl is safe for children in the hands of experts. Propofol produces sedation and hypnosis, but no analgesia. It can be titrated to the effect, but can result in rapid onset of GA. It is practically impossible to demarcate where deep sedation ends and GA begins. These agents should preferably be reserved for use by anaesthesia personnel.[2] Low-dose ketamine-propofol infusion is a more effective and safer sedo-analgesia regimen than propofol-fentanyl infusion in paediatric patients.[21] Combinations of more than one sedative with more than

one analgesic have a narrow margin of safety and should be avoided.

Relatively Pain-Free but Stressful Procedures

CT scan is less noisy and requires lesser time than MRI. In both, there is limited access for airway management due to hindrance from the gantry which produces a claustrophobic environment. Ambient noise precludes use of precordial or oesophageal stethoscope. Satisfactory observational monitoring is not possible from outside the suite. In MRI, hypothermia is a concern for paediatric patients due to cooling arrangement. Children with cardiac pacemakers and ICDs should not undergo MRI scan, which can defunct the device. Likewise, anaesthesiologists with pacemaker would not be able to work in MRI environment. Ferromagnetic matters become lethal projectiles if brought within 50 gauss line. MRI-compatible anaesthesia machine and monitors have to be used. All cables and wires should run a straight path (Not be wound in loops) to avoid generation of induction heat. The procedure of radiation therapy is also brief and painless, but the child must remain motionless to avoid radiation toxicity to adjacent anatomy. Monitoring with surveillance camera is required during radiation exposure.[13,20]

Small babies (Up to about 4 months) can tolerate these painless procedures without any sedatives if performed after a feed or with provision of oral sucrose solution, warmth, quiet environment, containment and especially if scheduled at nap time. Sedation/analgesia is usually administered by radiologists or other non-anaesthesiologists. Anaesthesia personnel become involved when sedation fails to control patient movement, thereby necessitating GA or there is a need to secure airway and to control ventilation. Oral/nasal/IV midazolam can be administered for anxiolysis and minimal sedation. Oral chloral hydrate is suitable for minimal-to-moderate sedation. These have a wide margin of safety. Children older than 3 years, who may not respond favourably to chloral hydrate may best be managed with GA with either an endotracheal tube or LMA. Volatile anaesthetics and propofol infusion can be titrated to effect. Deep sedation is not advisable due to compromised patient monitoring, limited patient communication and poor access to patient's airway during scan.[15,19]

Brief Painful Procedures

Interventional radiology/cardiology, endoscopies, etc., require video-screening in darkened room hampering patient monitoring. The duration of all these procedures is unpredictable; close communication with the specialist and choosing agents accordingly is of value. Patients undergoing GI endoscopy and CT-guided biopsies may be positioned in the lateral or prone position in which resuscitation becomes difficult; quick repositioning is warranted. During GI endoscopy and fibreoptic bronchoscopy, there is sharing of common passage. GA with endotracheal intubation or LMA is required to protect the airways. Local anaesthesia spray facilitates the passage of endoscope.

Paediatric patients ranging from premature neonates to the upper limits of paediatric age group may present for cardiac catheterisation procedures. Cardiac anomalies vary from relatively simple atrial septal defects to complex cyanotic cardiac anomalies with shunts at various levels. Following points are important: effects of oxygen and hyperventilation on pulmonary and systemic vascular resistance and their influences on measurement of flow and pressure, effects of sedative/anaesthetic agents on conduction system, interruption of forward flow with balloon expansion and potential devastating complications like, arrhythmias, vessel rupture. Contrast medium can result in anaphylaxis. Anaesthetic care ranges from sedation/analgesia to general anaesthesia. A 'steady state' must be maintained for diagnostic accuracy. Even in cyanotic children, it might be necessary to withhold supplemental oxygen unless the SpO_2 falls below the baseline. Oral midazolam premedication, combination of a rapid-acting, short-lasting opioid and low concentration of inhaled N_2O/volatile anaesthetics is helpful. Alternatively, TIVA using various combinations sedative, hypnotic and analgesics (Opioids, benzodiazepines, propofol and ketamine) can be used.

Painful and Complex Procedures

In accident and emergency scenarios, the problems are: incomplete medical history, inadequate fasting, haemodynamic or respiratory instability, chaotic environment and lack of dedicated recovery room. In dental clinics, the problems are sharing of airway, bleeding, airway obstruction, laryngospasm and pulmonary aspiration due to blood or debris in oropharynx; anxiety and fear caused by noise of hand-piece, trauma to surrounding tissue/eye from sudden movement. Down's syndrome poses specific challenges regarding cardiac conduction defects and other anomalies, risk of atlanto-occipital dislocation and a variety of airway problems like macroglossia, hypoplastic maxilla and palatal abnormalities. Nitrous oxide (in oxygen) and/or midazolam can be used to achieve moderate sedation. Dental and other procedures anticipated to last several hours may best be performed with elective GA (LMA/intubation) rather than late conversion. Ketamine (IM/IV) alone can be used to produce dissociative anaesthesia. Intravenous combination of ketamine or fentanyl with midazolam or propofol can be utilised to produce moderate-to-deep sedation for procedures in accident and emergency. Volatile anaesthetics and LA can be utilised as well to curtail the dose of intravenous sedative/hypnotic and analgesics.

Monitoring

The ASA basic standards of monitoring[22] should be adhered to in any location, where anaesthesia or sedation is being performed. Standard of care does not change with location. Young children desaturate more rapidly than older children, because of their proportionally smaller FRC and relatively greater oxygen consumption. The level of sedation should also be monitored clinically.

Post-Anaesthesia Concerns

ASA standards for post-anaesthesia care[23] should be adhered to. Once the child is able to stay awake for 20 minutes in a quiet environment, it is very probably that the transfer will be safe.[24] Paediatric patients with learning difficulties should return to their pre-sedation status. The following criteria should be fulfilled: (i) Child is awake or easily arousable, optimally hydrated, maintaining normothermia (Warm extremities) and having stable cardio-respiratory function;

(ii) Patent airways (Absence of tracheal tug, intercostal/suprasternal suction; absent alae nasi movement) with adequate protective reflexes (Swallowing, coughing).

Discharge criteria should remain the same for all post-anaesthetic patients, regardless of the location of the procedure. Besides the usual criteria, we follow in operating room for safe transfer out, the time based criteria can be used. The child is safe for transfer if he is able to remain awake for 20 minutes in a quiet environment. Nearly, 80% adverse events were present with respiratory difficulty and mostly due to lack of supervision, inadequate backup and skills of the care provider.

Adverse Events

Adverse sedation events were associated with drug overdoses, drug errors, drug interactions, inadequate monitoring and premature discharge. Polypharmacy increases complications. Nearly, 80% of the adverse events presented initially with respiratory difficulty and most of the unacceptable outcomes were the result of inadequate rescue and resuscitation.[23]

Summary

No drug is immune from adverse effects. No ready-made cook book is available. Drug regimens depend upon the pain and complexity of the procedure and patients' sensitivity and comorbid condition. It should be learnt under the guidance of expert in that area and thereafter to maintain updating. Time tested drug regimes with high therapeutic index should be individualised for the particular patient and procedure to get optimal degree of sedo-analgesia. Combinations of more than one sedative with more than one opioid should be avoided owing to narrow margin of safety of such combinations. We have to ensure that paediatric patients receive the same care as in OR. Proper selection of patients, prior evaluation of patients and environment (suite) and proper planning has no alternatives. Adequate knowledge on the physiologic effects of anaesthetic agents in various comorbid states and training under supervision of experts give them a distinct advantage over non-anaesthesia personnel. The secret of success lies with the skilled anaesthesia provider armoured with proper equipment and drugs along with adequate backup facilities. The anaesthesiologist should leave the protected environment of OR and venture into the unfamiliar territory to ensure that these ill-fated tender population receive the same level of care as in operating room.

Declaration

The first author delivered an invited lecture on 'Paediatric anaesthesia outside the operating room' in the 33rd Annual State Conference of Indian Society of Anaesthesiologists, West Bengal [ISA(WB)CON-2012], held at Kolkata on 22nd to 23rd September 2012. A write-up containing some portion of text, quite different from this article, has been circulated as limited copy booklet (Neither a published book nor a journal) exclusively among the attendees (Approximately 200) of the said conference. The present article, in its present shape has not been submitted or published in any journal. This elaborate article sufficiently distinct from the texts in that booklet is submitted to this esteemed journal for wide dissemination of information to a greater number of readers.

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