Prospective audit of sedation/anesthesia practices for children undergoing computerized tomography in a tertiary care institute

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Abstract

Background and Aims: The aim of the study was to enumerate the sedative drugs used, assess the efficacy of sedative drugs, and determine the incidence of adverse events.

Material and Methods: A prospective audit of children sedated for computerized tomography (CT) by anesthesiology team was conducted for a period of 4 months. The data included patient demographic variables, fasting period, medications administered, adequacy of sedation, imaging characteristics, adverse events, and requirement for escalated care.

Results: A total of 331 children were enrolled for sedation by the anesthesia team. The drugs used for sedation were propofol, ketamine, and midazolam. Twenty-two percent children received one sedative drug, 60% children were administered two drugs, and 5% children required a combination of all three drugs for successful sedation. Sedation was effective for successful conduct of CT scan in 95.8% patients without the requirement of a repeat scan. Twelve (5%) children experienced adverse events during the study period. However, none of the adverse events necessitated prolonged postprocedural hospitalization or resulted in permanent neurologic injury or death.

Conclusions: The current practice of sedation with propofol, ketamine, and midazolam, either single or in combination was efficacious in a high percentage of patients. The incidence of adverse events during the study period was low.

Keywords: Adverse events, CT suite, pediatric sedation, sedative drugs

Introduction

The evolution of medical science and technological innovation in imaging has significantly increased a demand for complex invasive and noninvasive procedures in locations outside the operating room, especially in children.[1-3] The limitations and challenges in these areas have prompted several organizations to formulate guidelines for the provision of safe sedation.[2,4] Sedation is routinely provided to children for computerized tomography (CT) scan in our institute. However, the sedation technique used depends upon the physician providing sedation. We conducted a prospective audit of the sedation practices in children undergoing elective CT scan in the pediatric radiology suite of our institute with the aim to enumerate the sedative drugs used, assess the efficacy of sedative drugs, and determine the incidence of adverse events.

Material and Methods

A prospective, observational cohort study was conducted in the CT scan suite of a tertiary care institute after obtaining approval

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of the Institutional Ethics Committee (NK/3906/Res/2646). The trial was registered under Clinical Trial Registry India (CTRI/2018/02/011687). Sedation for CT scan at the pediatric radiology suite of our institute is provided by anesthetists on one day in a week and by pediatricians on rest of the 5 days. All the children posted for CT under the care of anesthetists from September, 2017 to December, 2017 were included in the study. Patients who were administered sedation by nonanesthetists were not included in the study. There were no other exclusion criteria.

Sedation was administered by a team of trained and qualified anesthesiologists along with an anesthesia technician. An intravenous cannula was placed prior to the procedure in all the patients. Monitoring during the sedation included continuous pulse oximetry and clinical monitoring of respiration and sedation in all the patients. Oxygen supplementation was done continuously during the entire procedure. A parent/guardian wearing a lead apron was present with the child during the procedure. The anesthesia team monitored the patient through a transparent glass from the control room.

The following patient-related data were collected: demographic variables, ASA physical status, significant medical history, and physical examination findings. Procedural data included medications administered along with their doses and efficacy, time from administration of sedative to the start of procedure, duration of procedure, and recovery time. The efficacy of sedative drugs was defined as successful conduct of the procedure without requiring repeat scan due to inappropriate sedation. The recovery time was defined as the time from the end of the procedure till the time of return of patients' vital signs and level of consciousness to baseline and their ability to maintain a patent airway.

Adverse events documented included nausea/vomiting; allergic reaction; desaturation (decrease in SpO2 by ≥10% of baseline for ≥30 s), upper airway obstruction, laryngospasm, pulmonary aspiration, and respiratory arrest; prolonged discharge time (hospital stay over 4 h after imaging) or need for hospital admission; and cardiac arrest or death.

The categorical data was expressed as numbers (%), ordinal data as median (IQR), and continuous data as mean ± standard deviation.

Results

A total of 1410 children were registered for CT scan during the study period, of which 331 (24%) children were enrolled for sedation by the anesthesia team. Of these, 264 (74%) children underwent CT scan on the scheduled date, whereas in 68 (26%) children, the procedure was postponed. The reasons for postponement included inadequate fasting (38), active upper respiratory tract infection (20), nonavailability of the results of renal function tests, required for contrast-enhanced scans as per the protocol of the Department of Radiology (6), unexplained skin rash (the children were referred to a dermatologist) (2), and stridor needing further evaluation as well as arrangement for hospital admission (2).

Table 1 shows the demographic characteristics of the children. A large number of ASA II and III children were included. The duration of fasting was found to be prolonged in children of all age groups. Most children (75%) underwent preanesthesia check-up (PAC) on the morning of procedure, while some (25%) were evaluated at the PAC clinic prior to the proposed date of the procedure. Fifty-two (20%) children had congenital heart disease with low baseline room air saturation and 6 (2%) children were found to have wheeze/bronchospasm during preprocedural evaluation. Out of the 263 procedures performed, 143 (54%) were contrast-enhanced scans and 120 (46%) were noncontrast scans. Table 2 shows the procedure distribution according to the body area scanned. Two noncontrast CT head scans were performed in the lateral decubitus position owing to large lumbosacral meningomyelocele masses, and the rest of the procedures were done in the supine position.

Table 1: Demographic characteristics and duration of fasting of the studied children

Characteristics	Values (number (%), mean±SD or median (IQR))
Age group:	
Neonates (1 d-1 m)	5 (2)
1 m-1 y	82 (31)
1 y-14 y	176 (67)
Gender: Male/Female	168 (64)/95 (36)
Weight (kg)	11.4±6.6
ASA physical status: I/II/III	178 (68)/83 (32)/2 (1)
Fasting period (hours)	
Neonates	7.0 (5.5-9.5)
1 m-1 y	6.3 (4.0-18.0)
1 y-14 y	12.0 (1.0-17.0)

y: year; m: month; d: day

Table 2: Body area-wise distribution of CT scans

Body area scanned	Number of procedures
Head	123
Chest	85
Orbit, face, and PNS	23
Abdomen and pelvis	23
Chest and abdomen	4
Chest, abdomen, and pelvis	3
Spine	1
Arm	1

CT scan was performed under sedation in 218 (83%) children while it could be done without any sedation in 45 (17%) children. Of those 45, 32 children were cooperative for the procedure, 10 were sleeping at the time of procedure, 2 were not administered sedation as they had received oral contrast prior to the procedure (and were therefore considered full stomach), and the parents of one child did not give consent for IV cannulation. The drugs administered for sedation were propofol, midazolam, and ketamine either single or in combination, at the discretion of the anesthesia consultant. Of the children who received sedation, 47 (22%) children were administered one drug, 159 (60%) received two drugs, and 12 (5%) required a combination of three drugs for successful completion of the procedure [Figure 1]. The median drug doses administered were as follows: propofol 1.0 mg/kg (IQR: 0.9–1.1 mg/kg), midazolam 0.04 mg/kg (IQR: 0.03–0.06 mg/kg), and ketamine 1.0 mg/kg (IQR: 1.0–1.1 mg/kg). None of the children received oral sedatives for the procedure.

The average time interval between administration of sedation to the start of the procedure was 1.8 min (SD: 1.4 min; IQR: 0.4–3.3 min), the duration of procedure was 2.6 min (SD: 1.9 min; IQR: 0.6–4.5 min), and the recovery time was 18.2 min (SD: 11.4 min; IQR: 6.8–29.6 min). The average duration of contrast-enhanced scans was 3.5 min (SD: 2.0 min; IQR: 1.5–5.4 min), whereas noncontrast scans lasted for an average of 1.5 min (SD: 1.1 min; IQR: 0.4–2.5 min).

Fifteen children required repetition of the procedure [Table 3]. Eight out of these repeat scans were contrast-enhanced scans and 7 were noncontrast scans. Nine of the 15 repeat scans were due to movement of the child due to inadequate sedation, resulting in efficacy of sedation as 95.8%. Out of the 15 children requiring repeat scan, 2 children were administered 1 drug for sedation, 4 children received 2 drugs, and 2 children required 3 drugs for successful completion of the procedure. In these children, the average time from administration of sedation to the start of the procedure was 4.1 min (SD: 0.8 min), procedure time was 2.9 min (SD: 1.6 min), and recovery time was 25.0 min (SD: 14.3 min). The duration of repeat scan in these patients was added to the total scan time.

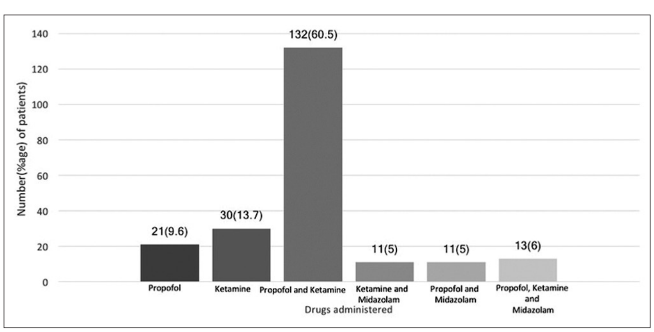

Figure 1: Drugs administered for sedation

Twelve (5.5%) children experienced adverse events during the study period [Table 3]. All the children who experienced desaturation returned to baseline saturation with interventions including: assisted positive pressure ventilation with face mask (*n* = 4), opening the airway using triple maneuver of head tilt, and jaw thrust and mouth opening (*n* = 1) or both (*n* = 1). Opening the airway (*n* = 1) and insertion of Guedel's airway (*n* = 2) successfully relieved the upper airway obstruction. In the two children who experienced nausea and vomiting after the procedure, ondansetron was administered in the dose of 0.1 mg/kg and there were no further episodes of nausea or vomiting. The IV cannula got blocked in a child during contrast injection. It had to be removed and a new one inserted for successful completion of the procedure. None of the adverse events necessitated prolonged postprocedural hospitalization or in permanent neurologic injury or death.

Discussion

The National Institute for Clinical Excellence defines clinical audit as a quality improvement process to achieve improvement in patient care and outcomes. Various aspects of the structure, processes, and outcomes of existing methods of care are systematically evaluated and reviewed against explicit criteria. Thereafter, changes are implemented at an individual, team, or service level and the improvement in healthcare delivery is confirmed by further monitoring.[5]

The present audit was done to evaluate the existing practice of procedural sedation for CT scan in children in our tertiary care center and further quality improvement.

During the study period, around 20% children coming for CT scan arrived full stomach due to which their procedures had to be postponed leading to delay in diagnosis and further medical

Table 3: Adverse events during sedation and reasons for repeat scan

Adverse event	Number (%) of patients
Desaturation	6 (50)
Upper airway obstruction	3 (25)
Nausea and vomiting	2 (17)
Blockage of IV cannula	1 (8)
Reason for repeat scan	**Number (%) of patients**
Motion artifacts due to inadequate sedation	9 (60.0)
Intraprocedural oxygen desaturation	2 (13.3)
Artifacts due to ornaments worn by the child	2 (13.3)
Technical faults in CT scan machine	2 (13.3)

treatment or surgical intervention. This causes unnecessary inconvenience and financial burden for the parents. Delays and cancellations will also impact other patients awaiting imaging procedures, thus reducing the quality of care delivered by the health care infrastructure. In order to improve adherence to the fasting instructions, parents/guardians of the children can be given a pamphlet attached to the CT requisition form stating the detailed NPO instructions in the commonly read/spoken languages. In case of illiterate parents/guardians, the fasting instructions must be clearly explained by the resident doctor or staff at the time of ordering the investigation. Prior communication by telephone or mail may prove to be difficult in our center owing to a large number of patients and the lack of resources and manpower.

On the other extreme, we encountered the problem of prolonged fasting periods among children of all age groups in our study, reaching close to 12 h in children more than 1 year. The risk of aspiration during sedation/anesthesia is rare but can have devastating outcomes. Multiple studies in pediatric patients suggest that the risk of pulmonary aspiration is between 2 and 10 per 10,000.[6] Fasting reduces the risk of aspiration and is required for all patients having elective procedures. However, for preoperative fasting, the child's age, pre-existing medical or surgical condition, and the anticipated time of procedure must be considered. Longer fasting times may be associated with the increased risk of vomiting, dehydration, and hypoglycaemia and decrease the efficacy of medications.[7,8] Shortened fasting times decrease patient anxiety and agitation, may reduce gastric volume content and may even shorten postoperative length of stay.[9] If the procedure is likely to be delayed beyond the scheduled time, the children should be fed clear fluids or an infusion of intravenous fluids must be initiated. There is good evidence that clear liquids can be administered up to 2 h before elective anesthesia or sedation.[9]

In addition, some children failed to undergo the procedure owing to nonavailability of renal function tests, which is a mandatory requirement for all contrast-enhanced CT scans, as per protocols by the radiology department of the institute. Here again prior clear instructions at the time of advising the investigation to the parents could have avoided the postponement of the procedure.

In this study, we observed that guidelines for minimal level of monitoring were not strictly followed. The American Academy of Paediatrics (AAP) guidelines recommend that vital signs, including heart rate, blood pressure, respiratory rate, oxygen saturation, and $ETCO_2$ (end tidal carbon dioxide), must be recorded at least every 5 min in deep sedation and every 10 min in moderate sedation.[2] The use of capnography monitoring during procedural sedation is associated with reduction in respiratory compromise.[10] Nasal cannulae, which deliver oxygen and measure expired carbon dioxide values simultaneously, may prove to be useful.[11] Similar information can be obtained by taping the $ETCO_2$ sampling line on the inner surface of face mask to reach near the nares. Children may routinely pass from the intended level of sedation to a deeper level, necessitating the use of minimal mandatory monitoring in each child.[12,13]

According to AAP guidelines, the practitioner responsible for the treatment of the child and administration of drugs must be skilled in management of apnea, laryngospasm, airway obstruction, suctioning of secretions, provision of CPAP, successful bag and mask ventilation, and endotracheal intubation in case the child progresses to a deeper, unintended level of sedation. In addition to the practitioner, an extra person should be present to monitor vitals and to assist in resuscitation measures if required. At least one practitioner must be skilled in obtaining vascular access in children. In our institute, sedation for CT scan is provided by a senior resident along with a junior trainee, under the supervision of an anesthesia consultant. All the personnel have adequate airway and resuscitation skills and are skilled at obtaining intravascular access.

Most of the patients in our study could be successfully sedated by the administration of one or two drugs; only few patients needed the addition of a third drug for their procedures. When the initial dose of a single sedative drug was too low to achieve successful completion of the procedure, the anesthetist added additional doses of the same drug or a second and/or third drug after consideration of the risk/benefit ratio and the patient's pre-existing medical comorbidities. Some patients did not require sedation as few of them were well fed and asleep, and some older children were explained the procedure prior and cooperated without sedation. In order to ensure safe practice, selection of the fewest number of drugs with the lowest doses and matching of the drug selection to type of procedure is essential. The potential for an adverse outcome like cardiorespiratory depression and airway obstruction may be increased when 2 or more sedative drugs are administered.[14,15]

The selection of sedative drug depends on patient's underlying medical condition, age, and type of procedure. Propofol is a commonly used sedative drug for brief and nonpainful radiological procedures such as CT scan owing to its quick onset of action and rapid, smooth recovery. However, there is a risk of serious adverse events like profound cardiorespiratory depression and loss of protective airway reflexes, making it suitable for use only by persons trained in the airway management and administration of general anesthesia.[16]

Cravero *et al*.[17] presented the largest experience with propofol sedation for children outside of the operating room involving 49,836 sedation/anesthesia procedures from 37 different locations. Serious adverse events were quite rare in procedures within their consortium. However, more minor, but potentially serious, adverse events were not as rare. Hence, the safety of this practice is dependent on a system's ability to manage less serious events. Ketamine is a popular sedative drug for sedation and analgesia for painful procedures because it supports the cardiovascular and respiratory systems while providing well-tolerated and effective sedation, analgesia, and amnesia. Ketamine-induced emergence reactions like hallucinations, delusions, nightmares, and agitation are fewer in children than in adults.[18,19] It is often combined with an anticholinergic for control of secretions and midazolam for prevention of emergence reactions. Midazolam is a potent sedative drug with rapid onset and short duration of action. It provides good anxiolysis and amnesia with minimal cardiorespiratory depression.

Nonpharmacological sedation like sleep deprivation, play therapy, hypnosis, and parental involvement may also be successfully employed for radiological imaging.[20] Play therapy may prove to be particularly useful in cooperative children older than 4 years, anxious children, and in children requiring repeat scans. Psychological preparation of older and cooperative children may reduce the requirement of sedative drugs. Sleep induced by feeding an infant at least 30 min prior to a scan may promote sleep.[21] In a study by Windram *et al*., 20 infants with complex congenital heart defects underwent cardiovascular MRI using a feed-and-sleep technique without the need for sedation.[22] Brief painless procedures may be performed on young babies using other techniques like swaddling (wrapping bands of tight material around an infant's body to restrict movement)[23] and pacifier and sucrose.[24]

In our study, 9 children required a repeat scan due to motion artifacts caused by inadequate sedation. Inadequate sedation leads to poor quality of the scan, wastage of time, administration of multiple drugs or overdosage of drugs increasing the possibility of adverse events; increased recovery times, increased costs from failed procedures, and inconvenience to patients and families in terms of loss of travel and work time; and delayed diagnosis and management. Hence, identifying patients at risk for inadequate or failed sedation may permit use of alternative techniques of sedation or even nonpharmacological means of sedation.

Our study had a few limitations. Due to the small study population and the absence of a control group, no conclusion can be drawn pertaining to the etiology of the adverse events. In addition, an objective assessment of the level of sedation was not done.

The data from this study have proved useful in identifying the problems in the current institutional practices in the CT suite in the form of 1) postponement of the procedure and 2) prolonged as well as inadequate fasting in a large number of children. Lack of prior preanesthetic evaluation in majority of the patients (PAC was done in only 25% patients) contributed to these problems. If prior PAC is done, proper instructions regarding fasting can be given, and adequate laboratory testing can be ensured, thus avoiding cancellation in some of the children. In addition, cooperative children can be identified and psychologically prepared to undergo the procedure without sedation. Another gap in the practice is nonavailability of $ETCO_2$ monitoring during sedation, incorporation of which may prove useful in early detection of airway adverse events.

To conclude, we used propofol, ketamine, and midazolam either single or in combination for sedation during CT scan, and the sedation proved efficacious in majority of the children. The incidence of adverse events was low and the events were minor.

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Conflicts of interest

There are no conflicts of interest.

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