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ORIGINAL ARTICLE

Sedation of Paediatric Patients Undergoing Magnetic Resonance Imaging Examination: A Clinical Audit

WCW Chu, WWM Lam

Department of Diagnostic Radiology and Organ Imaging, Prince of Wales Hospital, Hong Kong

ABSTRACT

Objective: *To evaluate the efficiency and effectiveness of the sedation practice adopted for paediatric patients undergoing magnetic resonance imaging examination in a local hospital in Hong Kong.*

Materials and Methods: *120 consecutive children with a mean age of 3.2 years (range, 13 days to 13 years) undergoing magnetic resonance imaging and requiring sedation were audited. The types and routes of sedative administration were recorded.*

Results: *105 patients (87.5%) were successfully sedated compared with 15 (12.5%) who were not. In the successful sedation group, 68 patients (65%) required the use of only a single agent via the oral, intravenous, or intramuscular route. Thirty six patients (34%) required the use of 2 agents and 1 patient (1%) required the use of 3 agents. Twelve patients (12%) had successful, but delayed, sedation. A total of 82 children were given oral chloral hydrate. Of these, 44 (54%) were successfully sedated with chloral hydrate alone, and a further 29 (35%) were successfully sedated with an additional sedation agent. Over 50% of children younger than 8 years were successfully sedated by chloral hydrate alone.*

Conclusions: *The rate of successful sedation in paediatric patients undergoing magnetic resonance imaging examination was 87.5%. We recommend using chloral hydrate as the first line of sedation for children younger than 8 years.*

Key Words: *Child, Conscious sedation, Magnetic resonance imaging*

INTRODUCTION

MRI has become the imaging modality of choice for many paediatric conditions because it is non-invasive and provides multiplanar, high-contrast images, particularly of the central nervous system (CNS). However, the image quality can be compromised by patient motion and cooperation from young children is difficult. Sedation or general anaesthesia is therefore required.

MRI-compatible general anaesthesia machines and monitors are expensive and might not be available in some MRI centres. This applies to the Prince of Wales Hospital. Sedation of paediatric patients serves as an alternative. However, it is not uncommon for sedation to fail before or during MRI study, resulting in rescheduling of the examination, or delay or prolongation of the scanning time.

The ideal sedation protocol is one that has an easy route of administration, with little or no adverse reactions, and allows for a quick, complete recovery. At the Prince of Wales Hospital, the sedation regimen for each individual patient is determined (and administered) by the referring clinicians/paediatricians, based on their own preference and familiarity with the sedating drugs available.

Sedation is usually required for patients who are aged 5 years or less. Occasionally, older children who are mentally retarded or in an irritated state may require sedation. It is departmental policy for children younger than 6 years to be sedated before they come to the MRI suite. An intravenous (IV) catheter is inserted before the child is sedated so that IV contrast medium or further IV sedating agents may be given if required.

Correspondence: *Dr WCW Chu, Department of Diagnostic Radiology and Organ Imaging, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, Hong Kong.*
Tel: (852) 2632 2270; Fax: (852) 2636 0012;
E-mail: winnie@ruby.med.cuhk.edu.hk

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The aim of this audit was to evaluate the efficiency and effectiveness of the sedation practice in children undergoing MRI examination — usually cranial scanning — and to see whether an efficient and effective sedation protocol could be established for children of different age groups.

MATERIALS AND METHODS

120 consecutive children with a mean age of 3.2 years (range, 13 days to 13 years) who required sedation for MRI examination performed between January 1998 and September 1998 were included in this audit. At the Prince of Wales Hospital, the MRI examination carried out most often on young children is cranial scanning; accordingly, these patients comprised the majority of subjects (91%) in this audit. Of the remainder, 6% underwent MRI examination of the body, 2% examination of the spine, and 1% examination of the extremities. The duration of the MRI examinations ranged from 20 to 46 minutes.

The sedation regimen performance of the patients was assessed with regard to:

- type of sedation and age of the patient
- total number of sedating agents used
- incidence of successful sedation for scanning
- incidence of inadequate sedation resulting in motion artifacts on MRI and whether this precluded an adequate radiological diagnosis
- incidence of prolonged induction of sedation and hence delay in scanning time
- incidence of unsuccessful sedation resulting in re-scheduling of the MRI examination.

Most patients included in this study (90%) did not have a history of previous MRI examination using sedation. Therefore, the sedation difficulty could not be estimated beforehand.

The names of the different types of sedatives used and their routes of administration are summarised in Figure 1. For each patient, this information was recorded on a standard form (Form 1; Figure 2).

The result of the sedation was also entered as one of the following:
(a) unsuccessful — sedation could not be achieved
(b) incomplete — sedation could be attained at the start of the scanning, but the patient either woke up in the middle of the scanning, so that a full set of imaging sequences could not be accomplished, or the sedation was not deep enough, so that the patient made periodic movements during the scanning resulting in image compromise
(c) successful sedation — the patient was fully sedated and the whole MRI examination was completed.
If achieved by the scheduled examination time, the

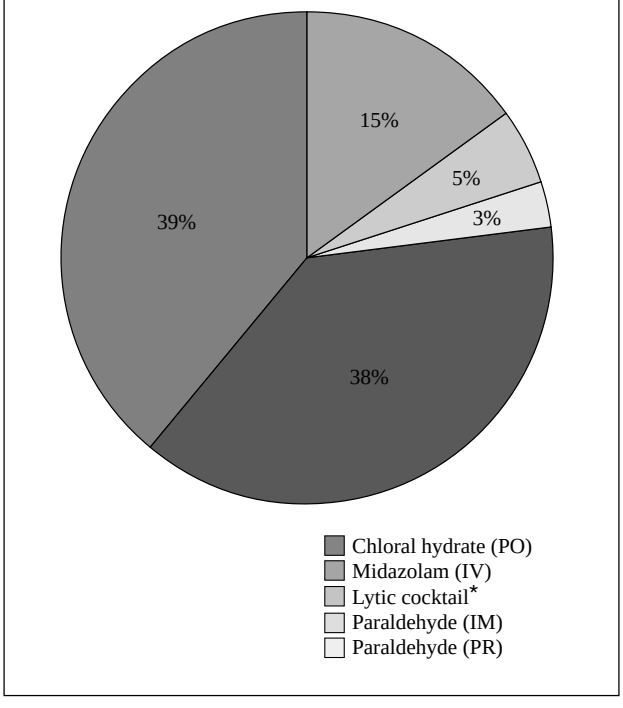

Figure 1. Summary of spectrum of sedating drugs and their routes of administration. *Abbreviations:* PO = oral; IV = intravenous; IM = intramuscular; PR = per rectal.
* Lytic cocktail = pethidine, promethazine, chlorpromazine.

Name of patient: _____

Age/ Sex: _____ PW number: _____

Route of sedation: Drug Dosage
PO ☐
IV ☐
IM ☐
PR ☐

Outcome: a) unsuccessful
b) incomplete sequences completed: _____
c) successful

Scheduled time of scanning: _____

Time of started scanning: _____

Delay: _____(minutes)

Any motion artefacts? ☐ Reporting affected? ☐

Figure 2. Form 1.

Table 1. Number of different types of sedatives used and corresponding successful sedation rates

Number of types of sedatives used	Number of examinations performed	Successful sedation (% of total successful sedation)
1	76	68 (65%)
2	41	36 (34%)
3	3	1 (1%)
Total	120	105

result of the sedation was regarded as successful without delay. If, on the other hand, sedation was achieved, but after the scheduled examination time, the result was regarded as successful, but delayed.

All scans performed were retrieved and assessed for any motion artifact(s). Patients' medical records were also retrieved to document whether repeat scanning was required due to significant motion artifact(s).

RESULTS

The number of different types of sedatives used and the corresponding successful sedation rates are summarised in Table 1. Overall, MRI was carried out in the scheduled sessions for 105 patients (87.5%) patients. For the successfully sedated subgroup, 68 patients (65%) required only a single agent, administered via the oral, IV, or intramuscular (IM) route. A further 36 children (34%) required the use of 2 agents and 1 child required the use of 3 agents (Figure 3).

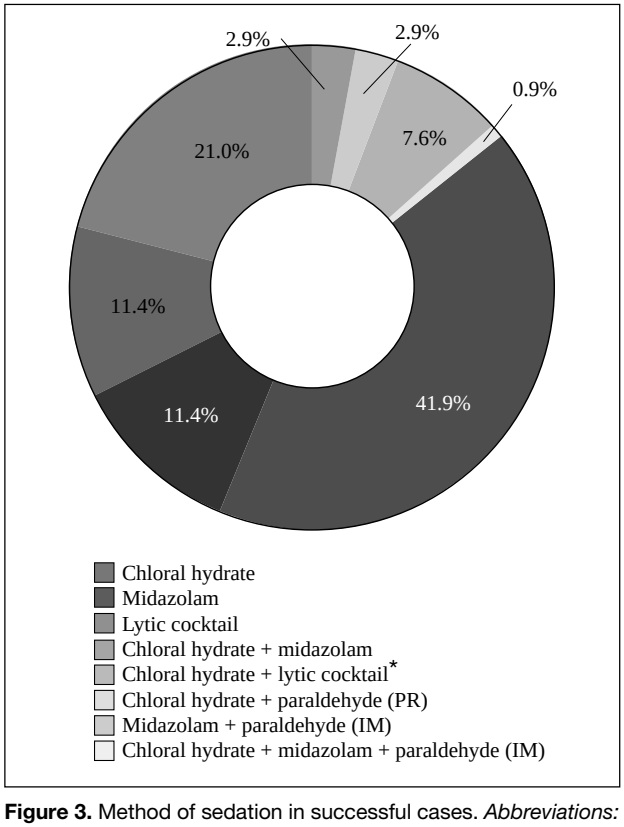

Figure 3. Method of sedation in successful cases. *Abbreviations:* PR = per rectal; IM = intramusclular.
* Lytic cocktail = pethedine, promethazine, chlorpromazine.

Successful sedation was attained for 93 of the 105 patients (89%) according to the scheduled start of scanning. However, 6 patients were incompletely sedated. Four showed intermittent movement during scanning, but repeated scanning was not necessary. Two children woke up before the scanning was completed and prolonged the imaging schedule. For the above 6 patients, 3 were given chloral hydrate only, 1 was given IV midazolam, 1 was given both chloral hydrate and IV midazolam, and one was given IM paraldehyde.

The total scanning time of each examination did not exceed 50 minutes. Twelve of the 105 children (12%) had successful, but delayed, sedation. The age of these patients and the type of sedative(s) used are summarised in Table 2.

Fifteen (12.5%) of the 120 patients were not successfully sedated and required rescheduling of their MRI

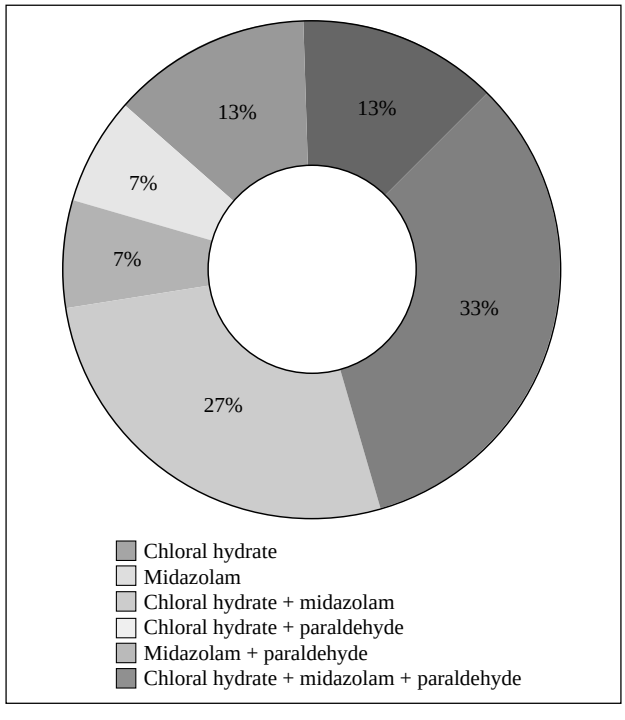

Figure 4. Method of failed sedation.

Table 2. Age and sedating agent(s) for children with successful, but delayed, sedation

Patient's age	Sedating agents (route)
3 months	Chloral hydrate (PO)
1 year	Lytic cocktail* (IM)
1 year	Midazolam (IV) + lytic cocktail (IM)
1 year	Chloral hydrate (PO) + midazolam (IV)
2 years	Midazolam (IV) + paraldehyde (IM)
2 years	Chloral hydrate (PO) + midazolam (IV) + paraldehyde (IM)
3 years	Chloral hydrate (PO)
3 years	Midazolam (IV)
3 years	Chloral hydrate (PO)
3 years	Chloral hydrate (PO) + paraldehyde (PR)
3 years	Chloral hydrate (PO)
5 years	Midazolam (IV)

Abbreviations: PO = oral, IM = intramuscular; IV = intravenous; PR = per rectal.
* Lytic cocktail = pethidine, promethazine, chlorpromazine.

examination. The types of sedative(s) that resulted in failed sedation are shown in Figure 4. In addition, the type of sedative(s) used in relation to 2 different age groups (children older or younger than 2 years of age) in the unsuccessfully sedated group are summarised in Table 3.

The percentages of successful and unsuccessful sedations for all the sedation regimens used are summarised in Table 4. The most commonly used sedative was chloral hydrate. This agent was given to 82 patients, of whom 49 received chloral hydrate alone, and 33 received an additional sedation agent. Of the 49 children given only chloral hydrate, 44 (90%) achieved successful sedation (Table 4). Over 50% of children up to 8 years of age were successfully sedated using chloral hydrate alone (Table 5). Of the 38 children who could not be sedated by chloral hydrate alone, 5 did not receive an additional sedation agent. In the remaining 33 patients, sedation was accomplished with an additional drug for 29 patients, while 4 patients could not be sedated despite further sedation attempts. The age distribution for successful or failed sedation with chloral hydrate is summarised in Table 5 and Figure 5.

DISCUSSION

Radiologists, paediatricians, and anaesthesiologists have been working closely together to develop guidelines for paediatric sedation, with the aim of improving the efficiency and safety of sedating children for diagnostic procedures, particularly MRI.[1-3]

The ideal sedation drug would allow optimal imaging with minimal side effects. Chloral hydrate remains a popular drug for the sedation of children; this agent has a reportedly high success rate.[4-6] In this audit, 82

Table 3. Age and method of sedation for children with failed sedation.

	Children aged < 2 years (n = 8)	Children aged > 2 years (n = 7)	Total number of children (n = 15)
Chloral hydrate only (PO)	2	3	5 (33%)
Chloral hydrate and midazolam (PO + IV)	1	0	1 (7%)
Chloral hydrate and paraldehyde (PO + PR)	0	1	1 (7%)
Midazolam only (IV)	2	2	4 (27%)
Midazolam and paraldehyde (IV + IM)	2	0	2 (13%)
Chloral hydrate + midazolam + paraldehyde (PO + IV + IM)	1	1	2 (13%)

Abbreviations: PO = oral; IM = intramuscular; IV = intravenous; PR = per rectal.

Table 4. Percentage of successful and failed sedations with various sedation regimens.

Sedating agent (route of administration)	Successful (%)	Failed (%)	Number of patients
Chloral hydrate (PO)	44 (90)	5 (10)	49
Midazolam (IV)	12 (75)	4 (25)	16
Lytic cocktail* (IM)	12 (100)	0	12
Chloral hydrate + midazolam (PO + IV)	22 (96)	1 (4)	23
Chloral hydrate + lytic cocktail* (PO + IM)	3 (100)	0	3
Chloral hydrate + paraldehyde (PO + PR)	3 (75)	1 (25)	4
Midazolam + paraldehyde (IV + IM)	8 (80)	2 (20)	10
Chloral hydrate + midazolam + paraldehyde (PO + IV + IM)	1 (33)	2 (67)	3
Total	105 (87.5)	15 (12.5)	120

Abbreviations: PO = oral; IM = intramuscular; IV = intravenous; PR = per rectal.
* Lytic cocktail = pethidine, promethazine, chlorpromazine.

Table 5. Age distribution and incidence of successful and failed sedation for children receiving oral chloral hydrate.

	Children aged ≤ 2 years (n = 43)	Children aged 3 to 5 years (n = 26)	Children aged 6 to 8 years (n = 10)	Children aged > 8 years (n = 3)	Total (n = 82)
Successful sedation	25 (58%)	14 (56%)	5 (50%)	0 (0%)	44 (54%)
Failed sedation	18 (42%)	12 (46%)	5 (50%)	3 (100%)	38 (46%)

children were given chloral hydrate, of whom 44 (54%) were successfully sedated without needing to add another agent. Of the 38 children who could not be successfully sedated with chloral hydrate alone, 29 (76%) were sedated with the addition of another agent. Greenberg et al found chloral hydrate to be less effective for children older than 2 years.[7] In our audit, chloral hydrate seemed to be efficient for over 50% of children up to 8 years old (Figure 5 and Table 5). However, it was true that the age group that was most successfully sedated using chloral hydrate as the sole agent was less than 2 years, with a success rate of 58% (Table 5).

Hubbard et al reported a better success rate for IV sedation in older children undergoing MRI.[6] However, sedation with parenteral barbiturates and opiates is not as safe as sedation with chloral hydrate because of the increased risk of respiratory depression.[8-12] Close monitoring of the child's vital signs is therefore required when these sedatives are used. Allied to this, local constraints mean that it is not possible for an anaesthetist to be available in the MRI suite. Accordingly, the safest drugs are used, i.e. those with a shallower and shorter duration of sedative effect, in daily practice. Chloral hydrate is thus the agent of choice, and the overall success rate (87.5%) is comparable to that of other centres that use this drug as their main sedating agent.[7,8]

In this audit, chloral hydrate had a greater than 50% success rate as the sole sedating agent in the group of children usually required to be sedated according to departmental protocol, i.e. those aged 5 years or less (Figure 5). Only 17 children older than 5 years required sedation, 13 of whom were given chloral hydrate alone. Among children up to the age of 8 years in this small subgroup, the success rate of chloral hydrate as the sole sedating agent was again over 50%. However, chloral hydrate seemed not to be effective for the 3 patients older than 8 years, all of whom had failed sedation (Figure 5).

Based on these findings, and in view of its easy administration and small respiratory depression effect, we recommend that chloral hydrate to be used as the first-line drug for children younger than 8 years. We recommend IV agents and per rectum agents to be used as the second- and third-line agents, respectively, when chloral hydrate fails. In this study, IV midazolam was a good choice as a second-line agent (Table 4).

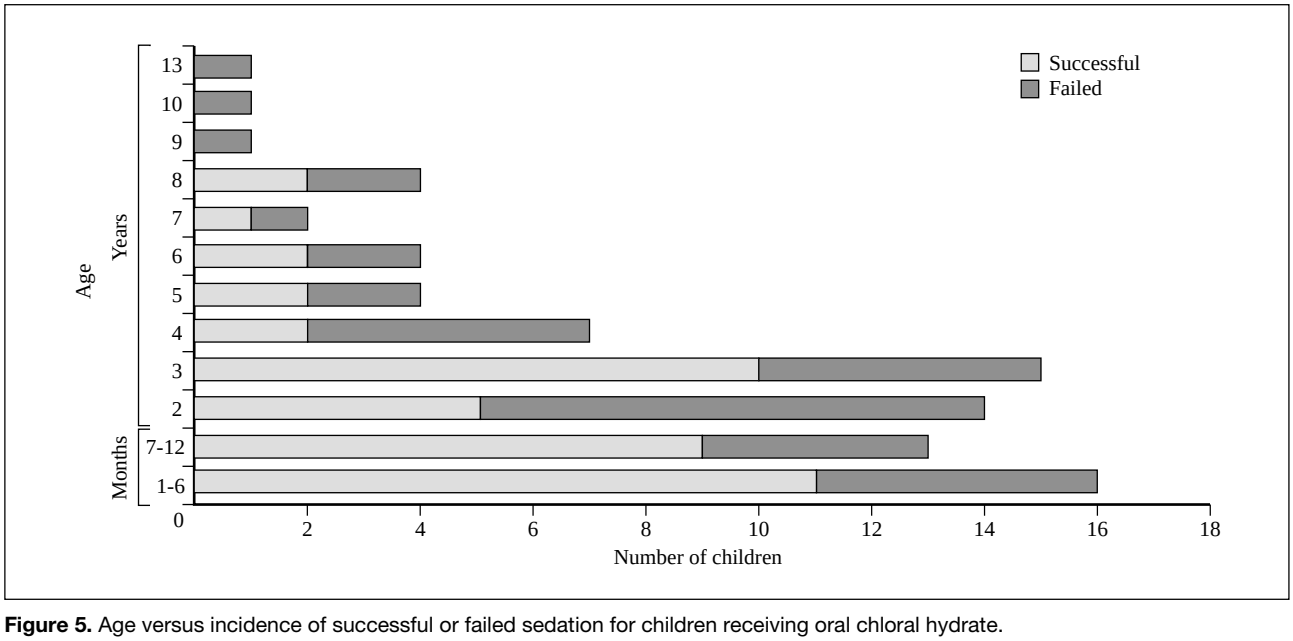

Figure 5. Age versus incidence of successful or failed sedation for children receiving oral chloral hydrate.

Midazolam had a success rate of 75% when used alone and 96% when added to chloral hydrate. Paraldehyde (IV or per rectum) was a suitable choice for a second- or third-line agent. Paralehyde had a success rate of 75% when added to chloral hydrate and 80% when added to IV midazolam if the latter alone failed to achieve adequate sedation.

Despite the apparent effectiveness of IM agents (100% success rate when used alone or in combination with chloral hydrate) in this audit, lytic cocktail (pethidine, promethazine, chlorpromazine) is not included in the guidelines by the Hospital Authority[13] because its dose cannot be easily and individually titrated. It has the further disadvantages of delayed onset and protracted duration of action, as well as a lack of anxiolytic and amnesic properties.

Given the unsatisfactory results with chloral hydrate in these older children, we advocate using an IV drug initially in preference to chloral hydrate for children older than 8 years. In our experience with 7 children who were older than 8 years, IV midazolam alone successfully sedated 2 children, while with the addition of per rectal paraldehyde, 2 more patients were successfully sedated. The remaining 3 children received no more sedation apart from chloral hydrate. The reasons for this were either parental refusal or the patient had an unstable condition meaning that further sedation was not attempted.

We have compared our results with the local sedative guidelines (Table 6) for all radiological procedures. In general, our results do not conflict majorly with the recommended guidelines. However, in the guidelines, chloral hydrate is no longer recommended for children older than 5 years. This is contradictory to the results of this study in which the success rate of chloral hydrate alone in children up to 5 years of age (> 50%) was not greatly different from that in children up to 8 years of age (50%) [Table 5]. We hypothesise that the depth of sedation required for MRI examination is low because it is a non-invasive technique with no pain stimulation. The scanning environment is also kept dark to minimise light stimulation. Furthermore, parents are encouraged to try to keep their child awake and exhausted (energy-wise) before the MRI examination. With this in mind, the first-line use of chloral hydrate might be extended to include children up to the age of 8 years.

In this study, the scanning time of the majority of MRI examinations (90%) was less than 30 minutes. Among the 105 patients who completed the scan after sedation, only 6 had an insufficient duration of sedation resulting in intermittent movement during the scanning or woke up before the scanning was finished. It seemed, therefore, that once the child was successfully sedated, there was little chance (5.7%) of incomplete sedation, provided that the scanning was finished after approximately 30 minutes. In our study, there seemed to be no significant difference regarding the choice of sedative agents and the duration of the sedation effect. This might be explained by the relatively small variation in the duration of the MRI studies, the majority (90%) of which were cranial scans. A drug with a longer duration of sedative effect may be required if a more lengthy MRI examination is performed.

Table 6. Recommended choice of drugs for painless procedures that require immobilisation.[13]

First-line drugs	
Neonates	Chloral hydrate 50 mg/kg (PO)
Children < 5 years	Chloral hydrate 75 mg/kg 30 minutes before the procedure ± a top-up dose of 25 mg/kg for unsuccessful cases
Children > 5 years	Midazolam 0.2 mg/kg (IV), with additional doses of 0.1 mg/kg at 2- to 3-minute intervals up to a maximum of 0.5 mg/kg *Or in children with no pre-existing central nervous system depression* Pentobarbital 2 mg/kg (IV) in 30 seconds, with further doses titrated against sleepiness up to a maximum of 5 mg/kg
Second-line drugs	
Children < 5 years	Midazolam 0.1-0.2 mg/kg (IV), repeat dose of 0.1 mg/kg at 2- to 3-minute intervals up to a maximum of 0.5 mg/kg *Or in children with no pre-existing central nervous system depression* Pentobarbital 2 mg/kg (IV) in 30 seconds, with further doses titrated against sleepiness up to a maximum of 5 mg/kg
Children > 5 years	Paraldehyde 0.3 mL/kg (PR), with equal parts of olive oil or cotton seed oil, administered through a feeding tube within a few minutes
Third-line drugs	
Children < 5 years	Paraldehyde (PR)
Children > 5 years	Ketamine 1 mg/kg (IV), with an additional dose of 1mg/kg if adequate sedation is not achieved

Abbreviations: PO = oral; IV = intravenous; PR = per rectal.

CONCLUSIONS

From our results, we recommend using chloral hydrate as the first-line sedation agent for children up to 8 years old when performing MRI examination. Intravenous or per rectal agents serve as second-line sedation agents. For children older than 8 years of age, IV drugs should be considered as first-line sedation agents.

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