



French survey of sedation practices for pediatric magnetic resonance and computed tomography imaging

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Received: 3 October 2022 / Revised: 15 February 2023 / Accepted: 17 February 2023 / Published online: 18 March 2023
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Abstract

Background Pediatric magnetic resonance imaging (MRI) and computed tomography (CT) require patient immobility and therefore often require sedation or general anesthesia of patients. Consensus on these procedures is lacking in France.

Objective Thus, the aim of this study was to describe the current sedation practices for pediatric MRI and CT in France.

Material and methods From January 2019 to December 2019, an online questionnaire was delivered by electronic mail to a representative radiologist in 60 pediatric radiology centers registered by the French-speaking pediatric and prenatal imaging society. Questions included protocols, drugs used, monitoring and side effects.

Results Representatives of 40 of the 60 (67%) radiology centers responded to the survey. Among them, 31 performed sedation including 17 (55%) centers where radiologists performed sedation without anesthesiologists present during the procedure. The premedication drugs were hydroxyzine ($n=8$, 80%) and melatonin ($n=2$, 20%), Sedation drugs used for children ages 0 to 6 years old were pentobarbital ($n=9$, 60%), midazolam ($n=2$, 13%), chloral hydrate ($n=2$, 13%), diazepam ($n=1$, 6.5%) and chlorpromazine ($n=1$, 6.5%). A written sedation protocol was available in 10/17 (59%) centers. In 6/17 (35%) centers, no monitoring was used during the procedures. Blood pressure monitoring and capnography were rarely used (< 10%) and post-sedation monitoring was heterogeneous. No life-threatening adverse effect was reported, but 6 centers reported at least one incident per year.

Conclusion For half of the responding radiology centers, radiologists performed sedation alone in agreement with the local anesthesiology team. Sedation procedures and monitoring were heterogeneous among centers. Adjustment and harmonization of the practices according to the capacity of each center may be useful.

Keywords Imaging · Monitoring · Pediatric · Safety · Sedation · Side effects

Introduction

Performing computed tomography (CT) or magnetic resonance imaging (MRI) in children is challenging. Depending on the age of the child, control of excessive movement that might compromise image quality and improving the examination experience sometimes require drug-assisted sedation or even general anesthesia. The imaging session can be long, especially for MRI, whereas CT scans are performed within a few seconds with current multidetector CT units [1]. A recent study described the variety of practices in North America for neonatal sedation [2]. In children younger than

6 months, pharmaceutical sedation is usually not required: after being fed and swaddled, the child falls asleep. This practice is especially effective for examinations requiring a short examination time, such as brain CT scans [3], but is also effective for MRI. For children under age 6 years, depending on the CT or MRI examination, several methods exist to produce a calm child without any movement. MRI preparation programs are helpful [4]. For example, a teddy bear MRI mock scanner or movies displayed on a screen have been found beneficial for reducing mobility in children during examinations, thus limiting artifacts [5]. Medical hypnosis in adults has been effective [6]. With current technical improvements, the number and acquisition time of MRI sequences can be decreased, such as with MRI free-breathing sequences, which reduce the need for general anesthesia in neonates and infants [7]. In children, whatever

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the age, radiology teams in France are familiar with limiting sedation and use alternative methods of distraction to achieve immobility in the child: hypnosis, music or video clips displayed on a tablet for CT or an adapted screen for MRI. When these methods are efficient, medical sedation is avoided.

If necessary, to maintain immobility and calmness in children and when all previous “tricks” have failed, a wide range of medical sedation exists, from anxiolytics and moderate to deep sedation to general anesthesia, depending on the pathology and the imaging examination. Sometimes, particularly in children ages 6 months to 6 years, radiologists administer the sedation, owing to the increased need for imaging, the simplicity of the medication used, the lack of availability of anesthesiologists and the possibility of avoiding general anesthesia [8]. Guidelines on sedation and how it must be administered by anesthesiologists exist [9, 10], but only a few recommendations are available for pediatric radiologists. The sedation procedure within each radiology department depends on collaboration with anesthesiologists and pediatricians; the availability of a dedicated room with cradles, dimmed light and reduced activity and ambient noise; and a dedicated team of pediatric radiology technologists and nurses. The variability of these factors might lead to heterogeneity in practice. In response to the variety of sedation protocols, their reported side effects and monitoring requirements, the North American and British radiology societies have provided and updated guidelines [11–13]. Such consensus regarding sedation practices in children from ages 6 months to 6 years for imaging procedures does not exist in France. In children older than 6 years, radiology teams perform CT or MRI without sedation and with methods of distraction.

Before suggesting national guidelines, the aim of this study was to collect information on sedation practices for pediatric MRI or CT via an online survey addressed to a representative cohort of pediatric radiology centers.

Material and methods

This national survey was conducted from October 2018 until December 2019. A survey form was sent by electronic mail to all pediatric radiology centers registered with the French-speaking pediatric and prenatal imaging society (*Société Francophone d’Imagerie Pédiatrique et Prénatale*). These centers could be public hospitals, private centers or medical offices.

The questionnaire was sent in January 2019 and was followed by two mailed reminders at 4 and 8 months, plus a phone reminder to non-respondents. The deadline for the data collection was December 2019.

The questionnaire (appendix) was anonymous and included 30 questions with both short open-ended and closed

answers. These questions concerned the centers’ characteristics and activities, the premedication and sedation used, the possible side effects noted and the presence and type of cardiovascular and respiratory monitoring during sedation (oxygen saturation, blood pressure, pulse and respiratory rates and electrocardiography (ECG)).

Statistical analysis

Data for both quantitative and ordinal qualitative variables are expressed as number and/or percentage. The frequency of side effects reported was extrapolated over one year for each center. We considered the most unfavorable hypothesis to estimate the side effects (i.e. we considered the upper limit of side effects estimated per year as well as the lower limit of the number of examinations performed under sedation per year).

Results

In total, 40 of 60 (67%) centers responded to the survey. Of these, 31 centers (77.5%) performed pediatric CT or MRI with sedation, 17 (55%) with an autonomous radiologist and 14 (45%) with an anesthesiologist present during the entire procedure. Overall, 25 (81%) centers were public hospitals (university, $n = 21$) or regional hospitals ($n = 4$); 4 (13%) were private centers and 2 (6%) were private health care institutions with public contracts.

Concerning the number of scans performed, 16 centres (52%) performed more than 500 CT scans per year while 23 (74%) had more than 500 MRI sessions per year. All but 2 centers had at least one dedicated pediatric radiologist (median = 2). The 2 exceptions had general radiologists.

When sedation was performed by a radiologist, it concerned children under age 6 years in all centers. Depending on the center, 50% to 75% of children were sedated. Beyond the age of 6 years, only a few centers performed sedation as necessary. Among the 17 centers without an anesthesiologist or pediatrician, 10 (59%) had a sedation protocol, including one (5.8%) that used a sedation score. The sedation protocol included premedication with hydroxyzine ($n = 8$, 80%) or melatonin ($n = 2$, 20%), followed or not by sedation. The drugs used for sedation were pentobarbital ($n = 9$, 60%), midazolam ($n = 2$, 13%), chloral hydrate ($n = 2$, 13%), diazepam ($n = 1$, 7%) and chlorpromazine ($n = 1$, 7%).

When sedation was ineffective, the examination was postponed until general anesthesia ($n = 10$, 60%), sedation on other day ($n = 6$, 35%) or a distraction protocol ($n = 1$, 5%) could be attempted.

The rate of side effects reported during sedations performed by radiologists, for all examinations combined,

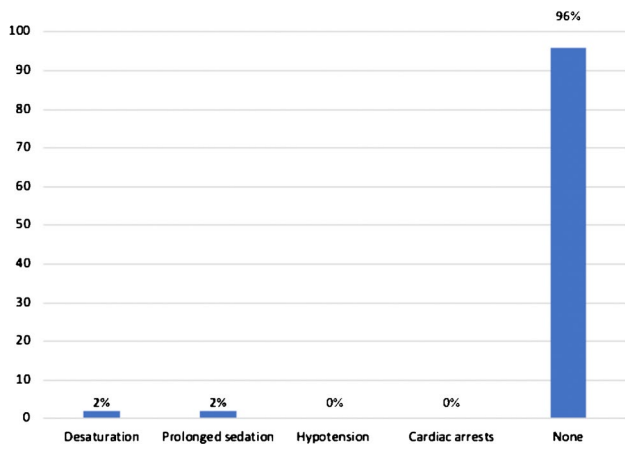


Fig. 1 Percentage of side effects occurring with sedation

was 24 of 444 sedations per year (5.4%). Side effects were reported by 6 centers (Fig. 1): 4 noted transient desaturation, with a frequency of 1 to 2 per year; the drugs involved were pentobarbital and hydroxyzine combined with midazolam. Delayed arousal was reported by 4 centers, with a frequency of 1 to 10 per year; the drugs involved were chloral hydrate, pentobarbital and hydroxyzine associated with premedication with midazolam. No apnea, hypotension or cardiac arrest was reported. There was no dedicated sedation protocol in 14 centers (82%) in which a side effect occurred.

Regarding sedation monitoring during CT and MRI, only 1 center (6%) used ECG, pulse oximeter and capnography. No center used a blood pressure monitor. No monitoring was used in 6 (37%) and 2 centers (12%) for CT and MRI, respectively (Fig. 2). After an imaging examination performed under sedation, monitoring was performed in a Day Hospital in 7 centers (41%), 3 (18%) in a dedicated room near the imaging department, 2 (13%) in a radiology waiting room, 1 (6%) under close supervision in a hospital ward, and 1 (6%) in a post-anesthesia recovery unit. There was no room/facility dedicated to surveillance in 3 centers (16%) (Fig. 3).

Discussion

Focusing on pediatric sedation practices, our survey highlights that in just over a half of the centers that responded, sedation during MRI and CT was performed by radiologists alone in agreement with the local anesthesiologist team, with heterogeneous protocols. In this context, monitoring during sedation was not systematic and the post-sedation monitoring methods were heterogeneous. However, few side effects were reported and none were life-threatening.

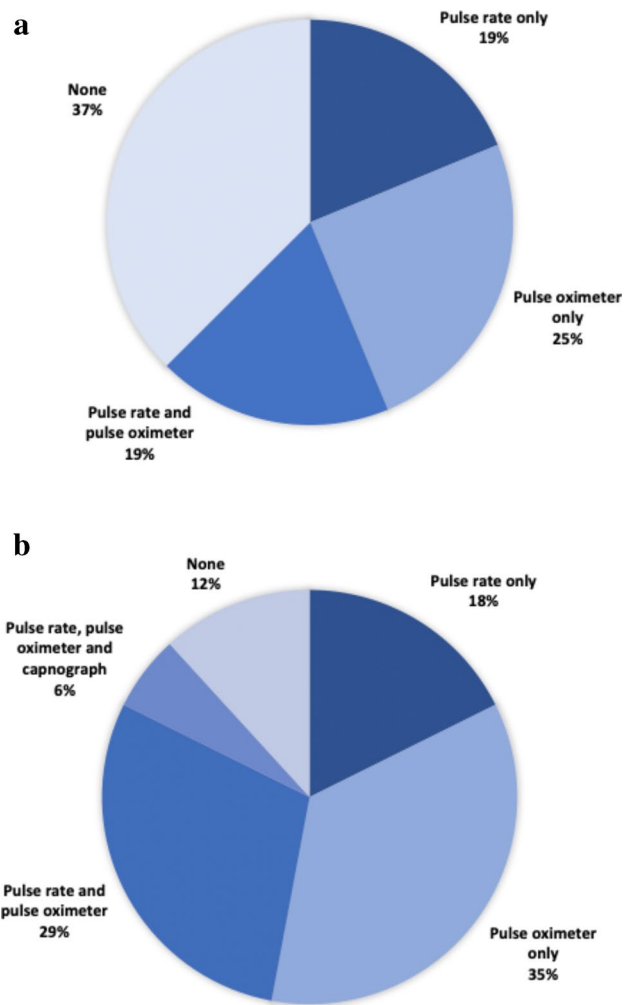


Fig. 2 Percentage of centers monitoring patients while performing computed tomography (a) and magnetic resonance imaging (b)

More than two thirds of centers responded to our survey. This rate of response is acceptable and is the same as for the two latest surveys in French radiology centers (74% and 43% [14, 15]). This survey mostly included public centers familiar with performing a high number of pediatric radiology examinations. It may be that the non-responding centers practiced less sedation and so found this survey less relevant. This study is likely to be representative of the sedation practices in French radiology pediatric centers.

Sedation performed by radiologists alone was a common situation in pediatric radiology centers (about half of the responding centers). This result may have several explanations. First, radiologists are confident in performing sedation for an examination such as CT, which is quick. Reducing general anesthesia might reduce the potential risk of long-term

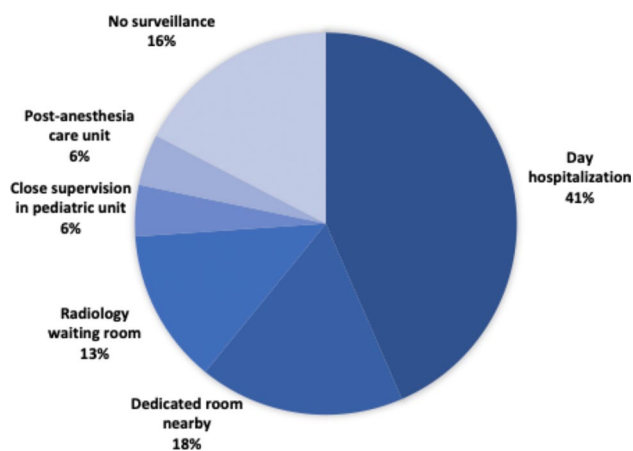


Fig. 3 Location of surveillance after sedation (percentage of centers)

adverse effects in neonates or children under deep sedation [16, 17]. Indeed, the long-term effects of multiple episodes of general anesthesia with or without surgery are still debated [16, 18–20]. The US Food and Drug Administration produced recommendations on the use of sedation and general anesthesia in young children and pregnant women [21]. A second explanation might be the organizational constraints that lead radiologists to practice sedation to compensate for the lack of availability of anesthesiologists. For the same reason, pediatric radiologists are familiar with performing sedation to reduce intestinal intussusception. Rosenfeld et al. reported that in 20% of cases in Great Britain, this sedation was performed by a radiologist [22].

Our study highlights the heterogeneity of drugs used for sedation and local protocols and the need for a national protocol in France. The drugs used in North America [12] are similar to those used in France. Although chloral hydrate was historically used because of its bioavailability and efficiency, its use was discussed and then restricted since 2019 because of a potential mutagenic effect [23, 24]. Midazolam and intra-rectal pentobarbital are preferred because they are more manageable, with short-term effects. All these drugs are respiratory and cardiovascular depressants. In Great Britain and North America, fentanyl or a mix of nitrous oxide and oxygen are used. In France, oral hydroxyzine is a frequent pre-medication to provide light sedation. This drug has few side effects and decreases anxiety while maintaining a good level of consciousness. However, paradoxical excitation may also be observed. Propofol and ketamine are reserved for anesthesiologists because they are considered to induce deep sedation. Such drugs should not be used by radiologists alone.

Guidelines about the titration of sedation and advice about the drugs used and their doses exist in most centers [13, 25]. Recommendations to assess the depth of sedation and how to manage reversal agents such as naloxone or flumazenil are

available in the literature and might be distributed in France to centers that practice sedation in children.

Few side effects and no serious adverse events were reported in our survey, with a rate of reported adverse events of approximately 5.4%. This rate is comparable to those reported in the USA (4.2%) [26]. No deaths have been reported, as in our study.

The low rate of adverse events suggests that sedation was safe in our self-reporting study. The two side effects reported were desaturation and prolonged sedation. Minor side effects might not have been reported, especially in centers using no monitoring.

The fact that most of the side effects occurred in centers with no sedation protocol would suggest that protocol development might improve safety.

Results of this survey indicate that there is scope for improvement in monitoring children during CT and MRI so that it is in full compliance with standards of care reflected in guidelines for sedation [10, 26, 27]. Monitoring is justified because sedation generates cardiovascular and respiratory complications, which need to be detected early for management.

The recommendations for monitoring in general anesthesia are use of ECG, blood pressure monitor and pulse oximeter and recording the sedation score. This monitoring distinguishes both light or moderate sedation from deep sedation. When deep sedation is needed, a capnography monitor is required.

The location for monitoring children after sedation depended on the type of center. The end of procedural stimulation and the pharmacokinetics of drugs used might lead to cardiovascular and respiratory events due to residual sedation. To prevent this, a safe place to monitor the children is necessary. In anesthesiology departments, after general anesthesia, the children are usually monitored in a post-anesthesia recovery unit, where a dedicated nurse checks vital signs and the anesthesiologist signs a monitoring sheet prior to discharge. We suggest that every radiology center monitor child during and after sedation.

To avoid or limit sedation, several alternatives exist to reduce the child's anxiety during CT or MRI. Efforts have been made to better estimate the benefit/risk ratio between cross-sectional imaging and the required sedation [28, 29].

A limitation of our study is its self-reporting design. However, similar studies have also been retrospective and did not focus on sedation practices [10, 26]. To our knowledge, this study is the first to address sedation in pediatric radiology by radiologists in France. An inventory was carried out in countries such as England and the USA [8, 30] and has generated recommendations [11, 13]. We were not able to compare the frequency of side effects depending on whether sedation was performed by anesthesiology teams or by radiologists.

Providing guidelines to improve the safety of pediatric sedation in radiology departments thus leading to homogenous

practices in France would be useful. However, in order not to inconvenience patients – who are not able to travel to reference centers and to ensure equal access to care, it is difficult to define a minimum number of sedations per radiology center, and this remains to be discussed. We hypothesize that radiologists who do not have a sedation protocol will adhere to the recommendations within national protocols to improve the quality of care for children.

Depending on the level of sedation, continuous monitoring (ECG, pulse oximetry, respiratory rate, blood pressure and pain level) should be performed routinely. The use of a single medication (monotherapy) is recommended to facilitate monitoring. Light and moderate sedation might be performed by radiologists for CT and MRI, with general anesthesia reserved for failures or medically complicated situations.

Conclusion

In about half of the responding centers, sedation for pediatric MRI or CT was performed by radiologists alone in agreement with the anesthesiology team. The heterogeneous sedation protocols and monitoring procedures among centers should promote the French radiology and anesthesiology societies to provide consensus recommendations to help pediatric radiologists perform sedation under safe conditions, dependent on local means, imaging modality and indications.

Data Availability The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflicts of interest None

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