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Intra-operative awareness in children: the value of an interview adapted to their cognitive abilities

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ABSTRACT

Intra-operative awareness in paediatric patients has been little studied for many years because of the difficulties in relying on children's testimony. Earlier questionnaires used to detect this complication were not adapted to children's language and memory capacities. By using a qualitative method, a semi-structured in-depth interview adapted to their cognitive abilities, we have now conducted a prospective evaluation of the incidence and risk factors for intra-operative awareness in children undergoing general anaesthesia. Data were obtained from interviews with 410 children (aged 6–16 years) which were conducted within 36 h of general anaesthesia for elective or emergency surgery. One month after surgery, 293 of these patients were interviewed again. Three independent adjudicators classified each potential case of awareness. We considered awareness to include both the 'confirmed awareness' and the 'possible awareness' cases. The accuracy of the children's recall was calculated. The relationship between their awareness and the anaesthesia management was examined. There were five cases of confirmed awareness, and six cases of possible awareness. The incidence of confirmed awareness was 1.2%, but when the possible cases were also considered, the overall incidence of this complication was as high as 2.7% (95% confidence interval, 1.4–5.0%). The only predictive factor identified was the multiple manoeuvres with which the airways were secured (odds ratio, 8.4; 95% confidence interval, 2.4–29.07%). The present study confirms the existence of intra-operative awareness in the paediatric population. The application of a semi-structured in-depth interview adapted to the cognitive capacities of the children appears to enhance the detection of awareness in this population.

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Awareness during general anaesthesia arises when a patient becomes conscious of events that occur during surgery or a similar procedure, and consciously recalls those events. The incidence of this phenomenon in adults undergoing low-risk surgical procedures (elective, non-obstetric and non-cardiac surgery) is 0.1–0.2% [1–3]. However, during some surgical procedures that have been considered to involve a risk of awareness, such as obstetric (1.3%), cardiac (1.5–23%) and traumatic surgery (11–43%), the incidence is higher [4–6]. Adults who experience this complication report auditory, visual and sensory perception, but may also complain about feelings of pain, weakness or paralysis and anxiety [7].

In children, awareness has been investigated relatively sparsely. Three studies performed 19 and 34 years ago furnished conflicting results [8–10]. McKie and Thorp [8] reported an alarming 5% incidence of awareness among 202 school-aged children who underwent elective and emergency surgery (without a standardised anaesthetic technique), whereas Hobbs et al. [9] and Sullivan et al. [10] did not describe any cases of awareness among 120 and 144 children, respectively, who participated in intravenous induction of anaesthesia without volatile agents for maintenance. In a very recent study on 864 children, in which modern techniques were applied for anaesthetic management [11], the incidence of awareness was reported to be 0.8%.

The potential occurrence of intra-operative awareness in children is still understudied. Indeed, the recent reviews devoted to this complication do not mention children [12]. This can be explained by two factors. First, there has been controversy in the literature as to the reliability of children's testimony. Some authors insist that children under the age of 16 should be excluded from surveys on awareness because of the uncertainty of accurate communication [13]. Secondly, no adapted interview has been developed for the detection of awareness in the paediatric population. The previous studies used the Brice interview [14], which was developed to identify awareness in adults. However, this tool is hardly applicable to children as its content is not adapted to their cognitive abilities. Children's episodic memory is still undergoing development and, accordingly, their performance is not comparable to that of adults. Episodic memory is limited by developmental factors such as restricted language skills, reduced source-monitoring capabilities (e.g. differentiation of whether an event happened or was merely suggested, when an event occurred, and who carried out an action) and reduced retrieval strategies. In other words, children are limited in self-conducting a memory search and recalling details of prior experiences and organising those details into a coherent narrative form as implied by the Brice questionnaire [15–17]. Despite identification of a higher incidence of awareness than in adults, this issue was neglected in the former studies on awareness in the paediatric population [11]. Although there are now well-documented methods that have been proven to increase the accuracy of children's recall and to reduce their suggestibility [15], these have been little used in studies on awareness in children.

The primary aim of the present study was to determine the incidence of intra-operative awareness duringgeneral anaesthesia among children aged 6–16 years using a qualitative method adapted to

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children's memory development and language level to enhance the quality of their recall and reduce their suggestibility [15]. Thesecondary aim was to measure the risk factors for awareness in children, currently unknown in the literature.

Methods

PARTICIPANTS

Following approval by the University Hospital Ethics Committee and the provision of written informed consent by the parents, 450 children aged 6–16 years old who were scheduled for general anaesthesia for elective and emergency procedures were included in this study from April 2003 to March 2006. Children who did not have a good command of the French language, or who had some mental impairment and/or psychiatric disorder that might have interfered with the reliability of the interview not included in the study, nor were children admitted for neurosurgery.

RECORDED PARAMETERS

The premedication and the anaesthetic procedure were left to the discretion of the anaesthetist in charge of the child in the operating room. The standard anaesthetic chart employed at our institution was completed with the relevant information about the patient; the type of surgery; the presence and effect of the premedication; the anaesthetic technique, with details on induction and maintenance; the use of tracheal intubation, a laryngeal mask; muscle relaxation; the type of ventilation (spontaneous or mechanical); and any possible technical difficulties that may have occurred. Additionally, we recorded any signs of wakefulness (movements, coughing, sweating, lacrimation, grimaces, opening of the eyes, tachycardia and an increase in blood pressure). The child's pre-operative anxiety was evaluated by the nurses on a 4-point Likert scale, the scores ranging from 0 (no signs of anxiety) to 3 (suggesting a high degree of anxiety).

SEMI-STRUCTURED IN-DEPTH INTERVIEW ADAPTED TO CHILDREN

A qualitative method, a semi-structured in-depth interview, was applied to detect awareness. For several reasons the use of qualitative methodology was considered the most suitable approach for the measurement of awareness. First, awareness relies exclusively on the patient's self-reporting and experience. Only a qualitative approach such as an in-depth interview is able to disclose the full content of a traumatising experience such as awareness, while being specific enough to exclude other causes of perioperative discomfort and stress. Second, the development and use of validated questionnaires with clear psychometric properties is unreliable for the measurement of awareness. This experience is unique and hence cannot be compared to anything else. Moreover, there is no valid criterion or 'gold standard' against which any 'awareness questionnaire' could be validated. Finally, awareness in children cannot be compared with awareness in adults. Perception and its development vary widely with the cognitive development of children. No standardised

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questionnaire would be equally able to capture signs of awareness in a 6-year-old child and a 15-year-old adolescent. For each stage of development a specific questionnaire would need to be developed and validated. For all these reasons, we applied a qualitative measurement method, a semi-structured in-depth interview, based on the Brice interview, and this was used for all the children (Appendix 1). As we had to pay close attention to the specific characteristics of children's cognitive development, the Brice interview, not designed for children, was modified by a group of neuropsychologists. They took into account the predominant issues in the psychological literature to enhance the quality of children's recall and to reduce their suggestibility (adapted syntax and simple vocabulary, introductory questions, respect of the chronology of events, and the use of specific questions rather than general open-ended questions) [15, 18]. Interviewing children with such methodology has proved to enhance the quality of children's recall and to be more reliable than a 'standard' approach [15, 19].

More specifically, the semi-structured in-depth interview was elaborated as follows: Introductory questions about general events that took place before the arrival of the children in the operating room were first used to help them establish the chronology of the events and thus to distinguish between the events that occurred before and those that occurred during the general anaesthesia. Questions that specifically evaluated awareness were hierarchically organised, beginning with general, open-ended questions, and moving on to increasingly specific probes for information not produced in response to the first queries. These specific questions were built around a series of identifiable features that consistently occur during each kind of operation and that might be consciously memorised, such as auditory, visual, tactile and painful sensations. Hence, the child was asked a general open-ended question ('After you fell asleep, do you remember anything that happened during the operation?'), followed by specific yes/no questions ('Did you hear anything during the operation?'). For each positive response reported, the child was asked to describe it in detail ('What did you hear during the operation?'). Finally, before the children were questioned more specifically about other features, they were asked to provide as much information as possible in response to general open-ended questions ('Do you remember any- thing else that happened during the operation?'). Yes/no responses were not accepted if the child could not give specific information about the intra-operative event, as their rate of correct responses is then comparable to the chance level [16]. Furthermore, the interview protocol incorporated simpler vocabulary and syntax (for instance, use of the passive voice, embedded clauses, pronouns, relational terms such as 'more or less', and so on were avoided), short and unambiguous questions, and the insertion of transitional sentences when the interviewer changed from one topic to another. The sequence of the questions respected the normal chronology of the perioperative events, as children have a reduced ability to remember specific events and to organise the details of their experience into a coherent narrative form [17]. The children were also given the possibility of showing what happened during the operation if they could not find a specific word.

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Four qualified and trained psychologists not involved in the anaesthesia management conducted all of the interviews, and adequate time was taken to gain the child's trust. The parents were generally absent during the interview; when they were present, they were asked not to influence their child's response. Two separate interviews were carried out, the first within 36 h of the anaesthesia, when the child was fully awake and comfortable, and the second one month after the surgical procedure. All interviews were recorded so as to allow their re-analysis by the two main investigators (IIC and UL). Every potential case of awareness as suggested by any positive answer to any of the questions was transcribed. The recordings, the transcriptions and the anaesthetic charts relating to the potential cases of awareness were then analysed by an independent end-point adjudication committee of three anaesthesiologists (one experienced in adult and the others in paediatric anaesthesia). These adjudicators did not know how many children were enrolled in the study. After listening to both interviews, they classified each case as 'awareness', 'possible awareness' or 'no awareness'. Confirmed awareness was defined as the unanimous coding of 'awareness', or two adjudicators coding as 'awareness' and the third as 'possible awareness'. Possible awareness was defined as one or more codings of the report as 'awareness' or 'possible awareness' [20].

The accuracy of the children's recall in the early and late interviews was examined by calculating the richness of each element reported by the child on a 3-point Likert scale: 1 point was awarded if the child could only mention a sensation, but without any precision (for example, 'I heard something during the operation'), 2 points were awarded if the child could clarify the sensation (for example, 'I heard voices during the operation'), and 3 points were awarded if the child could provide more details about the sensation (for example, 'I heard the doctor saying ''open your eyes'' during the operation').

STATISTICS

The choice of the sample size was guided by the precision of the standard error defined for the study, 1%. The aim was a 95% confidence interval (95% CI) not larger than 2% from our prevalence estimate. On the basis of previous literature prevalence estimates of 5%, the sample size was estimated at 450 patients.

Before analysis, a number of variables were re-organised. Pre-operative anxiety data were categorised into two groups (scores ranging from 0 to 1 in the first group; and scores ranging from 2 to 3 in the second group). Surgical procedures were divided into nine main categories, depending on the type of surgery (e.g. urology or orthopaedic surgery). Awareness was regarded as a binary variable.

To describe the incidence of awareness, we used frequency tables and proportions in percentage. We determined univariate significant risk factors for awareness using the Chi-squared test, Fisher's exact test (count less than 5) and binary logistic regression. Results were expressed as odds ratio (OR) with 95% CI. For continuous variables with normal distribution, we used Student's *t*-test. A value

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of $p < 0.05$ was taken as statistically significant.

Results

Of the 450 children recruited, 40 were excluded from the final analysis: five parents refused to continue the study, some questionnaires were not completed by three children with undiagnosed cognitive difficulties at the time of recruitment, three children proved not to speak French fluently, five children were too uncomfortable at the time of the interview, three children underwent sedation instead of general anaesthesia, and 21 children recruited before surgery were not interviewed because they had left the hospital too early. In all, 410 children (91.1%) were assessed within 36 h of the procedure, and 293 of them (71.5%) at 30 days. The reason why the late assessment was missed was difficulty in contacting the child and/or parents. The demographic and surgicaldata on the children with or without awareness are presented in Table 1. Comparison of the groups revealed no significant differences.

Table 1 *- Demographic and surgical data.*

	n	Patients without awareness (*n* = 378)	*n*	Patients with confirmed or possible awareness (*n* = 11)	OR	95% CI	*t*-tests, χ^2, logistic regression or Fisher's exact test (p)
Demography							
Age; years		11.1 (2.8)		9.8 (3.3)			0.1
Height; cm		145.8 (17.4)		141.8 (21.8)			0.4
Weight; kg		39.7 (14.6)		38.4 (18.2)			0.7
ASA physical status; %*							
1	235	62.5	7	63.6		Reference	Reference
2–3	141	37.5	4	36.4	0.95	0.2–3.3	0.9
Male/female; %*	(227/151)	60.1/39.9	(9/2)	81.8/18.2	0.3	0.07–1.5	0.2
Surgery							
Duration of anaesthesia; min		103 (73.3)		113.6 (86.9)			0.6
Duration of surgery; min		62.2 (57.9)		55.9 (34)			0.7
Elective/emergency surgery; %*	(360/17)	95.2/4.5	(11/0)	100/0			–**

OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologists. Data are mean (SD), or percentage for non-missing values (*).

***No statistical analysis was possible as no emergency surgery was performed in the awareness group.*

Table 2 *- Assessments of awareness.*

Patient	Adjudicator I	Adjudicator II	Adjudicator III	Final assessment*
1	awareness	possible awareness	awareness	confirmed awareness
2	awareness	possible awareness	awareness	confirmed awareness

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3	awareness	awareness	possible awareness	confirmed awareness
4	awareness	possible awareness	awareness	confirmed awareness
5	awareness	awareness	possible awareness	confirmed awareness
6	possible awareness	possible awareness	awareness	possible awareness
7	awareness	possible awareness	possible awareness	possible awareness
8	possible awareness	possible awareness	awareness	possible awareness
9	awareness	possible awareness	possible awareness	possible awareness
10	possible awareness	awareness	possible awareness	possible awareness
11	possible awareness	awareness	possible awareness	possible awareness

Adjudicator I is an adult anaesthesiologist; while adjudicators II and III are paediatric anaesthesiologists.

**Confirmed awareness is defined as a unanimous coding of 'awareness' or two adjudicators coding 'awareness' and the third 'possible awareness'. Possible awareness is defined as one or more adjudicators coding of the report as 'awareness' or 'possible awareness'.*

Table 3 *- Details of demographic, surgical and general anaesthesia data for children who experienced awareness.*

	Demography						Anaesthesia								
Patient No.	Sex	Age; years	Weight; kg	Height; cm	ASA grade	Surgery	Duration of anaesthesia; min	Premedication	Induction	Maintenance	Nitrous oxide	NMB	LRA	Airways	Intra-operative complication
1	M	8.2	27	132	1	Orthopaedic surgery	95	Midazolam	Propofol	Isoflurane	Yes	Atracurium	None	ETT	None
2	F	10.8	40	152	1	Orthopaedic surgery	70	Midazolam	Propofol	Isoflurane	Yes	None	None	LMA	None
3	M	7.3	31.5	140	1	Orthopaedic surgery	115	Midazolam	Propofol	Isoflurane	Yes	Atracurium	None	ETT	Multiple intubations
4	M	9.5	32	132	1	Facial surgery	120	Midazolam	Propofol	Isoflurane	Yes	Atracurium	None	ETT	Multiple intubations
5	M	7.6	30	?	2	Plastic surgery	90	Midazolam	Propofol	Propofol + isoflurane	Yes	None	Yes	ETT	Multiple intubations
6	M	13.11	61	155	2	Orthopaedic surgery	145	Midazolam	Propofol	Desflurane	Yes	Atracurium	None	ETT	None
7	M	16.1	82.5	195	1	Orthopaedic surgery	90	Midazolam	Propofol	Propofol + isoflurane	Yes	None	None	LMA	Multiple attempts at laryngeal mask airway insertion
8	M	14.11	43	140	2	Orthopaedic >surgery	360	Midazolam	Propofol	Isoflurane	Yes	Atracurium	Yes	ETT	None
9	M	7.3	24	123	2	Urological surgery	55	Midazolam	Sevoflurane	Isoflurane	Yes	None	Yes	LMA	None
10	M	6.11	23.7	121	1	Orthopaedic surgery	50	Midazolam	Sevoflurane	Isoflurane	Yes	None	None	FM	None
11	F	8.10	27.4	128	1	Plastic surgery	60	None	Sevoflurane	Propofol + isoflurane	No	None	Yes	LMA	Multiple intubations

ASA, American Society of Anesthesiologists; ETT, tracheal intubation; FM, facial mask; LRA, locoregional anaesthesia; NMB, neuromuscular block.

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ANAESTHETIC PROCEDURES FOR THE PATIENTS

Most of the children (80%) were given midazolam for premedication, as is the practice in our institution. In 55.6% of the cases, anaesthesia was induced intravenously with propofol, the most frequently used drug; the other patients underwent inhalation induction with sevoflurane. Anaesthesia was primarily maintained with inhalation agents (isoflurane, sevoflurane or desflurane), although approximately 6.1% of the patients received a continuous propofol infusion for maintenance. Nitrous oxide was part of the anaesthesia management in 68% of the children. Neuro- muscular blocking agents (primarily atracurium) were given in 42% of the subjects, and 19% of the children received combined regional and general anaesthesia.

The airways were secured by tracheal intubation in 51% of the patients, with a laryngeal mask in 36% and a face mask in 13% of the patients.

INCIDENCE OF AWARENESS AND INTRA-OPERATIVE PERCEPTION

The main investigators detected 32 potential cases of awareness. The study endpoint committee finally concluded that there were five cases of confirmed awareness and six of possible awareness. Therefore, the incidence of confirmed awareness was 1.2%; however, when the possible cases were also considered, the overall incidence of this complication was as high as 2.7% (95% CI, 1.4– 5.0%). Table 2 presents the assessments of awareness, and Table 3 lists the demographic, surgical and anaesthesia parameters for these 11 children. Table 4 summarises the intra-operative events recalled by the 11 children classified as displaying confirmed or possible awareness, and Table 5 reports the details of the intra-operative sensations, emotions and cognition recalled by the children. Seven patients had auditory perceptions (64%), hearing sounds or voices, and three had visual sensations (27%). All of the children had tactile sensations, which were unpleasant for three of them (27%). Five children had the impression that they had tried to move (45%), while one had felt paralysed (9%), and two children had experienced pain (18%). Four patients had had a feeling of anxiety (36%). Five patients (45%) were aware of the situation, four (36.4%) did not understand their situation during wakefulness, and for two patients (18.2%), it was not very clear if they had an immediate understanding. Among the five patients who were aware of the situation, two (18.2%) had tried to reassure themselves with positive thoughts, and one (9.1%) had negative thoughts.

Table 4 *- Intra-operative recall of children with confirmed or possible awareness.*

Patient N°	Experience
1.	Felt that something was pinching his right elbow and as if someone was taking things out of his arm. Heard people saying that they were going to remove a

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	plate.
2.	Felt something like 'a tube in her mouth' which 'tickled', but felt no pain. This tube 'went as far as the little wall but not in her throat' (laryngeal mask airway). Felt as if she was a 'stone', tried to 'close her mouth', but was unable to. Heard a 'little noise of metal' and 'felt a little bit scared', but was able reassure herself by telling herself that she was at the dentist. Saw 'a big, round and yellow light above her head.'
3.	Felt as if 'someone was moving his arm'. Then felt 'something hard which slid along his right arm'. Heard something like 'strange cracks, as if something was breaking', and which 'came from his arm'. Tried to move, but was unable to. Felt no pain and was not worried.
4.	Felt that he 'was opened up under his right eye and that they cut something'. Felt no pain, but an unpleasant sensation of 'smarting'. Was not anxious.
5.	Felt 'vibrations and tingles' in his left leg. Also felt heat and pain. Tried to move his leg. Was a little anxious.
6.	Felt something which 'came into his throat'. It 'rasped on his throat, and it stayed a moment at the end of his throat'. Felt discomfort and was anxious.
7.	Heard 'a man who asked for tools' and the noise of 'machines moving'. Saw 'a yellow light'. Felt something like a 'duvet on the lower part of his legs', and 'a pressure on both legs from the knee to the foot'. Felt 'three intravenous injections in his right arm' (which was confirmed by the anaesthesia chart). It was 'a little bit painful', it 'burnt'. Felt 'worried' and 'anxious' during the operation and was afraid of feeling pain. Tried to move, but could not. Had the impression that his 'spirit left his body and was above him'.
8.	Heard music (which was confirmed by the surgeon) and the doctor's voice. Saw three big lamps above him. Felt as 'if someone was moving him on the operating table and putting him on his left side' (his position was changed after the induction of anaesthesia in a left lateral position). Felt an injection on his hip (it was probably the puncture in the L4-L5 intervertebral space).
9.	Felt some pain when they opened his groin, felt his blood pulsing and his bone shaking. Thought that 'they would open up his whole leg'. Tried to move but 'could not because he felt too tired'. Heard people talking.
10.	Felt as if his arm was moving and jiggling. Felt no pain and was not worried.
11.	Felt something was placed upon her ears (this child had head phones placed after induction for a study about implicit memory).

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ACCURACY OF AWARENESS

Only one child (patient number 4) had no recall at the first interview but the awareness was detected at the second interview. The accuracy of the recall was comparable in the two interviews (p = 0.09).

ASSOCIATION BETWEEN ANAESTHESIA MANAGEMENT CRITERIA AND INTRA-OPERATIVE AWARENESS

Table 6 reports the rates of pre-operative anxiety, signs of wakefulness and different anaesthesia management criteria in the patients with or without intra-operative awareness. For total intravenous anaesthesia, statistical analysis was not possible as this did not feature in the awareness group. Among all the factors depicted in Table 6, only multiple manoeuvres to secure the airway was significantly associated with awareness. No association was found between the surgical procedure and the occurrence of intra- operative awareness.

Discussion

Through application of a semi-structured in-depth inter- view adapted to children's memory and language capacities, the present study has demonstrated an incidence of confirmed intra-operative awareness of 1.2% among children undergoing general anaesthesia. If we consider the possible cases of awareness, the overall incidence of this complication in children may reach 2.7%. Similarly to adults, the most frequent intra-operative sensations reported by the children were tactile or auditory. Among the risk factors analysed, only multiple manoeuvres to secure the airways was identified as an important risk factor associated with intra-operative awareness.

Table 5 *– Details of the intra-operative sensations, emotions and cognition.*

	Perception						Motor function	Mental reaction				Other phenomena
Patient No.	Auditory	Visual	Tactile	Unpleasant tactile sensation	Felt paralysed	Pain	Tried to move	Immediate understanding	Immediate anxiety	Negative thoughts	Positive thoughts	Decorporation
1	Yes	No	Yes	No	No	No	No	Yes	No	No	Yes	No
2	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	No	Yes	No
3	Yes	No	Yes	No	No	No	Yes	?	No	No	No	No
4	No	No	Yes	Yes	No	No	No	Yes	No	No	No	No
5	Yes	No	Yes	Yes	No	No	Yes	No	Yes	No	No	No
6	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No
7	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	Yes
8	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No
9	Yes	No	Yes	No	No	Yes	Yes	?	No	No	No	No
10	No	No	Yes	No	No	No	No	No	No	No	No	No
11	No	No	Yes	No	No	No	No	No	No	No	No	No

METHODOLOGICAL CONSIDERATIONS

To the best of our knowledge, only four earlier studies had evaluated the incidence of intra-operative awareness in children; three many years previously [8–10], and one very recently [11]. The reported incidence of this complication differed in all those studies. The definitions of awareness, and the

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times and structures of the interviews in those previous studies were so different that any comparison with the results of the present assessment is difficult. McKie and Thorp regarded awareness as 'definite' when the post- operative recall of facts had 'an obvious correlation with events occurring or spoken during the procedure' [8]. In the second and third studies, no clear definition was given [9, 10], whereas in the most recent publication, Davidson et al. [11] categorised the awareness as 'awareness' and 'possible awareness'. It is therefore critical to adopt a universal definition that can be applied in both paediatric and adult studies, to facilitate comparisons between studies and to permit the replication of the results. Further, the scoring of intra-operative awareness is subjective, as the conviction of an awareness experience can vary from one person to another [2, 21]. It is sometimes difficult to distinguish between awareness and the recall of events that occurred during the emergence and the early postoperative period. To avoid any investigator bias, we submitted the potential cases of awareness to the same scoring process as used by Myles et al. [20] In their survey, confirmed awareness was defined when at least two adjudicators coded the recall as 'awareness' and the third as 'possible awareness'. Davidson et al. used a similar adjudication process and defined a 'true awareness' case when four adjudicators rated the case as 'awareness' unanimously [11]. However, as shown in Table 2, the interpretations of the patients' experiences of awareness by the adjudicators can differ appreciably. Moreover, when analysing the descriptions of the cases of awareness published in the various studies [2, 3, 11, 20], readers may form different opinions from those of the authors. Nevertheless, to enhance the quality of the awareness scoring in the present study, we provided the adjudicators with the recordings of the children's recall in the two interviews, whereas in the previous studies, only written summary reports were provided [2, 3, 11, 20]. This last point is an important limitation, as the interviewer has his or her own interpretation of the recall and can introduce bias in a written narrative report.

Table 6 *- Anaesthesia management criteria in patients with or without intra-operative awareness.*

	Patients without awareness (*n* =378)		Patients with confirmed or probable awareness (*n* = 11)				
Factors	n*	%*	n*	%*	OR	95% CI	p value
Pre-operative anxiety							
0–1	294	90.2	6	75.0	Reference	Reference	
2–3	32	9.8	2	25.0	0.8	0.2–3.6	0.8

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Signs of wakefulness	53	17.0	1	10.0	0.5	0.06–4.3	1.0
Premedication	304	80.4	10	90.9	2.4	0.3–19.3	0.6
Myorelaxation	161	42.6	5	45.5	1.1	0.3–3.7	1.0
Tracheal intubation	197	52.1	6	54.5	1.1	0.3–3.67	0.8
Laryngeal mask airway	134	35.5	4	36.4	1.0	0.2–3.6	1.0
Locoregional anaesthesia	71	18.9	4	36.4	2.4	0.7–8.6	0.2
Nitrous oxide	224	67.5	10	90.9	4.8	0.6–38.1	0.1
Intravenous induction	211	55.8	8	72.7	2.1	0.5–8.07	0.3
Multiple manoeuvres to secure airway	34	9	5	45.5	8.4	2.4–29.07	0.002

**Counts and proportions for non-missing values of each characteristic. OR, odds ratio; CI, confidence interval.*

Earlier studies have suggested that an extended follow- up is relevant for the detection of awareness [2, 3, 11, 20]. Many reasons have been advocated in support of the value of a late interview in detecting awareness, such as:

- the enhanced cognitive capacity of a child who has recovered from the potential effects of anaesthetic and analgesic drugs;
- the potential influence of an interview carried out in a stressful environment, such as a hospital, on a child performance by reducing, for instance, the strategic processing (i.e. memory strategies to retrieve information);
- the avoidance of a first interview that could help a child elaborate a more coherent and structured representation of the events that took place during the pre-, intra- and postoperative periods.

Accordingly, authors who conducted only an early postoperative interview failed to detect intra-operative awareness in children [9, 10, 22]. Nevertheless, the present study failed to demonstrate a strong effect of the second interview, as only one of the 11 children was detected at the second interview. It is also necessary to point out the difficulties in conducting a late interview in the everyday practice of anaesthesia, which creates an obstacle to the detection of awareness by clinicians.

Finally, the quality and the structure of the interview are important aspects in the diagnosis of intra-operative awareness, particularly in children. Improvement in explicit memory in childhood depends on a combination of factors [23], such as the development of brain structures involved in explicit memory (the hippocampus formation and its connection with the neocortex), the

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improvement of language capacities, the enhancement of knowledge in many domains, the employment of deliberate memory strategies (such as imposing one's own semantic organisation on material to better memorise it), and the appropriate control of such strategies via meta-memory (the awareness of one's own memory abilities). These developmental factors constitute an important limitation on children's recall and point to the need to use different techniques during an interview to enhance a child performance. It is obvious that the Brice interview is not suitable for the cognitive and language capacities of children. In fact, in a preliminary pilot study conducted to evaluate the adequacy of our questions, we detected some limitation of Brice's questions, particularly when interviewing the youngest children. For instance, the vocabulary was inadequate, as some expressions were misunderstood (e.g. 'before going to sleep' was not always understood and was confused with the postpremedication period), and certain sentences sometimes proved too long and complex (e.g. 'Do you remember anything between going to sleep and waking up?'). Moreover, the chronology of the events was not respected: question 1 evaluated the pre-operative events, question 2 the postoperative events and question 3 went back to the intra-operative events. With such a structure, it was impossible for the children to be appropriately situated in time and to elaborate a coherent representation of the events. Thus, their reports were confused and presented as incoherent response. Finally, the absence of introductive questions and specific questions limited the children's capacity to understand and to retrieve information.

Our interview was based on Brice's questions, taking into account the main issues predominant in the psycho- logical literature to enhance the quality of the children's recall and to reduce their suggestibility (the use of adapted syntax and simple vocabulary, introductive questions, respect of the chronology of events, and by specific questions rather than general open-ended questions). We modified our questions by taking into account the difficulties observed in our preliminary study, so that the youngest children had no difficulty in understanding the queries and making clear a distinction between pre-operative, intra-operative and postoperative events. The use of an interview adapted to children's memory development and language level may explain the difference in the reported incidence.

Unlike the study recently performed by Davidson et al. [11], the present study used more introductory questions with more appropriate details to help the children establish the chronology of pre-operative events and distinguish them from the intra-operative events. We then investigated awareness by asking the child the open- ended question: 'And after you fell asleep, do you remember anything that happened during the operation?' Whatever the response (yes or no), we continued the questionnaire with specific questions (for example: 'Did you hear anything during the operation?'), whereas Davidson et al. [11] stopped their interview when a child responded 'no' to the first open-ended question. It is well known that the ability to remember specific past events and to organise the details of an experience into a coherent narrative form is limited in children [17]. Thus, specific questions should be integrated into the interview as younger children's recall can be

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elicited better when verbal retrieval cues are given. In fact, open-ended questions are more difficult to answer as performance depends on strategic processing, and thus on the children's ability to create their own contextual cues to retrieve the event experienced. In this context, specific questions allow children to complete their memory traces and to generate a more complete representation. In fact, when considering only the affirmative response to the first open-ended question at the first interview, we detected merely two cases of awareness (an incidence of 0.5%). We can assert with confidence that the recalled events in the present study can hardly be regarded as suggestions induced by the interviewers as memories were collected by psychologists not involved in the anaesthesia management; this avoided the use of any misleading questions and any yes responses were rejected when the child could not give specific information about the intra-operative events. Additionally, an identical interview was conducted after one month without taking into account the answers given in the first interview. Finally, unlike the procedure used in the previous studies [8, 11], it is crucial to address the questionnaire directly to the child and not to the parents. It is noteworthy that parents could have difficulties detecting this complication as they can have no clue about the sensations that a person may explicitly recall during general anaesthesia. Further, it is not impossible that parents may either use leading and suggestive questions [11], or trivialise their children's memories.

INTRA-OPERATIVE PERCEPTIONS

As in previous studies on adults [7] and children [11], the most frequent intra-operative sensations reported by the children in our study were tactile or auditory; pain was rare. Four children felt immediate anxiety and only one had negative thoughts during the period of awareness. It should be noted that most of these children were not receiving muscle relaxant drugs. These results contrast with the negative sensations frequently reported by adults, who experience intra-operative awareness and their relation to the use of muscle relaxants [3]. Although we did not search for potential negative consequences of awareness at the second interview, most children seemed not to be affected by this experience. It is possible that adults suffer more psychological sequelae from intra- operative awareness than children, given their greater life experience and their expectations of anaesthesia. How- ever, the absence of early complaints does not guarantee the absence of further psychological sequelae. Lennmarken et al. showed that despite the adequate early management of adults who had experienced intra-operative awareness, 44% presented important psychological sequelae two years after the event [24].

RISK FACTORS FOR INTRA-OPERATIVE AWARENESS

The only predictive factor identified from the anaesthesia management in our study was multiple manoeuvres utilised to secure the airways. Children undergoing multiple manipulations of their airways are at an eight times higher risk of developing awareness. This finding may be attributed to a lighter depth of anaesthesia developing during attempts to secure the airways. Anaesthetists may concentrate more on the airway management and not administer further doses of anaesthetic agents before attempting another manipulation on the airways. Sevoflurane is frequently discontinued during airway manoeuvres so as to avoid pollution, with no top-up intravenous anaesthesia in the event of multiple attempts to secure the airways. Among the other factors analysed in the present study, and unlike what has been reported in adults [2, 3, 12, 25], the use of a muscle relaxant or the absence of nitrous oxide does not seem to influence the occurrence of awareness in children. Nevertheless, this impression may be due to the relatively small number of children who experienced awareness. The higher incidence observed in the present study cannot be attributed exclusively to the specific pharmacokinetic and pharmacodynamic profile of anaesthetic drugs in the paediatric population. Finally, and in contrast with other institutions, we induced anaesthesia directly inside the operating theatre, avoiding any risk of anaesthesia discontinuation while the child was transferred from an induction room, and hence a risk of facilitating awareness. This latter risk may have played a role in the incidence of awareness observed by Davidson et al. [11].

The present study confirms the presence of intra- operative awareness in the paediatric population and reveals the need for a clear definition of the recall of intra-operative events, and the application of adequate methodology for interviewing children to detect this complication. The use of a semi-structured in-depth interview adapted to children's cognitive abilities is mandatory, but it needs to be applied in a large multicentre study to confirm the findings in the present study of a higher incidence of awareness in children than in adults. Multiple manoeuvres to secure airways is a risk factor of awareness in children. A large cohort is also required to identify other risk factors for awareness. Finally, it is essential to carry out a large-scale follow-up to evaluate any psychological consequences following intra-operative awareness.

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Appendix

BRICE QUESTIONNAIRE TO DIAGNOSE AWARENESS IN ADULTS

(1) What was the last thing you remember happening before you went to sleep?

(2) What was the first thing you remember after your operation?

(3) Can you remember anything in between?

SEMI-STRUCTURED IN-DEPTH INTERVIEW ADAPTED TO CHILDREN

Introductory questions

When did you come to the hospital? (if no answer: 'Did you come today?')

When did you have your operation? (if no answer: 'Did you have your operation this morning or this afternoon?')

What did the nurses do with you before your operation? If the child cannot answer, continue with these questions:

- Did the nurses change your clothes before your operation?;
- What else did the nurses do before your operation? (Try to help the child to specify the different facts that occurred at that time in order to help him / her to establish the chronology of the events).

Where did the nurses take you for the operation? (It is important for the child to be able to answer this question in order to help him/her better understand the next queries, and make the distinction between the pre- and intra-operative events).

Questions evaluating the last memories before falling asleep

What happened when you arrived in the operation room?

What did you see in the operation room?

Did the doctor tell you something in the operation room? How did the doctor make you go to

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sleep?/Can you show me how the doctor made you go to sleep?

If the child says 'I don't know' continue with these questions:

- Did the doctor put something on your arm to make you go to sleep?

If the child says 'Yes' ask: What did the doctor put on your arm?

- Did the doctor put something on your face to make you go to sleep?

If the child says 'Yes' ask: What did the doctor put on your face?;

After the child explains how the doctor made him/her go to sleep, use the words used by the child to formulate the next question. For example, if the child said 'The doctor put a mask on my face', ask the child:

- What happened after the doctor put the mask on your face?

Generally the child answers this question: 'I fell asleep'. Note that it is important for the child to give this answer because it helps him/her to make the distinction between the events that occurred before and during the general anaesthesia.

Questions evaluating recall during general anaesthesia

After you fell asleep, do you remember anything that happened during the operation?;

If the child says 'Yes', continue with this question:

- What do you remember?

For each element spontaneously reported by the child, try to obtain as many details as possible, but without suggesting any answer to the child. For example, repeat the child's words in order to enrich his description, but do not lead the child. Ask questions like: 'Can you give me more details?', 'Do you remember anything else that happened during the operation?' and so on.

If the child says 'No', continue with these questions:

- Did you hear anything during the operation?
- Did you see anything during the operation?
- Did you feel anything (on your body) during the operation?
- Did you feel any pain during the operation?
- Did you try to move during the operation?
- Did you think about anything during the operation?

If the child answers 'Yes' to any of these questions, try again to obtain as many details as possible,

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but without suggesting any answer to the child. For example: 'What did you hear/see/feel, during the operation?', 'Show me where you felt something', 'Can you give me more details?', and 'Do you remember anything else that happened during the operation?' Repeat the child's words in order to enrich the description, but do not lead the child, and so on.

Questions evaluating the first memory after recovery

Where were you when you woke up after the operation? What did you see when you woke up?

Do you remember the way from the operating room to the recovery room?