Original article

The effectiveness of a multimodal preoperative anxiety intervention on postanesthetic emergence delirium in preschoolers

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Background: Preoperative anxiety has been reported as one of the major contributors to emergence delirium (ED) in preschoolers.
Objective: This study investigated the effectiveness of multimodal preoperative anxiety intervention (MPreop-AI) in reducing the incidence and severity of ED in preschoolers.
Methods: A prospective study, posttest only nonequivalent groups design, was conducted in 44 children aged 2 - 6 years scheduled for tonsillectomy and/or adenoidectomy under sevoflurane anesthesia. They were equally allocated into two groups. The usual preoperative preparation group (control group) received narrative preoperative education, parental presence, and self-selected toy. The MPreop-AI group received 2-Dimensional (2D) animation modeling-based information, an operating room tour and the self-selected 2D distraction cartoon. Data were collected using the Pediatric Anesthesia Emergence Delirium Scale (PAED scale) for measuring ED.
Results: There was a significant difference in the incidence of ED between the MPreop-AI group and the control group (9.1% *vs.* 54.5%, $P = 0.004$). The percentage of children experiencing severe ED was significantly lower in the MPreop-AI group than in the control group (4.5% *vs.* 45.5%, $P = 0.005$).
Conclusions: The study proposes an innovative intervention for psychological preparation in preschooler prior to surgery in order to reduce emergence delirium. The approach is convenient and attractive to preschoolers and may be used to enhance the quality of care.

Keywords: Emergence delirium, multimodal intervention, postanesthetic, preoperative anxiety, preschoolers.

The incidence of emergence delirium (ED) in children in the postoperative period varies from 20.0 to 80.0%.[1] ED is a condition characterized by perceptual disturbance and psychomotor agitation. Malarbi S, *et al.*[2] found that children with ED aged 18 months to 6 years were more likely to display non-purposefulness, with eyes averted, staring or closed, and non-responsiveness. Other associated behaviors included inconsolable crying, irritability, lack of cooperating, and being unaware of the surroundings.[3, 4] ED usually occurs within 45 minutes after recovery from general anesthesia and lasts for 3 to 45 minutes.[5] Symptoms of ED increased the risk of self-harm, surgical wound dehiscence, and caregiver harm, and ED was associated with a 1.43 times greater risk of maladaptive postoperative symptoms, such as nightmares, separation anxiety, eating disorders, and bedwetting.[6, 7] High levels of preoperative anxiety and elevated ED scores were related to posthospital behavioral changes.[8] Negative behavioral effects were reported in 54.0% of children at two weeks, and the most common symptoms were nightmares, separation anxiety, eating disorders, and heightened dread of physicians. At the 6 - month follow-up, 20.0% of the children continued to exhibit negative behavior changes, with such behavior changes persisting in 7.3% at the 1- year follow-up.[9, 10]

Preoperative anxiety has been reported as one of four major contributors to ED. The four categories are patient-related risk factors, anesthesia-related factors, surgical factors, and preoperative anxiety levels. The experience of ED is common in preschoolers undergoing ear nose throat (ENT) or

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ophthalmologic surgery with sevoflurane anesthetic exposure. [1, 7] Sevoflurane is widely accepted for pediatric surgery because of its rapid uptake and elimination. Although it has become the preferred inhalation-induction anesthetic, it is associated with greater incidence of delirium and agitation than are others, especially when administered to children 1- 6 years old. [11, 12] Moreover, children commonly experience anxiety when faced with the need to undergo surgical procedures; since Getahun AB, *et al*. [13] reported preoperative anxiety in up to 75.4% of children (2 - 12 years old) in the operation room. Higher levels of preoperative anxiety were associated with an increased risk of emerging delirium, which was more prevalent in younger children.[6, 14] This suggests that ED may have a behavioral and cognitive maturity component.[11]

Non-pharmacological approaches have demonstrated that providing age-appropriate information prior to surgical operations reduces pre-operative anxiety in children.[15] Over the decades, education programs intended to reduce anxiety in children have progressed from orientation tours and narrative material to more complicated preoperative programs that incorporate role-play and the teaching of coping skills.[16] In recent years, the efficacy of digital intervention programs and technology-based therapy has gained increasing attention in pediatric research as convenient and attractive to preschoolers. A systematic study by Kim J, *et al*.[17] supported the use of interactive tablets and handheld devices as a viable option to decrease children's preoperative anxiety. Two - dimensional (2D) animation is an effective medium for conveying information to and distracting young children from surgical anxiety. Kain ZN, *et al*.[18] showed that 2D audiovisual intervention with procedural information allowed children (2 to 10 years of age) to cope with the anticipatory threat associated with surgical intervention. Lee J, *et al*. [19] indicated that allowing children 3 to 7 years of age to view 2D animated cartoons during induction of anesthesia effectively alleviated preoperative anxiety. As an edutainment application, 2D animation offers depth in the x- and y-axes, with cartoon-like and appealing colors that stimulate motivation and imagination, and it is less expensive to develop. [20] A lot of information can be transferred by using moving images because the eye-brain assembles a sequence of images and interprets them as a continuous movement. [21] Children can learn more effectively by combining animation and narrative rather than just narration. [22] Furthermore, preschoolers tend to have a short interest in a subject but when they have focus, it takes less time to recognize and understand.As children's attention spans are substantially shorter than adults. A child's greatest attention span is roughly 2 to 3 times his age, thus a preschooler would have a maximum attention span of 18 minutes at most.[23]

Despite the various evidence-based anxiety reduction approaches, the direct effects of preoperative anxiety interventions on reducing ED in preschoolers remain understudied. Given that ED has been reported most frequently in preschoolers, the use of technology offers a two-in-one advantage of combining preoperative information preparation and distraction in reducing preoperative anxiety, reducing the time required for face-to-face information preparation by staff nurses, and enhancing cooperation during anesthetic induction through distraction. Although the use of digital technology in the preoperative tour was reported to be effective in alleviating preoperative anxiety in children, it did not reduce the incidence and severity of emergence delirium.[24]

This study investigated the effectiveness of multimodal preoperative anxiety intervention (MPreop-AI), a combination of 2D animation and an operating room (OR) - tour, which is an age-appropriate intervention, to deliver information and distraction on the incidence and severity of ED in preschoolers.

Materials and methods

Study design

A prospective study, posttest only nonequivalent groups design was conducted at the Queen Sirikit National Institute of Child Health, Thailand, from June 2019 to March 2021. After the approval of the Institutional Ethical Committee (REC. 109/2562). Written informed consent was acquired from the parents of participating children in accordance with the ethical principles of the Helsinki Declaration.

Subjects

Children aged 2 - 6 years old who were classified as having a physical status of I to II according to the American Society of Anesthesiologists Classification System[25] and were scheduled for tonsillectomy or adenoidectomy or tonsillectomy with adenoidectomy under sevoflurane anesthesia with one parent present in the holding area were eligible for inclusion. Children with developmental delays, neurologic

comorbidities, anxiolytic premedication prior to anesthesia, complications from anesthesia or surgery, or whose parents refused to give informed consent were excluded.

The sample size was calculated using the G*Power 3.1.6 program (Heinrich-Heine-University), based on a relevant study by Zhong Q, *et al*.[26] that showed 21.7% and 73.9% incidence of ED, in the experiment and control groups, respectively. The calculated effect size was 0.494 with a power of 0.80 and an alpha of 0.05. The initial sample calculation, which recommended as 17 in each group, was increased by 30.0% to at least 22 per group. All eligible preschoolers hospitalized for day surgery were allocated to either the control or intervention groups by randomly drawn non-replaceable labels.

Study protocol

The usual preoperative preparation group

The preoperative preparation was carried out in accordance with the protocol of the institution. The control group was given a series of preparation steps. A day before surgery, a nurse anesthetist visited for about 15 minutes and provided narrative information to children and their parents about knowledge and preparation for surgery and anesthesia. On the day of surgery, the children were transported to the holding area with their parents about 30 minutes before the surgical schedule for preparation. They were encouraged to play with self-selected toys. When the child was called to the OR, the parent was separated from the child. The children were allowed to keep playing with their toys while they were transported to the OR for intravenous (IV) anesthetic induction and were accompanied by a nurse anesthetist until they fell asleep.

The MPreop-AI group

The design of MPreop-AI incorporated three effective evidence-based strategies for reducing preoperative anxiety. The components included 2D modeling for preoperative information, an OR tour for environment familiarity, and 2D entertainment cartoons for stressful situational distraction. The intervention group received the preparations as follows. A day before surgery, children in the MPreopAI group and their parents received information-based modeling about the anesthesia and surgical procedure they would experience the next day through a 2D animated cartoon titled "Bye...bye adenoid-tonsil" (Figure 1)

Figure 1. Screen samples of 2D preoperative animation "Bye...bye adenoid-tonsil".

that was about 7 minutes to ensure age relevance for technology-based preoperative preparation. Children also joined an operating theater tour for 10 minutes. On the day of surgery, parents accompanied their children to the holding area and were separated from their children when the OR called. Preschoolers were given a tablet computer containing a choice of five different age-appropriate 2D animated cartoons, which were free downloads of popular children's entertainment in Thai language. They were encouraged to watch the cartoons and continue to watch throughout their journey from the holding area to the OR, and from OR anesthetic induction until they fell asleep. The MPreop-AI had an overall content validity index (CVI) of 0.93. The CVI for the intervention one day before surgery was 0.88 and on the day of surgery was 1.0.

Outcome measures

The Pediatric Anesthesia Emergence Delirium Scale (PAED scale), a standard diagnosis of ED, developed by Sikich N, *et al.*[14] was used to described the ED. The scale denotes the cognitive and psychomotor behavior changes seen in ED. Five parameters are measured: eye contact with the caregiver, purposeful actions, awareness of surroundings, restlessness, and inconsolability. Each parameter is scored on a five-point Likert scale, with the last two parameters being scored in reverse order. The scores were summed up to obtain a total score, with a maximum possible value of 20. To achieve a high sensitivity of 1.0 and a specificity of 0.945 for detecting ED, a threshold score of ≥ 12 was considered a discriminator of the presence or absence of ED.27 score of ≥ 16. PAED scores were assessed continuously every 5 min Severe ED was defined as a PAED by two anesthesia nurse research assistants who were blinded to the groups' allocation (on arrival to the post anesthesia care unit, 5, 10, 15 min, and until the preschoolers were awake and their ED status had been determined). The inter-rater reliability of PAED was 0.82 between the two observers. Preschoolers with ED were referred to an anesthesiologist for pharmacologic treatment at their discretion.

Statistical analysis

Unpaired Student *t* - test and Chi-square tests were used to analyze the demographic variables. An analysis of the differences in the incidence of ED and the episodes of severity was performed by Chi-square with Yates correction as the expected values in any of the cells of the 2 x 2 contingency table were below 5.28 Statistical significance was set at a two-tailed *P* - value < 0.05. Analyses were performed with SPSS version 22 (IBM Corp. released 2013).

Results

The main characteristics of the children in the MPreop-AI and the control groups are shown in Table 1. A total of 44 children participated in this study, with 22 in each group. No significant differences were observed between the MPreop-AI and usual preoperative preparation groups in terms of age, body weight, gender, and time to discharge from Post-Anesthesia Care Unit (PACU) The distributions by surgical field and previous anesthesia experiences in the two groups were similar.

Table 1. Comparison of the demographic characteristics of the subjects between groups.

Variables	Usual preoperative preparation group (n = 22) (%)	MPreop-AI group (n = 22) (%)	*P - value*
Age (year) (mean ± SD)	3.7 ± 1.0	4.2 ± 0.9	0.081
Bodyweight (kg)	15.9 ± 3.1	18.8 ± 4.2	0.013
Gender			
Male	14 (63.6)	15 (68.2)	0.750
Female	8 (36.4)	7 (31.8)	
First-ever GA			
Yes	22 (100.0)	20 (90.9)	
No	0 (0)	2 (9.1)	
Type of surgery			
Tonsillectomy	2 (9.1)	3 (13.6)	
Adenoidectomy	1 (4.5)	0 (0)	
Tonsillectomy with adenoidectomy	19 (86.4)	19 (86.4)	
Time to discharge from PACU*	64.6 ± 7.9	64.8 ± 5.7	0.913

GA = General anesthesia, PACU = Post-Anesthesia Care Unit, SD = standard deviation
*All children remain in the PACU for at least one hour due to the institute's protocol

Comparing the occurrence of ED, 9.1% (n = 2) of the children in the MPreop-AI group exhibited ED or had a PAED score ≥ 12 upon recovering from anesthesia versus 54.5% (n = 12) of children in the control group, $\chi 2_{\text{Yates}} = 8.486$, $P = 0.003$. The results also showed a lower incidence of severe ED or PAED scores ≥ 16 in children in the MPreop-AI group (4.5%, n = 1) compared to those in the control group (45.5%, n = 10), $\chi 2_{\text{Yates}} = 7.758$, $P = 0.005$ (Table 2).

Discussion

The incidence of ED in preschoolers recovering from sevoflurane anesthesia in our investigation ranged from 9.1% to 54.5%. International literature reports incidences of ED ranging between 10.0% and 80.0%, which is supported by our findings.[29] However, when comparing the incidence among the Asian countries within a similar study population, results for the control group in this study differed from those observed in recent research findings, which reported 40.0% in India,[30] 60.0 - 77.3% in Korea,[31 – 32] 67.0% in Japan[33] and 73.9% in China.[26] The high degree of variation seen in the literature was caused by the use of different thresholds for the PAED scale to indicate a diagnosis of ED. Studies with incidences of 60.0 - 73.9% used a low threshold, with a PAED score of ≥ 10 indicating ED, while the study that reported a 40.0% incidence used a high threshold, with a score ≥ 16. We reported the presence of ED at a PAED score ≥ 12 out of 20, which results in higher sensitivity and specificity than does use a score ≥ 10 but still avoids underdiagnoses and undertreatment.

In evaluating the efficacy of MPreop-AI on ED in preschoolers recovering from sevoflurane-based general anesthesia, we found that the MPreop-AI resulted in a significant reduction in ED. Preschoolers in the MPreop-AI group had a six-fold lower incidence of ED and a ten-fold reduction in severe ED incidence compared to the group who received usual care. In our study, the MPreop-AI design was based on multimodal interventions derived from selected evidence-based activities proven to reduce preschoolers' preoperative anxiety. Our findings support Kain ZN, *et al.*[6], who stated that the development of ED was an adverse postoperative phenomenon associated with levels of preoperative anxiety.

As a means of helping children mentally prepare for surgical procedures, the MPreop-AI combined advanced age-appropriate technology with three critical concepts: content knowledge, context familiarity, and stressful situational distraction. A day before the scheduled procedure, preschoolers' knowledge about what would take place was developed through their observation of 2D cartoon animation model-based preoperative procedure and an OR visit with their parents. This affected the children's correct perception and familiarity with the process and operating theater environment in the preoperative period. On the day of surgery, preschoolers were distracted from the stressful situation. They were occupied watching and listening to self-selected 2D animated cartoons during the transfer from the holding area to the OR and from the time of IV anesthetic induction until they fell asleep. This continuity of 2D attractive distraction maximized the anxiety-reduction mechanism by diverting preschoolers from the adverse state of surgery to something relaxing and enjoyable throughout the journey of the preoperative period.

Despite the fact that this study did not evaluate preoperative anxiety, we noticed that the preschooler who received the MPreop-AI had a relaxed posture and did not cry, struggle, resist, or show fear when in the OR.

Table 2. A comparison of the incidence of emergence delirium and the incidence of severe emergence delirium between the groups.

Outcomes	Usual preoperative preparation group (n = 22) (%)	MPreop-AI group (n = 22) (%)	$\chi 2_{\text{Yates}}$	*P - value*
Incidence of emergence delirium*	12 (54.5)	2 (9.1)	8.486	0.004
Incidence of severe emergence delirium**	10 (45.5)	1 (4.5)	7.758	0.005

*PAED ≥ 12 scores and **PAED ≥ 16 scores were utilized to determine outcomes statuses based on post-operative cognitive disturbance and psychomotor behaviors.

Literature on the impact of anxiety intervention on preschoolers' postanesthetic ED was limited. Results from two previous studies evaluating the effects of preoperative uses of portable devices were incongruent. Chu L, *et al*.[34] found that watching a 10-minute cartoon video before general anesthesia combined with premedication (intranasal dexmedetomidine) significantly reduced ED incidence (PAED score ≥ 10) in children aged 3 - 6 years old when compared to the non-premedication group and that none of the children experienced severe ED (PAED score ≥ 15). However, the effectiveness of cartoon videos on ED reduction cannot be separated from the concurrent premedication. In contrast, tablet gaming research indicated that distracted children aged 3 to 6 years playing a game computer while in the holding area were less anxious during anesthetic induction than the control group. However, the incidence of ED following admission to the PACU appeared to be unaffected.[35]

Regarding the impact of OR tours, Zhong Q, *et al*.[26] studied children 3 to 6 years old under sevoflurane anesthesia. They reported that children who received OR tours accompanied by parents present before, during, and after surgery had a lower incidence of ED than those who received only anesthetist visits in the admission wards. However, when an OR tour was combined with 2D animation interventions, our MPreop-AI demonstrated that parental presence or absence had less of an influence on the ED of preschoolers. Previous studies on young children receiving computer-based interactive distractions found no significant difference in children's anxiety when parents were present or absent.[36, 37] In WY, *et al*.[38] reported no difference in ED scores after PACU admission based on parental presence versus parental absence in children 3 to 6 years old who were undergoing general anesthesia for tonsillectomy.

According to the existing literature on the non-pharmacological approach, no single preoperative anxiety activity has been demonstrated a strong influence on reducing the incidence and severity of ED in preschoolers. This study provides empirical data to support a multi-intervention strategy that maximizes better intervention to reduce ED in high-risk preschoolers who received sevoflurane with ENT surgery. The intervention design calls for three components: knowledge of the preoperative process, environmental familiarity, and stressful situational distraction via 2D cartoon animation technology and visits to the OR.

This study's limitations were, first, a focus on an immediate effect on preschoolers under sevoflurane inhalation anesthesia. Second, we had a small sample size based on the effect size from previous research. We proposed a larger group study and a long-term follow-up of behavioral effects in children with ED who received the MPreop-AI. Third, MPreop-AI utilized evidenced-based anxiety reduction activities without the actual comparison of the preoperative anxiety levels between groups. Thus, future assessment of anxiety scores prior to the operation is recommended.

Conclusion

The MPreop-AI elucidates the role of non-pharmacological multimodal intervention in lowering ED in children with significant risk factors, such as preschoolers undergoing tonsillectomy and/or adenoidectomy under sevoflurane anesthesia. A combination of three components is needed to maximize preventative measures with enjoyable alternatives to sedation. Preschoolers' preoperative awareness, OR familiarity, and continuity of distraction from holding area to induction must be incorporated into the design. The benefit of 2D cartoon animation has been recognized as one of the most effective interventions for a preschooler at the operational development stage. The use of educational multimedia as an intervention reduces anxiety associated with surgery admission, preoperative procedures, illness, and potential negative consequences,[39] and enjoyable cartoons are effective in distracting preschoolers from the stressful preoperative situation. Our findings suggest that MPreop-AI with 2D animation tablets should be utilized in clinical practice due to its effectiveness in reducing ED and severe incidence. The 2D animation application is simple to use and may serve as an alternative for staff-provided interventions, potentially lowering hospital costs.

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Conflict of interest statement

Each of the authors has completed an ICMJE disclosure form. None of the authors declare any potential or actual relationship, activity, or interest related to the content of this article.

Data sharing statement

The present review is based on the reference cited. Further details, opinions, and interpretation are available from the corresponding authors on reasonable request.

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