A New Mobile Application to Reduce Anxiety in Pediatric Patients Before Bone Marrow Aspiration Procedures

Pornchanok Wantanakorn, MD, MRes Child Health, a, b Supamas Harintajinda, MD, b Jariya Chuthapisith, MD, MMedSci, b Usanarat Anurathapan, MD, b Prapaporn Rattanatamrong, PhD c

ABSTRACT

OBJECTIVES: Insufficient preparation for children who are undergoing bone marrow aspiration can cause anxiety and negative outcomes. Nonpharmacological therapies have been proven to reduce fear in children who are undergoing painful procedures. We have therefore developed a mobile application to help reduce these patients’ anxiety by providing them with procedural information and coping skills.

METHODS: This single-blinded, randomized controlled trial included 60 patients age 5 to 12 years old who were undergoing bone marrow aspiration procedures in Thailand that were conducted between May 2015 and May 2016. Sixty participants were randomly assigned to the intervention group (mobile application added to usual care) or the control group (usual care only). Preprocedural anxiety levels were evaluated by visual analog scales (child anxiety visual analog scale); this was repeated in the intervention group immediately after patients used the mobile application. On the day of the procedure, the patients’ cooperation levels were assessed by using the modified Yale Preoperative Anxiety Scale. The total amount of sedative drugs that were used was also recorded. The paired t test and the Wilcoxon signed rank test were used to analyze within-person change, whereas the t test and the Wilcoxon rank sum test were used for group comparisons.

RESULTS: The child anxiety visual analog scale score of patients in the intervention group decreased significantly after they used the mobile application (P < .0012). The modified Yale Preoperative Anxiety Scale score of patients in the intervention group was significantly lower than that in the control group (P < .01). There was no difference in sedative use between the 2 groups.

CONCLUSIONS: This mobile application possibly had effectiveness in routine use for reducing anxiety and increasing patients’ cooperation in bone marrow aspiration procedures.
In pediatric medicine, some medical procedures may induce stress, which may affect treatment outcomes.\textsuperscript{1–3} Behaviors such as temper tantrums or aggression, developmental regression, and secondary enuresis often emerge after suboptimal communication and poor patient preparation.\textsuperscript{4–6} This is particularly true for children with chronic illnesses, such as those with cancer, who may be subject to a number of invasive medical procedures during the course of treatment.\textsuperscript{7} Bone marrow aspiration is 1 such highly invasive, traumatic, and painful procedure.

Several nonpharmacological interventions have been proven to be useful in decreasing stress, including the use of distractions (such as cartoons, music, videos, visits by clowns, and play), hypnosis, and cognitive-behavioral therapy.\textsuperscript{8–10} Giving age-appropriate information about invasive procedures and improving patient preparation might be another way to help patients cope with preoperative fear\textsuperscript{17} and improve cooperation, which lessens the potential for complications. However, in a Cochrane review in 2013, the authors found no evidence that preparation and information plus distraction can be psychosupportive against needle-related procedures.\textsuperscript{11} In the world of advancing technology, mobile applications are another possible tool.\textsuperscript{12} For example, Web-Based Tailored Intervention for Preparation of Parents and Children for Outpatient Surgery\textsuperscript{20} and a smartphone application for a preoperative behavioral intervention program\textsuperscript{21} were both effective in reducing preoperative anxiety in pediatric patients. Furthermore, in Thailand, there is a limit to human resources, such as child-life specialists. We therefore developed Children-Friendly Hospital, the first tablet application of which we are aware for pediatric patients who need bone marrow aspiration procedures. It is used to provide medical information and as part of preprocedural preparation.

To the best of our knowledge, there have been no previous studies in Thailand in which nonpharmacological intervention was examined by using a mobile application to reduce anxiety and fear in patients who were undergoing bone marrow aspiration. We developed 3 hypotheses: First, we expected that patients who used this mobile application (intervention group) would have lower preoperative anxiety. Second, we expected patients in the intervention group to cooperate more with the procedure, and finally, we predicted that patients in the intervention group would need a lower overall dosage of sedative drugs.

**METHODS**

**Study Design**

This study was a single-blinded, randomized controlled trial that took place at 2 medical centers in Thailand. All participants were randomly assigned across 2 sites either to an intervention group, which used the mobile application plus received usual care, or the control group, which received usual care only. Usual care involved the pediatric resident and oncological fellow giving the patient information about bone marrow aspiration and covering preparation for postprocedure management in the ward the day before the procedure.

The medical ethics committee of Ramathibodi Hospital, Mahidol University approved this study, and informed consent was obtained from all the participants. The study was conducted according to the Declaration of Helsinki.

**Instrument and Scoring System**

The Children-Friendly Hospital mobile application is an application that is designed for children age 5 to 12 years old who need bone marrow aspiration procedures. It has 2 main parts for patients and health care providers. The patient part provides information about the procedure, including the instrument used and the whole process of bone marrow aspiration from positioning, local anesthesia, and sedation (when patients fall asleep) to postprocedure recovery. This information is provided as a short, animated video with cartoon child patients and doctors who use easy words about the bone marrow aspiration procedure according to the preoperational and concrete operational stage of school-aged children’s cognitive development level.\textsuperscript{21} There is also a game section to help children cope with anxiety. This includes a breathing exercise and a game to match medical instruments. Another part of the patient section is the anxiety visual analog scale (A-VAS), a self-evaluation of anxiety or fear level (Fig 1).

The health care provider section requires a login with a username and password. It contains the modified Yale Preoperative Anxiety Scale (mYPAS) and is used by the third observer to evaluate the patient’s anxiety level and cooperation before the bone marrow aspiration procedure.
A-VAS

A-VAS is a self-report, graphic rating scale that is used to measure subjective feeling or attitude.\textsuperscript{23,24} It is commonly used to assess depression or anxiety levels in patients.\textsuperscript{25} It consists of 6 faces that represent increasing levels of anxiety from none to high (Fig 2). Many studies have revealed its good validity and reliability.\textsuperscript{26–28} This tool has previously been modified into a Thai version and used in many studies.\textsuperscript{29–31}

mYPAS

The mYPAS is a well-known preoperative anxiety assessment tool with good construct validity, concurrent validity, and interrater reliability (Supplemental Table S). It consists of 5 domains (activity, vocalization, emotional expressivity, state of apparent arousal, and use of parents). We had already asked for permission to have it translated into Thai and then back translated by a qualified translator. The mobile application uses an English version with Thai subtitles to reduce any language barriers. The total score was automatically recorded and calculated by the application. The mYPAS score ranges from 23.33 to 100, with higher scores indicating increased anxiety.\textsuperscript{32–34}

Participants

All patients age 5 to 12 years old who were undergoing bone marrow aspiration on the pediatric ward of either medical center between May 2015 and May 2016 were eligible to participate. Children with unstable vital signs, impaired consciousness, or an intellectual disability were excluded (Fig 3).

Patient Enrollment and Study Procedures

Sixty inpatients from 2 medical centers who had already given informed consent were randomly assigned in blocks of 4 into 2 groups (30 participants in each group): the intervention group (usual care plus the mobile application) and the control group (usual care). Neither the participants nor the nurse who was acting as the third observer knew the participants’ groups. Only the researcher who had to use the mobile application had this information.

On the day before the actual procedure, all patients and their parents received routine information about the bone marrow aspiration procedure as usual care. Both groups were asked to self-evaluate their anxiety level using the child anxiety visual analog scale (Child-A-VAS) within an hour after being given information by the pediatric resident. They did not receive any other mobile application intervention about the bone marrow aspiration procedure; however, we did not limit their routine tablet use for their enjoyment.

Patients in the intervention group then used the application step-by-step. They started with the cartoon about the procedure then played matching games and practiced the breathing exercise game to reduce anxiety. The researcher ensured that patients only did each task once. The anxiety levels of patients were reevaluated after they had finished all parts of the mobile application immediately or within an hour (postintervention Child-A-VAS).

On the day of the procedure, the health care providers who were acting as the third observers assessed the patients’ anxiety levels and their cooperation using mYPAS. Sedative and anxiolytic drugs (fentanyl, midazolam, and ketamine) were freely selected by the pediatric resident according to hospital guidelines without ordering. The dosage of these drugs was in the same

The results from A-VAS-and mYPAS were recorded automatically into the application’s database.

The development of the mobile application was conducted in 3 phases: planning, production, and evaluation. In the planning phase, the development team studied the characteristics and requirements of the target user group: young pediatric patients. To motivate and attract the attention of young users, the multimedia that were designed for the mobile application incorporate animated cartoon characters along with a relevant story that is easy to understand and gamelike activities that encourage young users to play to reduce their anxiety. The instruction voice and background music were also carefully selected to keep children as calm and comfortable as possible while using the application. The development phase was based on the iterative and incremental model. Prototypes were created to gather feedback from pediatricians and then from that experience to build the real application. For evaluation, usability was tested by 18 children who were developing typically in grades 1 to 6 for the best format before using real patients. Almost all participants were able to understand the procedural content of the mobile application and were able to use the functions available in the application properly. Minor adjustments were made after the evaluation.\textsuperscript{22}
sedative dose range: 1 μg/kg per dose of fentanyl, 0.1 mg/kg per dose of midazolam, and 1 mg/kg per dose of ketamine. The total amount of sedative drugs that were used during the procedure was also recorded.

Statistical Analyses
From the calculated sample size, we need at least 40 patients in each group to detect a 15% difference with 80% power at the 2-sided α level of .05. Baseline characteristics, such as sex, age, diagnosis, and any previous experience of bone marrow aspiration were recorded. Categorical data were described as the number and its percentage. Mean ± SD with 95% confidence interval (CI) or median with interquartile range (IQR) were used for describing normally and nonnormally distributed continuous data, respectively. The χ² test was used to compare 2 categorical data sets whereas the Student’s t test or the Wilcoxon rank sum test was used to compare 2 continuous data sets on the basis of their distribution. Either the paired t test or the Wilcoxon signed rank test was used to compare within-person pre- and postintervention anxiety level scores of patients individually. The percentage of change in Child-A-VAS was calculated as [(post-intervention score – pre-intervention score)/pre-intervention score] × 100. All statistical analyses were performed by using SPSS version 17.0 (SPSS Inc, Chicago, IL).

RESULTS
The baseline characteristics of participants are shown in Table 1. The mean age of all participants in both groups was ~9 years old, and 38 children were boys. There was no difference in bone marrow aspiration experience between the control group and the intervention group, with 23 patients across both groups having previous experience.

The children’s baseline A-VAS scores on the day before the actual procedure were 6.70 ± 2.76 (95% CI: 1.29 to 12.11) and 6.56 ± 1.77 (95% CI: 3.09 to 10.03; P = .82) for the intervention group and the control group, respectively. For children in the intervention group, compared with their preintervention anxiety level, their anxiety levels changed immediately after using the mobile application (5.06 ± 2.70 [95% CI: −0.23 to 10.35]; P = .0012) The mean mYPAS score in the intervention group was significantly lower than that in the control group (see Table 2).

In a subgroup analysis, we compared Child-A-VAS scores of patients who were undergoing their first bone marrow aspiration procedure with those of patients with experience. There were no differences in baseline Child-A-VAS scores between patients with experience in the intervention group (n = 9) and in the control group (n = 14; 7.11 ± 2.66 [95% CI: 1.90 to 12.32] vs 5.78 ± 1.67 [95% CI: 2.51 to 9.05]; P = .16).

In the intervention group, there was no difference in the baseline anxiety level (preintervention Child-A-VAS score) between patients who were having the procedure for the first time and patients with experience (6.5 ± 2.85 [95% CI: 0.91 to 12.09] vs 7.11 ± 2.66 [95% CI: 1.90 to 12.32]; P = .60). The mean postintervention Child-A-VAS scores were 5.23 ± 3.11 (95% CI: −0.87 to 11.33) and 4.66 ± 1.41 (95% CI: 1.90 to 7.42) for patients who were having the procedure for the first time and patients with experience, respectively. The median postintervention Child-A-VAS scores were 4 (IQR 2 to 8) in the first-time group versus 4 (IQR 4 to 6) in the
TABLE 1  Patient Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention Group (n = 30)</th>
<th>Control Group (n = 30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean ± SD</td>
<td>9.22 ± 3.43</td>
<td>9.57 ± 5.06</td>
<td>.67</td>
</tr>
<tr>
<td>No. boys, %</td>
<td>63</td>
<td>63</td>
<td>.99</td>
</tr>
<tr>
<td>First-time bone marrow aspiration procedure, %</td>
<td>70</td>
<td>53</td>
<td>.18</td>
</tr>
<tr>
<td>Diagnosis, n</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malignancy (leukemia, lymphoma, neuroblastoma)</td>
<td>17</td>
<td>14</td>
<td>---</td>
</tr>
<tr>
<td>Hematological disease (bone marrow disease: HLH, ITP, AA, or hyperesinophilia)</td>
<td>10</td>
<td>9</td>
<td>---</td>
</tr>
<tr>
<td>Autoimmune disease (JIA or UC)</td>
<td>2</td>
<td>3</td>
<td>---</td>
</tr>
<tr>
<td>Other (prolonged fever or acute flaccid paralysis)</td>
<td>1</td>
<td>4</td>
<td>---</td>
</tr>
</tbody>
</table>

AA, aplastic anemia; HLH, hemophagocytic lymphohistiocytosis; ITP, immune thrombocytopenic purpura; JIA, juvenile idiopathic arthritis; UC, ulcerative colitis; ---, not applicable.

experienced group (P = .72). When comparing pre- and postintervention Child-A-VAS scores in both patients who were having the procedure for the first time and patients with experience, there was a significant decrease in Child-A-VAS scores in both groups. There was also a higher mean percentage of change in Child-A-VAS scores in patients with experience (34%) than in patients who were having the procedure for the first time (20%). The median (IQR) percentage of change in Child-A-VAS scores in the intervention group is shown in Table 3. In the control group, the Child-A-VAS scores for those who were undergoing bone marrow aspiration for the first time were higher than for those with previous experience (7.25 ± 1.61 [95% CI: 4.09 to 10.41] vs 5.78 ± 1.67 [95% CI: 2.51 to 9.05]; P = .020). The mYPAS scores in the intervention group also revealed no differences by level of experience (Table 3).

There were no differences in total sedative drug use between the intervention group and the control group (P = .74) as shown in Table 4.

**DISCUSSION**

As we predicted in the first hypothesis, our results revealed that the Children-Friendly Hospital mobile application may help children who are undergoing invasive medical procedures, such as bone marrow aspiration, to reduce their stress before the procedure. This is consistent with previous studies about using a mobile application to reduce preoperative anxiety in pediatric patients, although mobile applications may vary in the way they present medical information or conduct an intervention (eg, through a game, cartoon, or relaxation technique) and should be appropriate to the developmental level of the children concerned. However, more studies are needed to explain the fear-relief mechanism of those applications. The anxiety levels of parents might also affect their children’s anxiety. Kain et al found that parents play a major role in pediatric patient preoperative preparation and that family-centered care improves perioperative outcomes. Parents who understood what was going on and parental education about medical procedures facilitated preprocedural preparation and eased children’s preprocedural anxiety. Therefore, our mobile application can be used by both children and their parents, especially the animation clip about the bone marrow aspiration procedure. However, the results of parental anxiety was not reported here.

The second hypothesis was that the mobile application could improve patient cooperation during a bone marrow aspiration procedure. The mYPAS scores of patients in the intervention group were significantly lower than those in the control group, which is consistent with previous studies. This suggests that giving patients information combined with the use of distraction techniques, such as games or breathing exercises, was an effective form of preprocedural preparation and reduced patient anxiety during an invasive procedure.

We were also concerned that previous bone marrow aspiration experience might affect patients’ anxiety levels. In our subgroup analysis, we compared baseline Child-A-VAS scores between patients who were having bone marrow aspiration for the first time and those with experience of the procedure. In the intervention group, there was no difference in mean baseline and postintervention anxiety levels between patients who were having the procedure for the first time and patients with

---

**TABLE 2  Patients’ Anxiety and Cooperation Levels in the Intervention Group Compared With Those in the Control Group**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention (n = 30), Mean ± SD (95% CI)</th>
<th>Control (n = 30), Mean ± SD (95% CI)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline Child A-VAS</td>
<td>6.70 ± 2.78 (1.29 to 12.11)</td>
<td>6.56 ± 1.77 (3.09 to 10.03)</td>
<td>.82</td>
</tr>
<tr>
<td>Postintervention Child A-VAS</td>
<td>5.06 ± 2.70 (−0.23 to 10.35)</td>
<td>---</td>
<td>.0012*</td>
</tr>
<tr>
<td>mYPAS</td>
<td>55.37 ± 12.86 (30.16 to 80.58)</td>
<td>63.08 ± 15.05 (37.50 to 88.66)</td>
<td>.01</td>
</tr>
</tbody>
</table>

---, not applicable.

* Within-person P value is used to compare pre- and postintervention Child-A-VAS scores.
experience. Although patients with experience showed a larger mean percentage of change in fear level after the intervention than patients who were having the procedure for the first time, it was not significant. Similar to the mYPAS score, there was no difference between patients who were having the procedure for the first time and patients with experience. It may be that patients’ experiences influence their subsequent attitudes, which depend on the nature of the previous experience, although negative experiences may be partially improved by good preprocedural preparation to reduce anxiety. Additional research with a larger sample size is needed to conclude this issue. To contrast with the control group, patients with experience had significantly lower baseline Child-A-VAS scores than new patients. This may be because of issues with the randomization process, but it may also be that if patients had a previous bad experience because of poor patient preparation or distress during the procedure, they may be more anxious. Patients who have had a previously good experience of the same procedure might be less anxious.

We expected that minimizing patient anxiety and increasing cooperation would result in a lower total sedative drug dosage. We found no significant differences between the intervention group and the control group. Although we used different medication with each patient, the medications were all in the sedative dose range for pediatric patients. This may be difficult to evaluate, partly because of different sedative protocols between hospitals, and synergistic effect should be considered if combination protocol is used. Another possible reason is that there are a number of other factors that affect the requirement for sedatives, including biological factors such as genetic predisposition for individual pain thresholds and the requirement for analgesic drugs. Some studies have revealed that using combination nonpharmacological interventions can decrease doses of sedative drugs. However, another study revealed that both pharmacological and nonpharmacological preparation can reduce preoperative anxiety but that nonpharmacological intervention did not reduce or affect the dosage of sedative drugs when used as a combination.

Our study had some limitations. First, we did not record baseline variables, such as the number of previous bone marrow aspiration procedures, which might influence patients’ levels of anxiety. Second, children’s temperament and social adaptability may also predict levels of anxiety. Children with high levels of emotionality and shyness tend to be more anxious, but we did not assess the children’s temperament. We did not record any patient characteristics, such as age, socioeconomic status, or level of education, because we aimed to use this mobile application with children patients. However, baseline socioeconomic status, education level, and anxiety traits of parents may influence their and their children’s anxiety levels. Third, the sample sizes were small, especially for the subgroup analyses, which made it harder to measure the effect of previous experience on anxiety levels. Researchers of future studies should use larger sample sizes, if possible. Another limitation was that we did not assess patients’ anxiety scores on the day of the procedure, which might reveal persistence of the intervention effect. However, we recorded mYPAS scores as an indirect tool, which implied that if patients’ cooperation improved, their anxiety level might decrease. Lastly, we did not assess the satisfaction of patients and parents with the mobile application, although this is an important part of evaluating its feasibility.

CONCLUSIONS

Children may suffer from preoperative anxiety. Good preoperative preparation, including giving patients and parents information and teaching coping skills using the Children-Friendly Hospital mobile application, might help to lower preprocedural anxiety and increase patient cooperation.

Acknowledgments

We are grateful to all the nurses and pediatric residents on the pediatric wards of Ramathibodi Hospital, Mahidol University and Maharat Nakhon Ratchasima Hospital, Thailand for data collection, all patients for participating in this research, Pongsakorn Atikasawadtrapit, MD for clinical statistic consultation; and Melissa Leffler, MBA (Edanz Group, www.edanzediting.com/ac), for editing a draft of this article.
REFERENCES


---


---

WANTANAKORN et al
A New Mobile Application to Reduce Anxiety in Pediatric Patients Before Bone Marrow Aspiration Procedures

Pornchanok Wantanakorn, Supamas Harintajinda, Jariya Chuthapisith, Usanarat Anurathapan and Prapaporn Rattanatamrong

Hospital Pediatrics 2018;8;643

DOI: 10.1542/hpeds.2018-0073 originally published online September 13, 2018;

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://hosppeds.aappublications.org/content/8/10/643

Data Supplement at: