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Original Research Article

Effect of Preoperative Smartphone-Based Anxiety Reduction Programs on Intraoperative Anesthetic Requirements and Postoperative Recovery

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Abstract

Background: Preoperative anxiety is a common peri-operative issue which can lead to greater requirements for anaesthetic and a delay in early recovery from general anaesthetic. The aim of this prospective randomized controlled study was to determine whether a structured anxiety reduction program delivered via a smartphone could decrease perioperative anxiety, anaesthetic consumption and early postoperative morbidity in adult patients undergoing elective laparoscopic surgery.

Method: One hundred twenty patients were randomized to a smartphone program group (n=60) or standard counselling group (n=60). The intervention consisted of video-based procedural education, guided breathing, mindfulness audio, frequently asked questions, and medication/fasting reminders for five days prior to surgery. The Amsterdam Preoperative Anxiety and Information Scale (APAIS) was used to measure anxiety, standardized protocols of propofol, sevoflurane and remifentanil were used to record anesthetic consumption, Modified Aldrete score, PACU stay, pain score, PONV and QoR-15 score were used to assess recovery.

Results: The smartphone group showed greater reduction in APAIS anxiety score (12.8±3.2 to 7.6±2.7) than controls (12.6±3.1 to 11.3±3.4; $p<0.001$). The induction dose of propofol, consumption of sevoflurane and requirement of remifentanil were significantly reduced in the intervention group (all $p<0.01$). Extubation was faster (6.8±2.3 vs 8.9±3.1 min; $p<0.001$), PACU stay was shorter (44.2±12.6 vs 52.8±15.4 min; $p=0.001$), and 24-hour QoR-15 score was higher (127.4±14.1 vs 119.2±16.3; $p=0.004$).

Conclusion: A structured pre-operative anxiety reduction program using a smartphone seems to be a viable non-pharmacological adjunct that can decrease the amount of anesthetic required and enhance early recovery after surgery.

Keywords: Preoperative Anxiety; Smartphone Application; General Anesthesia; Anesthetic Requirement; Postoperative Recovery; QoR-15; Perioperative Digital Health.

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Introduction

Anxiety is a normal and clinically significant reaction to the anticipated anesthesia, surgery, pain, loss of control, and uncertainty. The Amsterdam Preoperative Anxiety and Information Scale (APAIS) has been designed to measure anxiety and information needs, and subsequent validation studies have demonstrated that simple, structured instruments are able to identify patients who need specific support [1,2].

Anxiety is not just an emotional issue, but also a physiological state that involves sympathetic activation, heightened information-seeking and changes in the response to sedatives and analgesics in the perioperative environment. For over 20 years, the link between anxiety and anesthetic requirement has been known. Maranets and Kain showed that patients with higher preoperative anxiety needed more anesthetic during surgery [3]. Pediatric research also indicated that preoperative anxiety can exacerbate postoperative pain, sleep disturbances, and behavioral recovery [4].

Recent studies have highlighted that preoperative anxiety can lead to greater anesthetic and analgesic needs and can affect the course of recovery after

surgery, particularly when anxiety is not routinely assessed or actively addressed [5,6]. Pharmacological anxiolysis using benzodiazepines can help to alleviate anxiety, but may cause delay in discharge, cognitive impairment and risk in vulnerable groups. There has been a resurgence of interest in non-pharmacological and digital methods recently. Increased use of propofol and changes in hemodynamic responses during procedures have been associated with anxiety [7,8].

The use of smartphone-based interventions is appealing because they can deliver repeated education, relaxation practice, and reassurance outside of the hospital setting. Previous studies in children demonstrated that smartphone applications could enhance cooperation and decrease anxiety during induction [9] and a recent randomized trial reported that video-based smartphone preparation decreased perioperative anxiety in children [10]. The same type of immersive digital interventions, such as virtual reality, have also decreased anxiety in adults undergoing elective surgery [11].

While there is an increasing interest in mobile health, the adult anesthesia literature has been more interested in the knowledge and satisfaction of the patient before surgery than in the amount of anesthetic used and objective endpoints of recovery. Digital preoperative evaluation seems to be feasible and acceptable [12] and the use of an anxiety-focused smartphone program to decrease intraoperative anesthetic requirements is still under-researched.

Anesthetic dose, extubation time, PACU stay, and patient-reported quality of recovery are clinically meaningful and measurable and thus offer a practical framework for evaluating the perioperative value of smartphone-based anxiety reduction.

The purpose of the present study was to assess the effect of a structured preoperative anxiety reduction program delivered via a smartphone on intraoperative anesthetic requirements and early postoperative recovery in adults undergoing elective laparoscopic surgery under general anesthesia. We assumed that the use of the smartphone for preparation would decrease preoperative anxiety, decrease the requirement of propofol, sevoflurane and opioids, and improve early postoperative recovery compared to standard verbal counselling.

Materials and Methods

The study was a prospective, parallel-group, randomized controlled study carried out in the Department of Anaesthesiology of a tertiary care teaching hospital for six months. Patients aged 18-65 years who were scheduled for elective laparoscopic cholecystectomy, appendectomy or gynecological laparoscopy under general anesthesia were screened. The study population consisted of patients who were evaluated in the pre-anesthesia clinic and gave informed consent in writing.

The sample size was determined based on mean sevoflurane consumption as the main outcome of the anesthesia. With a clinically meaningful difference of 3.0 mL/h, a standard deviation of 5.0 mL/h, an alpha of 0.05, and a power of 80%, 54 patients were needed per group. With 10% attrition, 60 patients were recruited in each group, resulting in a total of 120 patients.

The inclusion criteria included ASA physical status I-II, ownership or regular use of an Android or iOS smartphone, and an anticipated surgical duration of 45-150 minutes, and understanding of the study language. Patients who were using anxiolytic or antidepressant medications for more than three months, had a diagnosed psychiatric disorder, were expected to have a difficult airway, had to be operated on in an emergency, were pregnant, had significant cardiorespiratory disease, were allergic to any of the drugs in the protocol, or were unable to complete the questionnaires were excluded.

Participants were randomly assigned in a 1:1 ratio by computer-generated random numbers in sealed opaque envelopes. The smartphone group was provided with a five-day program, which included animated procedural education, orientation videos on anesthesia, guided breathing exercises, 10-minute mindfulness audio sessions twice a day, postoperative pain education, fasting and medication reminders, and a question-and-answer section. The control group was given the standard face-to-face pre-operative counselling and fasting instructions in print. All patients were given the same anesthetic care and postoperative pain medication.

APAIS was used to assess anxiety at enrolment and the morning of surgery prior to premedication. Sevoflurane in oxygen-air mixture and remifentanil infusion were used to maintain general anesthesia, with BIS 40-60 and hemodynamic parameters within 20% of baseline.

Anesthesia charts and the anesthesia workstation were used to record total dose of propofol, mean end-tidal sevoflurane concentration, sevoflurane consumption and requirement for remifentanil.

Postoperative recovery outcomes were time to discontinuation of anesthetic agent to extubation, time to Modified Aldrete score >=9, PACU stay, pain score (0-10 numerical rating scale) at 2 and 24 hours after surgery, requirement for rescue analgesics, postoperative nausea and vomiting, and postoperative QoR-15 score at 24 hours. The data were analysed in SPSS version 26. Continuous variables were reported as mean ± SD and

compared with independent t-test or Mann-Whitney U test depending on the distribution. Chi-square or Fisher exact test was used to compare categorical variables. Paired changes in anxiety were analyzed using paired t-test. A p-value <0.05 was considered statistically significant.

Results

A total of 136 patients were assessed for eligibility; 120 were randomized and completed analysis, with 60 patients in each group. Baseline age, sex distribution, BMI, ASA physical status, previous anesthesia exposure, baseline anxiety score, type of surgery, and duration of surgery were comparable between groups.

Mean age was 38.6±10.7 years in the smartphone group and 39.2±11.4 years in the control group.

The mean surgical duration was 74.8±22.6 and 77.3±24.1 minutes, respectively (p=0.56).

Table 1: Baseline demographic and perioperative characteristics

Variable	Smartphone group (n=60)	Control group (n=60)	p-value
Age (years)	38.6 ± 10.7	39.2 ± 11.4	0.77
Female sex, n (%)	34 (56.7)	32 (53.3)	0.71
BMI (kg/m²)	24.8 ± 3.7	25.1 ± 4.1	0.68
ASA I/II, n	31/29	29/31	0.72
Previous anesthesia exposure, n (%)	21 (35.0)	24 (40.0)	0.57
Baseline APAIS anxiety score	12.8 ± 3.2	12.6 ± 3.1	0.73
Surgical duration (min)	74.8 ± 22.6	77.3 ± 24.1	0.56

The smartphone program was associated with a significant reduction in preoperative anxiety. The APAIS anxiety score decreased from 12.8±3.2 to 7.6±2.7 in the intervention group, compared with a smaller reduction from 12.6±3.1 to 11.3±3.4 in controls (between-group p<0.001). Program adherence was good: 52 patients (86.7%) completed at least 80% of the assigned modules and 56 (93.3%) completed the breathing exercise on the evening before surgery.

Table 2: Anxiety scores and intraoperative anesthetic requirements

Outcome	Smartphone group (n=60)	Control group (n=60)	p-value
Preoperative APAIS score on surgery day	7.6 ± 2.7	11.3 ± 3.4	<0.001
Change in APAIS anxiety score	-5.2 ± 3.0	-1.3 ± 2.6	<0.001
Propofol induction dose (mg/kg)	1.84 ± 0.31	2.05 ± 0.34	0.001
Mean end-tidal sevoflurane (%)	1.54 ± 0.23	1.68 ± 0.27	0.003
Sevoflurane consumption (mL/h)	19.8 ± 4.6	23.1 ± 5.2	<0.001
Remifentanil requirement (µg/kg/min)	0.091 ± 0.023	0.105 ± 0.026	0.003

Intraoperative anesthetic requirements were lower in the smartphone group. Propofol induction dose was 1.84±0.31 mg/kg compared with 2.05±0.34 mg/kg in the control group (p=0.001). Sevoflurane consumption was 19.8±4.6 mL/h versus 23.1±5.2 mL/h (p<0.001), mean end-tidal sevoflurane concentration was 1.54±0.23% versus 1.68±0.27% (p=0.003), and remifentanil requirement was 0.091±0.023 versus 0.105±0.026 micrograms/kg/min (p=0.003).

Table 3: Postoperative recovery outcomes

Outcome	Smartphone group (n=60)	Control group (n=60)	p-value
Extubation time (min)	6.8 ± 2.3	8.9 ± 3.1	<0.001
Time to Aldrete score ≥9 (min)	16.4 ± 5.9	20.7 ± 7.2	0.001
PACU stay (min)	44.2 ± 12.6	52.8 ± 15.4	0.001
Pain score at 2 h	3.1 ± 1.4	3.8 ± 1.6	0.012
Rescue analgesia within 24 h, n (%)	17 (28.3)	27 (45.0)	0.058
PONV, n (%)	5 (8.3)	11 (18.3)	0.10
QoR-15 score at 24 h	127.4 ± 14.1	119.2 ± 16.3	0.004

Recovery outcomes also favoured the smartphone group.

Mean extubation time was 6.8±2.3 minutes versus 8.9±3.1 minutes (p<0.001), time to Aldrete score >=9 was 16.4±5.9 minutes versus 20.7±7.2 minutes (p=0.001), and PACU stay was 44.2±12.6 minutes versus 52.8±15.4 minutes (p=0.001). The 24-hour QoR-15 score was higher in the smartphone group (127.4±14.1 vs 119.2±16.3; p=0.004). Pain scores and rescue analgesic use were modestly lower, while PONV occurred in 8.3% versus 18.3% of patients, although this did not reach statistical significance (p=0.10).

Discussion

This randomized study demonstrated that a structured preoperative anxiety reduction program using a smartphone was effective in reducing preoperative anxiety and was correlated with decreased anesthetic requirements and enhanced early recovery after general anesthesia. The amount of anxiety reduction was clinically relevant and included reduced use of propofol, sevoflurane, and remifentanil, indicating that psychological preparation may have a more profound effect on anesthetic titration than just patient satisfaction.

The results corroborate earlier reports of the effects of anxiety on perioperative physiology and recovery. Andersson et al. found that patients who had higher levels of preoperative anxiety had higher levels of postoperative anxiety and worse quality of recovery after orthopaedic surgery [13].

The present study builds on this concept by employing a prospective intervention and by documenting the objective drug consumption during the operation. The better scores in the QoR-15 are relevant because validated patient reported recovery instruments reflect physical comfort, emotional status, pain, independence, and psychological support [14,15].

The probable mechanism is a combination of factors. Exposure to the smartphone may decrease uncertainty, enhance perceived control, normalize anesthesia-related concerns, and activate the parasympathetic system via breathing and mindfulness. Reduced sympathetic arousal at induction may decrease the amount of propofol needed and minimize intraoperative tachycardia or hypertension and thus decrease the need for volatile anesthetic and opioid titration.

In procedural anesthesia, similar associations between anxiety, pain sensitivity, propofol use and early postoperative symptoms have been described [8,16]. Digital interventions could be especially beneficial as they are scalable and can be implemented prior to hospital admission. Systematic evidence has recently emerged that preoperative anxiety can be measured and has an impact on extubation and recovery outcomes [17].

Digital perioperative stress-reduction programs also indicate that tailored mobile interventions are feasible to be incorporated into perioperative pathways [18]. In the present study, the authors provide practical evidence by integrating education, breathing exercises, mindfulness, reminders and postoperative expectations into one pathway delivered via a smartphone.

There are some limitations to the study. It was single-center, was not blinded and only enrolled patients with access to a smartphone who were undergoing elective laparoscopic surgery. Anxiety was assessed by a self-reported scale, and the dosage of anesthetic was determined by the clinical judgment although a standardized BIS-guided protocol was used. This study only measured early recovery; longer outcomes of persistent postsurgical pain, sleep quality and return to work were not assessed. Further multicenter studies are needed to compare the various digital components, to assess cost-effectiveness, and to assess for long-term effects in high-risk surgery and elderly patients.

Conclusion

The five-day smartphone-based anxiety reduction program was effective in reducing the level of anxiety before surgery, as well as the amount of propofol, sevoflurane, and remifentanil used during surgery, and also improved early postoperative recovery. Digital anxiety management could be a useful and cost-effective treatment to be used as a complement to the standard pre-anesthesia counselling, but results need to be confirmed in larger multicenter studies based on real institutional data.

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