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ORIGINAL RESEARCH

Virtual reality for perioperative anxiety treatment in a resource-variable setting: an observational trial

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Background: Most children experience preoperative anxiety. Virtual reality (VR) safely reduces this anxiety in high-resource settings. However, identifying patients with high anxiety requires an efficient affect scale. In settings with variable resources, clinical affect scales have not been validated, and financial constraints have limited VR's anxiolytic use. The primary aim was to determine if an affordable VR headset reduced preoperative anxiety at a resource-limited hospital in Kenya. The secondary aim measured the correlation between a novel clinical anxiety scale and standard scales for identifying anxiety in this setting.

Methods: Patients aged 6–18 years presenting for elective surgery requiring general anaesthesia (GA) were enrolled in this observational trial. Anxiety scores were collected from standard-of-care (SOC) patients without VR. After implementing preoperative VR, anxiety scores were measured again. The primary outcome compared preoperative anxiety between SOC and VR groups, measured with the modified Yale Preoperative Anxiety Scale (mYPAS). The secondary outcome measured the correlation of the clinically efficient Happy, Relaxed, Anxious, Distressed, with a yes/no answer to cooperation (HRAD±) scale to the mYPAS and Induction Compliance Checklist (ICC).

Results: The study included 97 patients, 59 in the SOC group and 38 in the VR group. Analyses demonstrated a reduction in mYPAS scores in the VR group by a median of 5.8 ($p = 0.02$) while in the waiting room and 6.3 ($p = 0.002$) upon arrival at the operating room (OR). There was a positive association between mYPAS and HRAD± in the waiting room and upon OR arrival ($p = 0.0003$, $p < 0.0001$, respectively). Induction HRAD± and the ICC were positively correlated ($p = <0.0001$).

Conclusion: Patients who used VR reported less anxiety than patients in the SOC group. The HRAD± scale had a moderate correlation to the mYPAS and ICC. Integrating the HRAD± scale with VR may increase the detection and treatment of preoperative anxiety in resource-variable settings.

Keywords: virtual reality, paediatric anaesthesia, perioperative anxiety, anxiolysis, anxiety scale

Introduction

Perioperative anxiety affects 40–60% of paediatric patients undergoing surgery, resulting in increased morbidity.[1-3] Children who experience anxiety have a higher incidence of emergence delirium, greater postoperative pain, and increased analgesic medicine use.[3-7] Traditional preoperative paediatric anxiety reduction techniques include parental presence, preoperative education programmes, and anxiolytic medications such as midazolam.[8] However, none of these are optimal. Parental presence can have a detrimental effect on the child's experience and may increase anxiety during induction.[9] Preoperative education programmes are laborious to implement and have variable efficacy.[10,11] Midazolam, which is the most reliable and effective anxiolytic, can lead to paradoxical delirium and delayed emergence.[12,13]

Virtual reality (VR) is a relatively novel adjunct for preoperative anxiolysis. In high-resource settings, VR reduces pain perception during dressing changes in burn victims, improves compliance during dental procedures, and reduces anxiety during venous access.[14-18] VR is also effective in reducing perioperative anxiety in paediatric patients.[19,20] Despite VR's efficacy and limited side effects, it has been underutilised in resource-variable settings due to high costs. However, with increased commercial availability and lowered costs, VR is now a feasible adjunct in these settings. Given the unreliable access to anxiolytic medications due to drug shortages and staffing required to monitor patients after receiving pharmacologic anxiolysis, VR is positioned to be a valuable tool in resource-variable settings.[21,22]

To better recognise and treat preoperative anxiety, resource-variable settings require an efficient and facile method to guide treatment.[23] The most common perioperative anxiety scales (the modified Yale Preoperative Anxiety Scale [mYPAS] and Induction Compliance Checklist [ICC]) are time-consuming, require trained observers, and are too cumbersome for routine use.[24] A novel scale (Happy, Relaxed, Anxious, Distressed, with a yes/no answer to cooperation [HRAD±]) has been proposed as an efficient assessment tool for routine clinical use. However, this scale's correlation to well-validated research scales has not been investigated in resource-limited settings.[24]

We hypothesised that VR would reduce preoperative paediatric anxiety in a resource-variable setting in sub-Saharan Africa. Our primary aim is to examine the effect of VR on paediatric preoperative anxiety in rural Kenya. The secondary aims correlated the HRAD± scale to research-based scales in this particular population to better routinely identify anxiety.

Methods

Design

This was an interventional study of preoperative anxiety reduction in children presenting for procedures under general anaesthesia (GA) compared to a historical cohort of similar patients. This study and its manuscript adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational studies.[25]

Setting

This study was conducted at AIC Kijabe Hospital, an academic tertiary care centre in Kijabe, Kenya. The hospital has 350 beds, 12 operating rooms (ORs), and a collective preoperative bay.

Participants

The patients included were children aged 6–18 years presenting for a procedure under GA. This age group was selected to optimise the fit and experience of the VR headset. Children with allergies to anaesthetic agents, acute head trauma, significant cognitive impairment, injuries to the face prohibiting wearing the headset, infectious conditions of the head or face, and visual or hearing impairment were excluded. Intervention group data were collected from 19 January to 30 March 2023. Intervention data was compared to historical controls from 29 November 2021 to 18 January 2022, for which data was collected for a separate, unrelated study.

Intervention

Patients presenting for surgery who received the standard-of-care (SOC) preoperative preparation had their anxiety assessed in the waiting room (T0) and upon OR entry (T1) as a historical comparison group (the historical comparison group was collected using a similar methodology as part of a previous study). SOC anxiolysis in this resource-variable setting did not include any pharmacologic anxiolytics or parental presence during induction. There were no changes in the type of procedures offered by the hospital or patient demographics of the population during the collection period of the SOC or intervention groups.

After informed consent and collection of demographics, patients in the VR group were introduced to a Google Cardboard (Google, Inc., Mountain View, CA) VR headset with a smartphone inserted. This Cardboard headset was selected due to its compatibility with the smartphone (iPhone 6, [Apple, Inc., Cupertino, CA]) and low cost (USD 10 per headset). The headset's lens and head straps were cleaned with rubbing alcohol after patient use per approved infectious control standards, allowing a single headset to be repeatedly used for the duration of the study.

Of note is that participation in this study may have been the first time the child or parent encountered VR. Therefore, study personnel performed demonstrations involving parents to demonstrate how the technology works. Parents and children were given the option to opt out of the study at any point during the intervention.

VR software was downloaded onto the smartphone using free videos on YouTube (Google, Inc., Mountain View, CA). Videos were selected to appeal to a broad range of ages with relaxing qualities, recognisability (e.g. SpongeBob), and cultural appropriateness. The three video options included *Crow: The Legend* (a journey through the forest, © Baobab Studios), *Invasion!* (a story about two aliens, © Baobab Studios), and *SpongeBob SquarePants*. Additionally, videos that went through a short story to simulate interactive features were chosen to captivate the child. It was observed that older children tended to pick *Crow*, while younger children tended to select SpongeBob. The excluded videos were hyper-realistic or frightening scenarios, such as an astronaut floating through space or running from a dinosaur.

Before administration, patients received a brief overview of the VR headsets, including an explanation of how to interact with VR and a demonstration of fit. Then, the headset was fitted to the patient in the preoperative area before transport to the OR. The average length of the VR experience was 10–15 minutes. Patients underwent either inhalational or intravenous (IV) inductions.

Outcomes

The primary outcome compared preoperative anxiety in the waiting room (T0) and upon entry to the OR (T1) for patients using VR with those receiving SOC. The first secondary outcome explored whether a clinical affect scale correlated with a conventional, well-validated, research-based anxiety assessment scale. The final secondary outcome explored the correlation between the same clinical affect scale and a research-based cooperation assessment scale.

Measures

All data were collected via observation by study personnel trained by the principal investigator on mYPAS, HRAD±, and ICC tools. Patient data were recorded in a secure, web-based application (REDCap, Vanderbilt University, Nashville).[29]

The primary outcome was assessed using the mYPAS, a validated measure for assessing paediatric anxiety before anaesthesia.[26] The scale rates five items (activity, vocalisations, emotional expressivity, state of apparent arousal, and use of parent) scored on a scale of 1–4 or 1–6, with higher scores indicating more anxiety. There was a score adjustment for time points when parents were not present. The minimum score is 23, and the maximum is 100. Participants in both groups were rated while wearing the VR mask at T0 and T1. The VR group was also

scored during the induction of anaesthesia (T2) to support the secondary outcome.

The secondary outcomes were evaluated by correlating the mYPAS and ICC to the HRAD± scale in the VR group. HRAD± rates patients as happy, relaxed, anxious, or distressed, with a yes/no answer for cooperation.[27] The ICC evaluates patient compliance with anaesthesia induction. The ICC is an assessment of 10 negative behaviours scored at induction, with one point awarded for each negative behaviour, with higher scores indicating poor compliance.[28] VR participants were rated with the mYPAS and HRAD± scale at T0, T1, and T2. The ICC was scored only at T2.

Bias

Due to the nature of the intervention, patient blinding was not possible. However, historical comparison data were collected without the observers knowing the study's aims.

Study size

The sample size calculation was based on previously described reductions in paediatric anxiety when using VR. Considering a standard deviation (SD) of 12, an effect size of 0.6 (about a 25% difference in mYPAS units), alpha of 0.05, and power of 80%, the required sample size was 36 per group.

Statistical analyses

Demographic and baseline characteristics were reported as mean ± SD or median and interquartile range (IQR) as appropriate for continuous variables. Categorical variables were presented as percentages. The primary outcome was analysed using a univariate comparison of mYPAS scores between SOC and VR groups at T0, and the Mann–Whitney U test at T0 and T1. Secondary outcomes were compared using Spearman's correlation test. The statistical significance threshold was set at 0.05. R (version 4.3.2) was used for the statistical analyses. Patients with missing mYPAS or HRAD± scores were eliminated from the final data analysis.

Ethical approval

The Kijabe Hospital Institutional Scientific and Ethical Review Committee provided ethical approval (02718/0032/2022). In addition, approval was granted from the National Commission for Science, Technology & Innovation (NACOSTI). Parental written, informed consent was obtained in English or Swahili, as well as paediatric assent.

Results

Demographics

In the VR group, 39 patients were assessed for eligibility, and one patient was excluded due to significant cognitive impairment. The SOC group included 59 patients. The baseline variables for the groups were similar (Table I). The average age in the VR and SOC groups was 12 and 10 years, respectively. The most common surgical service in the VR group was urology, and the most common in the SOC was general surgery.

Table I: Demographics and clinical characteristics of the SOC and VR groups

Characteristic	SOC (*n* = 59)	VR (*n* = 38)	Total (*n* = 97)
Mean age (years)	10	12	11
Sex (male)	42 (71%)	26 (68%)	68 (70%)
Procedure type			
Orthopaedic	0 (0%)	2 (5%)	2 (2%)
General	29 (49%)	6 (16%)	35 (36%)
Urology	27 (46%)	17 (45%)	44 (45%)
ENT	1 (2%)	9 (24%)	10 (10%)
Neurosurgery	0 (0%)	3 (8%)	3 (3%)

ENT – ear, nose and throat, SOC – standard of care, VR – virtual reality

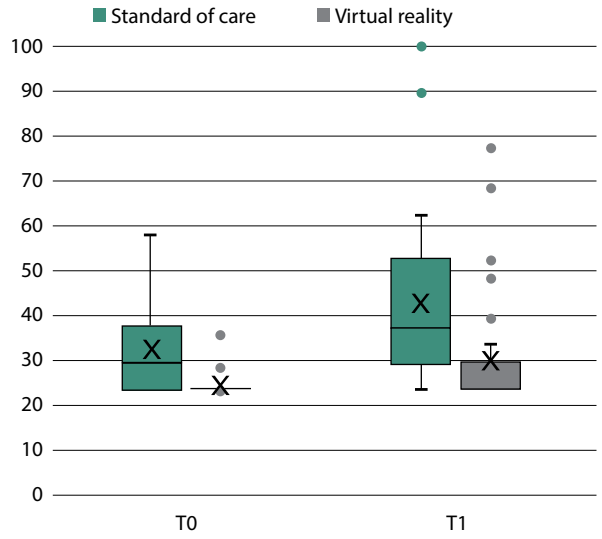

Figure 1: mYAPS scores at T0 and T1
T0 – in the preoperative waiting room, T1 – upon arrival at the OR

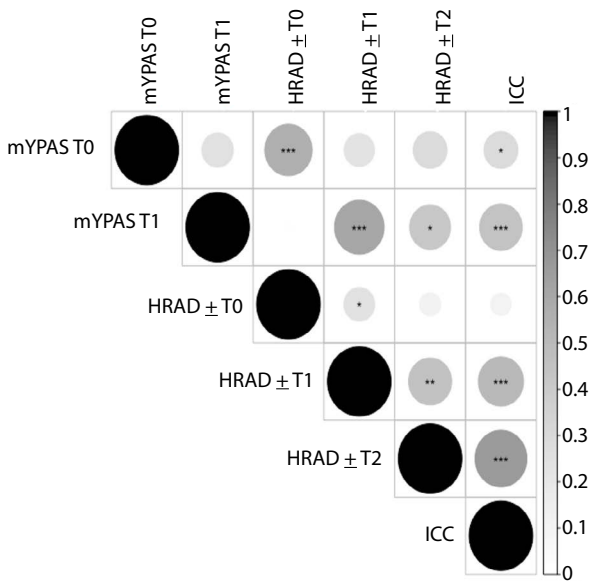

Figure 2: Correlation of the mYPAS to HRAD± and ICC in patients utilising VR
HRAD± – Happy, Relaxed, Anxious, Distressed with a yes/no answer to cooperation, ICC – Induction Compliance Checklist, mYPAS – modified Yale Preoperative Anxiety Scale

Primary outcome: preoperative anxiety

The mean mYPAS scores for the SOC and VR groups at T0 were 32.0 ± 10.6 (confidence interval [CI] = 28.5 to 35.5) and 24.4 ± 2.7 (CI = 23.5 to 25.3), respectively. At T1, the scores were 40.4 ± 22.1 (CI = 30.9 to 50.1) for SOC and 29.7 ± 13.1 (CI = 25.2 to 34.3) for VR. The mYPAS scores were lower in the VR group than the SOC group at both T0 and T1 ($\Delta = 5.8$, $p = 0.02$, and $\Delta = 6.3$, $p = 0.002$, respectively) (Figure 1).

Secondary aim: correlation of affect scales

The Spearman correlation indicated a positive association between the mYPAS and HRAD± scale at T0 and T1 in the VR patients (rho = 0.56, $p < 0.001$, and rho = 0.67, $p < 0.001$, respectively) (Figure 2). The HRAD± scale at T2 and the ICC were also positively correlated (rho = 0.66, $p = <0.001$) (Figure 2).

The correlation matrix demonstrates the relationship between the assessment scores. For each pair, colour and size indicate strength, and asterisks indicate degree of significance.

Discussion

The primary aim was to investigate paediatric preoperative anxiety while using VR compared to SOC. Patients experienced a reduction in paediatric anxiety when using VR. This study also further validated a novel clinical affect scale in patients utilising VR in this resource-variable setting, providing another tool for practitioners to easily adopt to improve recognition of preoperative anxiety.

Increasing accessibility to VR may reduce paediatric anxiety in resource-variable settings. Affordable, easy-to-use VR headsets made of cardboard and a smartphone reduced preoperative anxiety in this resource-limited hospital environment. Several features of the VR intervention rendered it feasible for widespread adoption. Regardless of resources, over 80% of the world's population owns a smartphone.[24] Additionally, VR video access is virtually free on websites such as YouTube. These videos can be downloaded for offline use where internet access is unreliable or limited.

Additionally, compared to a manufactured headset, the cost of a Google Cardboard headset is relatively affordable, typically USD 5–10. These headsets are durable and cleanable, reducing the cost per patient to as low as USD 0.05. The reduction of pre- and intraoperative anxiety with VR was consistent with the reduction of perioperative anxiety with VR reported in high-resource environments.[30] In settings without routine access to preoperative benzodiazepines, such as the one in this study, the long-term implications of perioperative anxiety reduction in children could be even greater. VR provides a sustainable and cost-effective alternative to ameliorate preoperative anxiety in resource-limited settings without the cost and reliance on medications with known deleterious side effects.[12,13] Given VR's potential cost-effectiveness and ease of use, this intervention could be integrated into preoperative workflows in resource-constrained work environments, as it was easily implemented in this single hospital centre.

The mYPAS and ICC were correlated to the clinically efficient HRAD± scale. Given the importance of recognising and treating preoperative anxiety, it should be routinely screened for. Treatment of preoperative anxiety is preceded by appropriate diagnosis. However, scales such as the mYPAS and the ICC are too time-consuming for routine use in a busy clinical environment. The correlations between the HRAD± scale and the mYPAS and ICC suggest it may be a suitable option for clinical implementation in this patient population and may have a role in clinical practice in resource-variable settings. Although other clinical affect scales have been proposed, they lack generalisation to these patient populations.[23,24] Future studies could use the HRAD± scale to reduce the staffing and training burden of scoring paediatric anxiety compared to more intensive scales, rendering studies more feasible in a resource-limited setting.

Limitations

This study had several limitations. First, because the study groups were not assessed concurrently, other system-related factors and confounding variables could have influenced the improvement in anxiety scores in the VR group. Unmeasured variables, such as pain, could have impacted anxiety differences between groups. Preoperative pain is associated with paediatric preoperative anxiety, and VR may influence pain perception, confounding the results.[31,32] Future work is necessary to directly compare VR to SOC in a larger, randomised study to elucidate these relationships.

While comparison of the HRAD± scale with the mYPAS and ICC in the intervention group is only useful for future studies utilising VR, the HRAD± scale may not be generalisable to non-VR patients based on the results of this study. Due to the nature of the intervention, it was not feasible to blind data collectors to this intervention group. Finally, this was a single-centre study in rural Kenya, and more studies are needed to validate this intervention in other settings.

Conclusion

The effective management of paediatric preoperative anxiety is pivotal in optimising the perioperative experience. Due to resource constraints, resource-variable settings have limited options for diagnosing and treating paediatric preoperative anxiety. Consistent with studies in high-resource settings, VR reduced anxiety in the perioperative period. The HRAD± scale was a reliable alternative to facilitate timely recognition compared to conventional research tools that are too complex for routine care. Future studies will investigate VR for other perioperative contexts, such as reducing postoperative pain or as a facilitating device for minor procedures in resource-variable settings.

Conflict of interest

TJ Caruso is a board member of a non-profit organisation that distributes immersive technologies to paediatric healthcare

settings. He receives no direct or indirect compensation for his role. All other authors declare no conflict of interest.

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Ethical approval

The authors declare that this submission follows the principles laid down by the Responsible Research Publication Position Statements as developed at the 2nd World Conference on Research Integrity in Singapore, 2010. Before the commencement of the study, ethical approval was obtained from the following ethical review board: Kijabe Hospital Institutional Scientific and Ethical Review Committee (02718/0032/2022).

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