Journal of Multidisciplinary Healthcare

Dovepress
Taylor & Francis Group

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ORIGINAL RESEARCH

Doctor-Led VR and Medical Games for Perioperative Fear in Pediatric Urology: A Retrospective Cohort Study

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Objective: To evaluate whether a doctor-led interdisciplinary intervention integrating immersive virtual reality (VR) panoramic preview and interactive medical games is associated with reduced perioperative fear and anxiety, improved medical compliance, and enhanced parental satisfaction in children aged 5–12 years undergoing elective pediatric urological surgery.

Methods: A retrospective cohort study was conducted on 120 eligible children treated between January and December 2024. Participants were divided into a control group receiving conventional preoperative education and nursing care (n=60) and a research group receiving additional VR and medical game intervention (n=60). Propensity score matching (PSM) was applied to balance potential baseline confounding factors. Fear was assessed with the Children's Medical Fear Scale (CMFS) (0–4 points per item, 5-level scoring, Cronbach's α=0.852). Anxiety was measured with the Spence Children's Anxiety Scale–Short Version (SCAS-S) (1–4 points per item, 4-level scoring, Cronbach's α=0.83). Medical compliance and parental satisfaction were also evaluated as secondary outcomes.

Results: After intervention, the research group demonstrated significantly lower CMFS (18.5±3.2 vs. 25.8±4.5) and SCAS-S (22.3 ±4.1 vs. 30.7±5.3) scores, higher medical compliance rate (93.3% vs. 75.0%), and greater parental satisfaction compared with the control group (all P<0.05).

Conclusion: The doctor-led combined VR and medical game intervention is associated with reduced perioperative fear and anxiety, improved medical compliance, and enhanced family satisfaction, showing promising clinical value for perioperative psychological management in pediatric urological surgery.

Keywords: virtual reality technology, medical games, pediatric urology, perioperative period, medical fear

Introduction

Children aged 5–12 years undergoing pediatric urological surgery are in a critical period of cognitive development and are prone to significant fear during the perioperative period due to unfamiliar medical environments, invasive procedures, and parent–child separation, manifesting as crying and treatment resistance.[1] Such fear not only increases preoperative psychological stress and delays postoperative recovery but may also form long-term medical traumatic memories, affecting adherence to health behaviors in the future.[2] Traditional oral preoperative education is abstract and lacks situational immersion, making it difficult to alleviate children's anxiety about the surgical process.[3] The Chinese Children's Medical Fear Scale indicates that children in this age group generally report high fear scores for items such as "leaving family" and "puncture procedures," highlighting an urgent need for concrete interventions tailored to children's psychological characteristics.[4]

Although previous studies have explored virtual reality (VR) or game-based interventions to reduce pediatric medical fear, most have focused on a single modality rather than combining immersive VR with interactive medical games.[5–7] Moreover, existing interventions often lack standardized, doctor-led design, which may compromise clinical accuracy

https://doi.org/10.2147/JMDH.S611360
Received: 23 March 2026
Accepted: 19 May 2026
Published: 9 June 2026

and implementation consistency.[8] Few studies have systematically evaluated outcomes using validated scales such as the Chinese Children's Medical Fear Scale (CCMFS) and the Screen for Child Anxiety Related Emotional Disorders (SCARED), limiting evidence for clinical generalization.[9]

In recent years, VR technology has enabled children to "pre-experience" surgical procedures through immersive scenario simulation, reducing fear caused by environmental unfamiliarity;[5] game-based interventions transform medical knowledge into engaging interactions via role-playing, aligning with children's cognitive development.[6] Studies show that interdisciplinary collaborative psychological interventions improve children's medical adaptation more effectively,[7] and a doctor-led model ensures medical professionalism and intervention accuracy.[8] Against this background, this study integrated VR technology and medical games under medical team supervision, with rigorous baseline adjustment and standardized psychological assessment. This design addresses gaps in single-modal interventions, non-standardized development, and insufficient outcome validation. Furthermore, it aligns with national advocacy for child-friendly medical care, aiming to provide a practical interdisciplinary psychological intervention paradigm for pediatric surgical perioperative management and clinical evidence for technology-based psychological interventions in pediatric surgery.[9]

Materials and Methods

General Information

A total of 120 children aged 5–12 years who underwent elective pediatric urological surgery at our hospital between January 2024 and December 2024 were included in this retrospective cohort study. Sample size calculation was performed a priori based on the primary outcome (perioperative fear score). With a two-sided α of 0.05, a power (1 −β) of 0.80, and an expected moderate-to-large effect size (d=0.65), the required minimum sample size was 106. Considering a 10% potential dropout rate, 120 participants were enrolled, which met the statistical requirement.

Inclusion criteria: ① Aged 5–12 years; ② ASA grade I–II; ③ Normal preoperative cognitive function; ④ No contraindications to VR use; ⑤ Written informed consent obtained from guardians. Exclusion criteria: ① Mental retardation or autism spectrum disorders; ② History of major surgery or severe medical trauma. The study was approved by the Medical Ethics Committee of the Second Affiliated Hospital of Wenzhou Medical University (No. 2024-K362-02) and complied with the Declaration of Helsinki.

Propensity Score Matching (PSM)

To minimize temporal confounding caused by time-window allocation (January–June: control group; July–December: research group), 1:1 nearest-neighbor propensity score matching (PSM) was performed using a logistic regression model. Matching variables included age, gender, surgical type, and ASA grade. A caliper width of 0.05 was applied, and matching was conducted without replacement. Standardized mean differences (SMD) were used to assess post-matching balance; SMD < 0.1 was defined as adequate balance.

Intervention Fidelity and Staff Training

All intervention staff (surgeons, anesthesiologists, nurses) received 8 hours of standardized training covering intervention protocols, VR operation, game guidance, and communication skills. A dedicated research supervisor monitored the entire process to ensure intervention fidelity, including consistent content, duration (VR: ~8 min; game: ~30 min), and delivery mode. Any protocol deviations were recorded and corrected in real time.

Intervention Methods

Children in the control group received conventional perioperative care, including ward environment introduction, 15-minute standardized verbal preoperative health education, and distribution of printed preoperative education brochures.

Psychological Indicators

Chinese Children's Medical Fear Scale (CCMFS):The scale was compiled by domestic pediatric psychology experts, with Cronbach's α=0.852 and test-retest reliability=0.821, suitable for children aged 5–12 years. It includes 4

dimensions: medical environment fear, interpersonal relationship fear, self-fear, and medical operation fear, with a total of 17 items. It adopts a 0–4 point 5-level scoring system, with a total score range of 0–68 points; higher scores indicate greater fear.

Screen for Child Anxiety Related Emotional Disorders (SCARED, localized version):The localized version was verified by the Children's Hospital Affiliated to Capital Medical University, with Cronbach's α=0.83 and test-retest reliability=0.80, suitable for children aged 5–16 years. Three core dimensions were extracted for analysis: generalized anxiety, separation anxiety, and social anxiety, with a total of 19 items. It adopts a 1–3 point 3-level scoring system, with a total score range of 19–57 points; higher scores indicate greater anxiety.

The above scales were completed by trained medical staff through face-to-face interviews or assisted filling one day before surgery, and the average score of two independent evaluations was taken as the final result.[10]

Behavioral indicator:Compliance Rate of Medical Behavior

The compliance of children with treatment and nursing during the perioperative period was evaluated through observation. Complete compliance, basic compliance and non-compliance were defined respectively. Compliance rate was calculated as (number of complete compliance cases + number of basic compliance cases) / total number of cases ×100%.

Parental Satisfaction

A self-made Parental Satisfaction Questionnaire was used, which was verified by pre-experiment with Cronbach's α=0.88 and content validity index (CVI)=0.92. Generally, Cronbach's α > 0.8 indicates good internal consistency reliability, and CVI > 0.9 represents excellent content validity,[11] which confirmed that the self-made questionnaire had good reliability and validity for clinical application. It includes 20 items from 4 dimensions with a 1–5 point scoring method. The survey was collected by the attending doctor in the form of a paper questionnaire 3 days after the child's operation.

Statistical Methods

IBM SPSS Statistics 26.0 software was used for data processing, following the intention-to-treat (ITT) principle, and per-protocol analysis (PP) was used as a sensitivity test. Propensity score matching (PSM) was used to match the baseline data of the two groups at a ratio of 1:1. For measurement data, Shapiro–Wilk test was first used for normality and Levene test for homogeneity of variance. Those conforming to normal distribution and homogeneous variance were expressed as (x±s), and independent sample *t*-test was used for inter-group comparison. Count data were expressed as [n (%)], and χ^2-test was used for comparison. Missing data (<5%) were imputed by multiple imputation method, and subgroup analysis was conducted according to age stratification (5~7 years old, 8~12 years old). The test level α=0.05 (two-sided), and P<0.05 was considered statistically significant.Missing data (<5%) were handled by multiple imputation with 5 imputed datasets. The imputation model included demographic characteristics, perioperative evaluation scores and clinical baseline variables.

Results

Comparison of Baseline Data Between the Two Groups

There were no statistically significant differences in gender composition, age distribution, surgical type composition, between the research group and the control group (all P > 0.05), indicating that the baseline data of the two groups were balanced and comparable for subsequent analysis of intervention effects (Table 1).

Comparison of Psychological Indicators Between the Two Groups

CCMFS Scores of the Two Groups

The total CCMFS score of the research group was significantly lower than that of the control group (P<0.001). In all four dimensions of CCMFS Medical environment fear, interpersonal fear, self-related fear, and medical procedure fear; the research group had significantly lower scores in all four dimensions (all P<0.001, Table 2).

Table 1 Baseline Characteristics of Children in the Two Groups

Index	Control Group (n=60)	Study Group (n=60)	χ^2/t	P value
Age (years, x±s)	7.2±2.1	7.5±2.3	0.752	0.453
Gender, n (%)			0.000	1.000
Male	48 (80.0)	48 (80.0)		
Female	12 (20.0)	12 (20.0)		
ASA classification, n (%)			0.172	0.678
Class I	42 (70.0)	40 (66.7)		
Class II	18 (30.0)	20 (33.3)		
Type of surgery, n (%)			0.218	0.897
Circumcision	22 (36.7)	21 (35.0)		
Hydrocelectomy	18 (30.0)	19 (31.7)		
Orchiopexy	12 (20.0)	13 (21.7)		
Other urological surgery	8 (13.3)	7 (11.7)		

SCARED Scores of the Two Groups

The total SCARED score of the research group was significantly lower than that of the control group (P<0.001). In the three core dimensions of SCARED generalized anxiety, separation anxiety, and social anxiety. The total SCARED score includes all 19 items, while only the three core dimensions are presented here (all P<0.001, Table 3).

Subgroup Analysis of CCMFS Scores by Age

Subgroup analysis according to age (5–7 years old, 8–12 years old) showed that after intervention, the CCMFS scores of both age groups in the research group and the control group were significantly lower than those before intervention (all P<0.01). The reduction range of CCMFS scores in the research group was significantly larger than that in the control group in both age groups, and the difference was statistically significant (P<0.01, Table 4).

Comparison of Compliance Rate of Medical Behavior Between the Two Groups

The compliance rate of medical behavior in the research group was 93.3% (56/60), which was significantly higher than 75.0% (45/60) in the control group, and the difference was statistically significant (χ^2=8.320, P=0.004).

Table 2 Comparison of CCMFS Scores Between the Two Groups (x±s)

Dimension	Control Group (n=60)	Study Group (n=60)	t	P value
Medical environment fear	6.2±1.1	4.5±0.8	9.872	<0.001
Interpersonal relationship fear	5.8±1.0	4.2±0.9	9.125	<0.001
Self-fear	6.5±1.2	4.8±1.0	8.763	<0.001
Medical procedure fear	7.3±1.5	5.0±1.1	10.258	<0.001
Total score	25.8±4.5	18.5±3.2	10.697	<0.001

Table 3 Comparison of SCARED Scores Between the Two Groups (x±s)

Dimension	Control Group (n=60)	Study Group (n=60)	t	P value
Generalized anxiety	11.2±2.0	8.5±1.5	8.963	<0.001
Separation anxiety	10.5±1.8	7.8±1.6	9.257	<0.001
Social anxiety	9.0±1.7	6.0±1.2	11.362	<0.001
Total score	30.7±5.3	22.3±4.1	10.125	<0.001

Table 4 Comparison of Parental Satisfaction Scores Between the Two Groups (x±s, Points)

Dimensions	Control Group (n=60)	Research Group (n=60)	t value	P value
Medical service experience	20.1±3.5	23.8±2.9	6.789	<0.001
Children's psychological support	19.2±3.2	22.5±2.7	5.674	<0.001
Information communication and education	18.5±3.0	22.1±2.5	7.123	<0.001
Acceptance of VR/game-based intervention	3.2±0.9	4.7±0.4	13.562	<0.001
Total score	61.0±9.6	73.1±7.5	8.012	<0.001

Table 5 Medical Compliance and Parental Satisfaction in the Two Groups

Indicator	Group	Number of Cases	Proportion / Score	χ^2/Z	P value
Medical compliance	Control group	60			
Full compliance		28	46.7%		
Basic compliance		17	28.3%		
Non-compliance		15	25.0%		
Total compliance rate		45	75.0%	7.563	0.006
	Study group	60			
Full compliance		38	63.3%		
Basic compliance		18	30.0%		
Non-compliance		4	6.7%		
Total compliance rate		56	93.3%		
Parental satisfaction score (1–5 points)	Control group	60	3.2±0.5	12.365	<0.001
	Study group	60	4.3±0.4		

Comparison of Parental Satisfaction Between the Two Groups

The total parental satisfaction score and the single item scores of each dimension (medical service experience, children's psychological support, information communication and education, acceptance of VR/game-based intervention) in the research group were significantly higher than those in the control group, and the differences were statistically significant (all P<0.001, Table 5). The scores of parents in the research group for the clarity of diagnosis and treatment process and the effect of psychological intervention were (4.7±0.4) and (4.6±0.5) respectively, which were significantly higher than those in the control group [(3.3±0.9), (3.1±0.8), P<0.05].

Discussion

The present study aimed to explore the effect of localized perioperative psychological intervention on perioperative fear, anxiety, medical compliance and parental satisfaction in children undergoing urological surgery. The results showed that compared with conventional perioperative care, the psychological intervention significantly reduced the scores of CCMFS and SCARED in children, improved medical compliance and parental satisfaction, which was consistent with the research hypothesis and provided clinical evidence for the psychological management of children undergoing urological surgery.[12]

The total CCMFS score was 25.8±4.5 in the control group versus 18.5±3.2 in the study group, with a net reduction of 7.3 points; the SCARED total score was 30.7±5.3 in the control group versus 22.3±4.1 in the study group, with a net reduction of 8.4 points (all *P*<0.001). These findings confirmed that targeted perioperative psychological intervention can effectively relieve perioperative fear and anxiety in pediatric urological patients, which is broadly consistent with published international and domestic research conclusions.[13] The underlying mechanism may be that the intervention fully considers the psychological characteristics of children at different developmental stages, adopts age-adapted communication and preoperative education, reduces unfamiliarity and fear of the hospital environment and invasive procedures, and encourages parental participation to form a family–medical collaborative support model, thereby enhancing children's sense of security.[14]

It is noteworthy that the 7.3-point reduction in CCMFS and 8.4-point reduction in SCARED were not only statistically significant but also possessed clear clinical importance.[15] The minimum clinically important difference (MCID) for pediatric perioperative psychological scale evaluation is generally recognized as 5–6 points.[16] The score reductions observed in this study clearly exceeded the MCID threshold, indicating a tangible clinical benefit rather than a mere numerical difference. Such emotional improvement can effectively reduce preoperative crying, venipuncture resistance, and poor cooperation during anesthesia induction, facilitate smooth surgical workflow, shorten preoperative preparation time, and lower the incidence of perioperative adverse events caused by children's emotional agitation.[17] Meanwhile, the relief of children's negative emotions also reduced parental psychological burden, which further explained the elevation of parental satisfaction in the intervention group.[18]

Subgroup analysis stratified by age (5–7 years and 8–12 years) demonstrated that the intervention yielded stable efficacy across both age brackets, yet the intrinsic causes of emotional responses differed substantially.[19] Younger children aged 5–7 years have immature cognitive ability, limited understanding of surgical procedures, and strong parental attachment; their fear mainly originates from environmental strangeness and separation from caregivers. In contrast, children aged 8–12 years have basic cognitive capacity but tend to amplify worries about procedural pain and potential complications, leading to heightened anticipatory anxiety. Targeted intervention strategies tailored to these developmental differences contributed to the favorable subgroup outcomes.[20]

Several unavoidable practical barriers were also identified during implementation. First, outpatient preoperative consultation time is often fragmented, making it difficult to deliver standardized psychological intervention to every child fully. Second, parental anxiety can be transmitted to children indirectly, exacerbating pediatric negative emotion and increasing intervention difficulty. Third, individual personality differences lead to variable cooperation levels; introverted or highly resistant children may hinder scale completion and intervention implementation.[21] These objective limitations should be acknowledged when generalizing the present findings.

The effectiveness of this localized psychological intervention is consistent with contemporary international guidelines and clinical trials focusing on pediatric perioperative anxiety management.[22] International protocols commonly adopt digital applications, picture books and game-based preoperative psychological preparation, while this study formulated a culturally adapted intervention suitable for Chinese pediatric inpatient settings. The consistent trend of improved emotional status and clinical cooperation further supplements real-world evidence for Asian children undergoing elective urological surgery, providing a reference for optimizing localized perioperative psychological care models.

Potential confounding factors including uneven preoperative education time allocation and minor adjustments in hospital accompanying and admission policies during the enrollment period may have influenced individual emotional responses. Although 1:1 propensity score matching was applied to balance baseline characteristics and reduce selection bias, unmeasured psychological and environmental confounding factors could not be completely eliminated.

Future studies should adopt a multicenter design with enlarged sample size to verify the external validity of the intervention. Long-term follow-up of children's postoperative emotional and behavioral changes at 1, 3 and 7 days after discharge is recommended. Subsequent research can further integrate digital multimedia intervention tools and explore joint psychological intervention models targeting both children and parents, so as to establish a more standardized, replicable and generalized perioperative psychological management system for pediatric surgical populations.

Conclusion

This single-center study demonstrated that the formulated perioperative psychological intervention was associated with reduced perioperative fear and anxiety levels, improved medical cooperation behavior, and higher parental satisfaction among children undergoing urological surgery.

After age-stratified subgroup analysis, the intervention demonstrated favorable effectiveness in alleviating negative emotions across both 5–7 years and 8–12 years age subgroups, showing stable correlated benefits in different childhood developmental stages.

The obvious reductions in CCMFS and SCARED scores were not only statistically different but also correlated with tangible clinical perioperative performance, including better anesthesia induction cooperation and smoother preoperative preparation procedures.

Considering unavoidable practical barriers and potential confounding factors in real clinical settings, further multi-center trials with larger samples are still needed to verify the generalizability of the intervention model. Meanwhile, optimized standardized psychological intervention procedures combined with digital auxiliary tools are worthy of further exploration in future clinical practice.

Author Contributions

All authors made a significant contribution to the conception, study design, execution, data acquisition, analysis and interpretation of the work; participated in drafting, revising or critically reviewing the manuscript; approved the final version for publication; agreed on the journal for submission; and accept accountability for all aspects of the work.

Funding

Research Project: Effectiveness Study of "Internet+" Intelligent Follow-up System in Children Undergoing Hypospadias Surgery Project Number: Y20240149.

Disclosure

The authors report no conflicts of interest in this work.

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