Received: 27 May 2023 | Accepted: 17 March 2024

DOI: 10.1002/hcs2.93

ORIGINAL ARTICLE

HEALTH CARE SCIENCE

Animation-guided family empowerment program on perioperative care after neurosurgery: A randomized controlled trial for preventing respiratory complications

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Funding information
Technology Foundation Project of Shanghai Jiaotong University School of Medicine, Grant/Award Number: Jyhz2015

Abstract

Background: This study aimed to evaluate the effectiveness of using animation as education material for family empowerment program on perioperative care for caregivers whose children were to undergo neurosurgery.

Methods: A total of 204 caregivers were randomly assigned to either the face-to-face oral nursing educated group (Oral Group) or the animation-assisted nursing educated group (Animated Group). The nursing education primarily focused on instructing caregivers about the manual vibration method. The primary outcome of interest in this study was participants' knowledge level, collected by a 10-item questionnaire. Secondary outcomes included child patients' clinical data, including hospitalization days, treatments, and signs of pneumonia.

Results: Participants in the Animated Group exhibited significantly higher accuracy in perioperative care knowledge assessment, and patients in this group had a lower chance of requiring atomization therapy compared to the Oral Group.

Conclusions: The animation-assisted nursing education program effectively enhances pediatric caregivers' knowledge, reduces respiratory complications after surgery, and offers valuable insights for future studies on the use of such programs to instruct caregivers.

KEYWORDS
empowerment, pediatric, perioperative care, pneumonia, animation

1 | INTRODUCTION

Complications within the first 30 days after pediatric neurosurgical procedures are relatively frequent, occurring at a rate of 16%–20% [1, 2]. Corresponding neuromuscular, cardiovascular, respiratory, and renal complications have been reported in relation to anesthesia and operative procedures during pediatric neurosurgery [3]. Bronchospasm is an adverse respiratory-associated outcome that can be caused by both surgical and anesthesia factors. This has been shown to be most commonly caused by acute respiratory problems affected by rhinorrhea, upper

Trial registration: The study has been registered retrospectively, registration number ChiCTR2000033825.

respiratory tract infection or hypostatic pneumonia, and irritation caused by increased secretions in the bronchial tubes of frightened, crying children [4]. Recent studies have focused on limiting such complications following pediatric neurosurgery to improve the quality of health care, thus leading to better clinical outcomes.

Perioperative care has been reported to facilitate the recovery of surgical patients [4]. Manual vibration, which combines compression and oscillation of the chest wall [5], is a widely used therapy to assist with the removal of lung secretions in patients with airway disease [6], and has been shown to help prevent postoperative pneumonia in children [7]. During pediatric neurosurgery, endotracheal intubation may irritate the trachea wall, causing microtrauma and hypersecretion in mucus. It is known that mucociliary transport stops at the tip of the endotracheal tube, where mucus may accumulate, and the use of muscle relaxants and sedation during ventilatory support impairs patients' ability to cough [6]. This may increase the risk of airway occlusion and pneumonia. Therefore, the aim of manual vibration is to remove excess mucus and limit complications from pneumonia after pediatric neurosurgery.

In China, family members are encouraged to participate in children's hospital care [8, 9]. Family-centered nursing interventions have been shown to provide protective and beneficial outcomes in the management of many diseases [10]. Therefore, it is necessary for caregivers to learn how to perform manual vibration to prevent or manage respiratory problems in children [11]. Effective nursing education for family members can support them for perioperative management and reduce related concerns [12]. The manual vibration method is mainly taught through face-to-face oral nursing education, supplemented by simple gestures and language, which is inefficient and lacks standard protocols, and could increase the workload of medical staff. Moreover, according to the cognitive load theory [13], oral and pictorial nursing education may be ineffective, as it can be difficult for caregivers to understand and remember the procedures.

Compared with written or oral instructions, animation contains procedural information and may increase efficiency and effectiveness by enhancing initial learning [14]. Compared with using static graphics or text materials, animated instructions can help users visualize procedures [15], help them perform tasks better and attract attention [16]. Therefore, animation may be more suitable for nursing education. Multimedia-assisted nursing education has been widely used and achieved good results. Additionally, higher satisfaction scores have been reported for portable video media compared to standard verbal communication in one study [17]. Another study showed that animated videos were an effective educational tool for enhancing health research literacy among minority populations [18]. However, the use of animation in nursing guidance and caregiver education after pediatric neurosurgery has not been evaluated yet.

In the present study, we evaluated whether animation-assisted educational videos could improve the ability of caregivers to recall the manual vibration method and their knowledge acquisition on education materials regarding the procedure. We also examined the effectiveness of using animation for educating caregivers in preventing postoperative neurosurgery complications in their children.

2 | METHODS

2.1 | Design, setting, and participants

This study was a randomized controlled study, and was performed at our hospital. The participants were caregivers whose children underwent pediatric neurosurgical procedures between January 2020 and July 2020. After participant recruitment, they were randomly assigned to either the face-to-face oral nursing educated group (Oral Group) or the animation-assisted nursing educated group (Animated Group) according to computer-generated random numbers by a research assistant (Figure 1). Specifically, the research assistant utilized a computer program that generated random numbers to ensure a randomized allocation of participants. The allocation process was conducted in a manner that minimized bias and ensured each participant had an equal chance of being assigned to either group. In the Animated Group, animation-assisted nursing education was conducted instead of face-to-face oral nursing education. In the Oral Group, only traditional face-to-face oral nursing education was provided to caregivers, aligning with the established standard operating procedures for pediatric neurosurgery treatment at our hospital. The information provided to both groups during nursing education was the same. Participants' acquisition of knowledge after nursing education was evaluated by a 10-item questionnaire.

Child patients and their caregiver were screened for participation by the research assistant. Eligibility criteria were as follows. Inclusion criteria: (1) caregivers of patients under 7 years old; (2) caregivers of patients diagnosed with hydrocephalus and brain dysplasia or undergoing surgery for more than 3 h; and (3) caregivers being the primary caregiver of the patient. We included patients with brain dysplasia due to prior research indicating an elevated risk of aspiration pneumonia in children with developmental disabilities [19, 20]; and

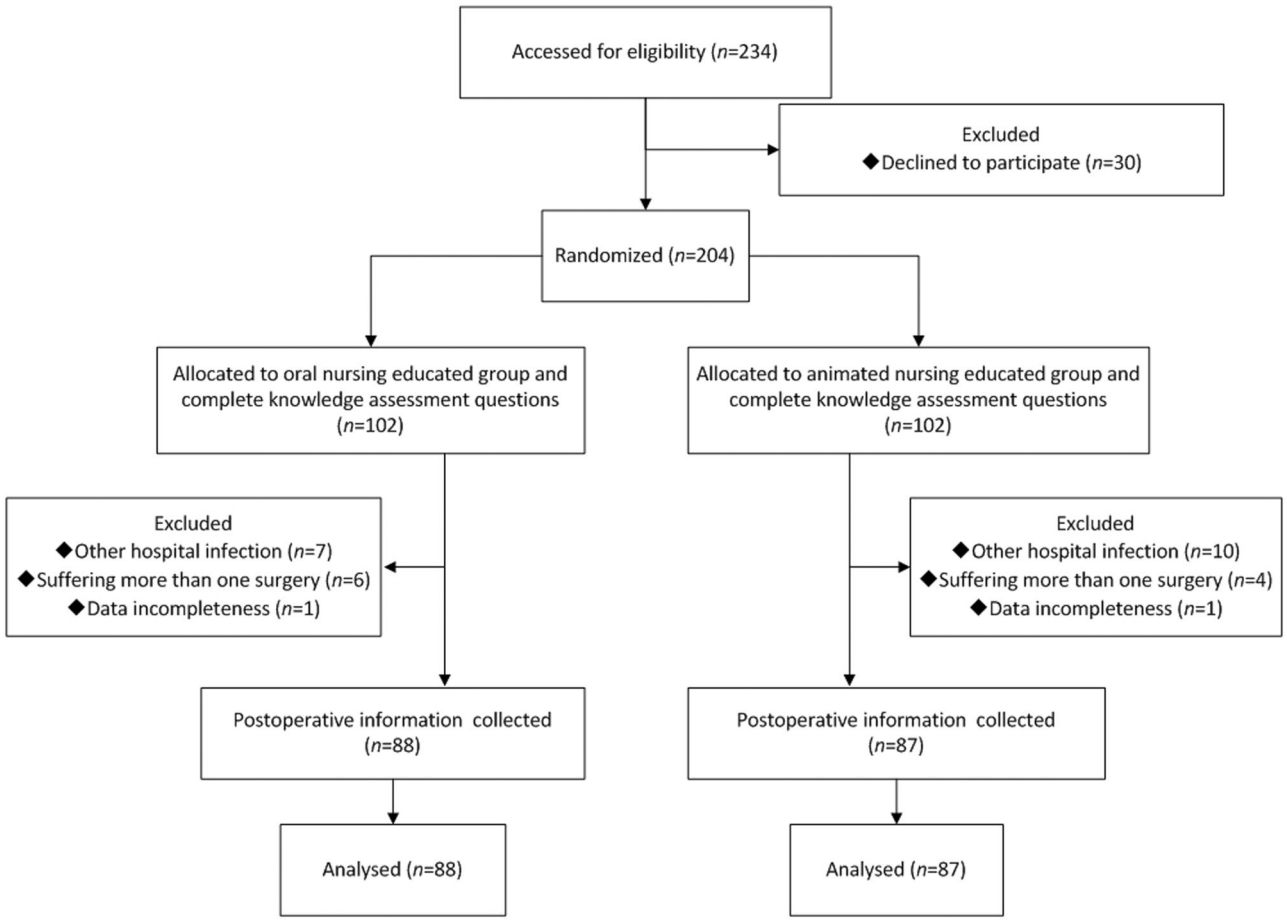

FIGURE 1 Study procedure.

hydrocephalus often coexists with brain dysplasia. We included patients undergoing surgery for more than 3 h based on evidence indicating that this subgroup faces a heightened risk of postsurgery respiratory complications [21]. Exclusion criteria: caregivers of patients (1) who had been using a ventilator for a long time; (2) with a known history of respiratory malformation; (3) with infections before surgery; (4) who had respiratory depression caused by central nervous system inhibition; (5) with other infections, for example, infections of the central nervous system or urinary system; and (6) who had undergone double or multiple surgeries during hospitalization.

2.2 | Intervention

The Oral Group and Animated Group received traditional face-to-face oral nursing education and animation-assisted nursing education, respectively, on perioperative respiratory management before surgery. Participants in both groups were informed that they could contact the nurses as needed. During the nursing education, the caregivers were mainly educated to (1) raise the head of the bed by 15–30 degrees 6 h after surgery and (2) help the child turn over every 2–4 h when bed rest was required. Further, if the child went tracheal intubation during surgery so that required aerosol inhalation or sputum suction, the manual vibration method would be taught to the caregiver.

For the Animated Group, an animated video was played during nursing education to provide the introduction and instructions for the manual vibration method. The animation presented the key points of this method, including the mechanism and principle of how the manual vibration method could assist expectoration, the standard gestures, and other important information. Nurses were available for assisting participants with video watching and questionnaire answering to ensure completion of the education process; the whole process must be completed before the surgery, but still having a time window that allowed caregivers to watch the video repeatedly before answering the questionnaire. In addition, the animation-assisted education material was available online on the hospital's official website when using the local area network, allowing caregivers to

watch the animation videos repeatedly with their mobile devices after the education process, for example, during postoperative management. All nurses underwent training to execute a standardized process, ensuring the consistency and quality of the intervention. Caregivers in the control group did not have access to the local area network.

2.3 | Data collection

The demographic data of both participated patients and caregivers were collected by the research assistant during eligibility screening on admission. The primary outcome of interest in this study was participants' knowledge level, mainly their acquisition of knowledge of the manual vibration method and perioperative care. These data were collected by a 10-item questionnaire. During nursing education, participant in both groups were informed of the following questionnaire survey. Secondary outcomes included child patients' clinical data, including hospitalization days, treatments, and signs of pneumonia, which were collected after discharge and were set as exploratory variables to compare the potential effects of caregivers' postoperative care in the two groups. The blinding of participants to treatment was not possible as treatment exposure was evident. However, the blinding of the statistical analysist is strictly executed.

2.4 | Design of the animation video and questionnaire

The animation was mainly created using the Crazy Talk Animator v3.12 (Reallusion). Participants watched animated characters explaining the method through recorded dialogue, together with some cartoon medical images, all provided with Chinese subtitles. The animation, a 4-min multimedia presentation on instructions for the manual vibration method, explained why and how to use the method to assist expectoration in a vivid manner (Figure 2). The use of background music created a relaxing and pleasant atmosphere, and some cartoon pictures were made into eye-catching gestures to simplify understanding and help memorization.

Participants' acquired knowledge regarding the concepts and details about the manual vibration method was measured according to the guidelines for the prevention of postoperative pneumonia in children. Experienced experts in pediatric nursing developed a 10-item knowledge questionnaire on postoperative respiratory care. The content validity index (0.97) was

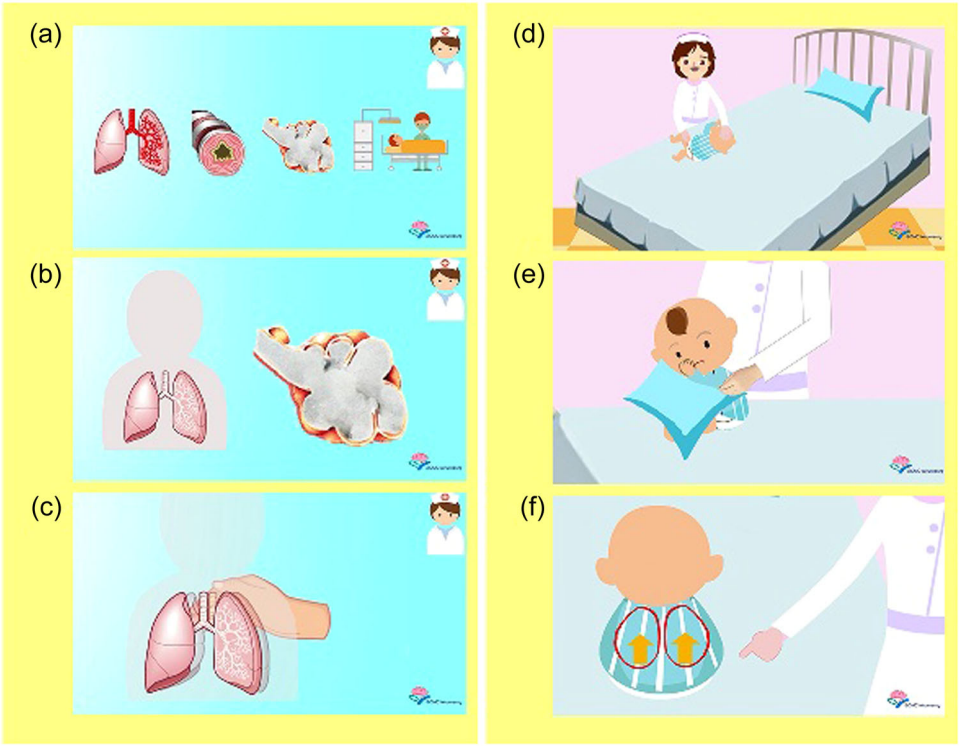

FIGURE 2 Screenshots of the animated video. (a–c) The pathophysiologic mechanisms of respiratory-associated complications during perioperative period and the operation principle of the manual vibration method. (d–f) The specific ways of the manual vibration method operation.

calculated by three pediatric nursing experts. Three different choices were offered for each question and only one was correct. Each participant's accuracy rate was calculated according to how many questions were correctly answered, presenting the level of postoperative respiratory care knowledge acquisition.

2.5 | Sample size

We calculated the sample size of this study using PASS (Power and Sample Size) software 12.0; α was 0.05, β was 0.2, and tolerable bias was 0.1. Based on our pilot study, the accuracy rate of the Animated Group and the Oral Group was 83.3% and 66.7%, respectively. We used these data for sample size calculation, which resulted in a predicted sample size of 135 participants in each group, that is, 270 participants in two groups. Data collection discontinued in July 2020 before reaching the predicted sample size since admission policies and treatment options of the hospital changed due to the COVID-19 outbreak.

2.6 | Statistical analysis

Data analyses were performed using SPSS software version 22.0 (SPSS). Descriptive statistics were used to analyze demographic data and the level of knowledge acquisition. *T*-test was employed to analyze continuous variables. Pearson's chi-squared test was applied to analyze the association between categorical variables. Fisher's exact test was used to analyze associations in groups with a small sample size.

3 | RESULTS

A total of 234 caregivers of patients were approached between January 2020 and July 2020. Among them, 30 caregivers refused to participate, resulting in a participation rate of 85.8%. Briefly, 21 caregivers refused because they were unable to ensure there would be only one regular caregiver, which was necessary for this study, and the remaining caregivers did not provide specific reasons. A total of 204 caregivers were preliminarily included in this study, with 102 participants in each group. Among them, 29 patients were subsequently found ineligible during hospitalization; 17 patients were excluded due to occurrence of extra pulmonary infections (e.g., infections of the central nerve system, urinary tract infections, incision infections), 10 patients were excluded because they underwent double or multiple surgeries, and two patients were excluded because of data incompleteness. The effective rate of the control and intervention group was 86.27% (88/102) and 85.29% (87/102), respectively.

A total of 175 patients were included, and each child had one regular caregiver registered as the participant in this study. The mean age of the patients was 2 years old. All patients were diagnosed with one of the five types of common pediatric neurosurgery diseases. Most participants were either the father or mother of the patient, and all participants had a median age of 34 years old. No significant differences were observed between the two groups across various characteristics of the patients and their caregivers (Table 1).

The results of the 10-item questionnaire survey are presented in Table 2. Participants in the Animated Group achieved significantly higher correct rates for most questions, with significant differences observed for five questions between the two groups (Q3 & Q4: $p = 0.001$, Q7: $p < 0.001$, Q8: $p = 0.021$; Q10: $p = 0.030$). The performance of participants in the Oral Group was substantially worse, except for question 1, where a slightly higher correct rate was observed. The accuracy rate in the Animated Group was significantly higher than that in the Oral Group (91.03% vs. 82.05%, $p = 0.009$).

Table 3 shows that patients in the Animation Group had a higher likelihood of not requiring atomization therapy for treating dysexpectoration after the operation ($p = 0.024$). No significant difference was observed between the two groups in hospitalization days, duration of antibiotic treatment, and signs of pneumonia ($p > 0.05$). A slightly longer hospitalization days and duration of antibiotic treatment was reported in the Oral Group (9.2 vs. 9.0; 8.6 vs. 8.1; $p > 0.05$), as well as a higher rate of signs of pneumonia (59.8% vs. 55.7%; $p > 0.05$; 20.5% vs. 13.8%; 3.4% vs. 2.3%; $p > 0.05$), but there was no statistical significance.

4 | DISCUSSION

Postoperative respiratory complications are common and can cause adverse effects. The highest number of postoperative complications reported in children was bronchospasm [4]. Since family empowerment may be an effective strategy for managing respiratory problems in children [11, 22], we performed training of the manual vibration method in this family empowerment program to facilitate the recovery of surgical patients. Here, we conducted a randomized controlled trial study to compare the caregivers' acquisition of knowledge of the manual vibration after two different nursing education practices—face-to-face oral education and animation-assisted education. We also examined child patients' signs and treatment of respiratory complication after pediatric neurosurgery. We demonstrated that

TABLE 1 Demographic characteristics of patients and caregivers.

Characteristics	Oral Group ($n = 88$)	Animated Group ($n = 87$)	p value
Patients			
Age (yr) (mean ± SD)	2.6 ± 2.1	2.4 ± 2.1	0.370
Sex (%)			0.257
Boys	53 (60.2)	45 (51.7)	
Girls	35 (39.8)	42 (48.3)	
Diagnosis (%)			0.989
Tethered spinal cord	25 (28.4)	24 (27.6)	
Cranial defect or abnormality	9 (10.2)	9 (10.3)	
Hydrocephalus	19 (21.6)	19 (21.8)	
Arachnoid cyst	27 (30.7)	25 (28.7)	
Brain tumor	8 (9.1)	10 (11.5)	
Participants			
Age (yr) (mean ± SD)	34.4 ± 8.9	34.4 ± 7.8	0.168
Gender (%)			0.710
Male	30 (34.1)	32 (36.8)	
Female	58 (65.9)	55 (63.2)	
Living status (%)			0.133
Urban	50 (56.8)	59 (67.8)	
Suburban	38 (43.2)	28 (32.2)	
Relationship (%)			0.727
Parents	80 (90.9)	80 (92.0)	
Grandparents	5 (5.7)	3 (3.4)	
Others	3 (3.4)	4 (4.6)	
Education (%)			0.407
Junior and high middle school	36 (40.9)	28 (32.2)	
College and university	49 (55.7)	57 (65.5)	
Graduate	3 (3.4)	2 (2.3)	

Note: *T*-test, Pearson Chi-square or Fisher exact test was conducted.

animation-assisted nursing education might improve the knowledge of caregivers for pediatric patients regarding the manual vibration method and reduce the need for postoperative atomization therapy.

In this study, the caregivers' knowledge of the manual vibration method and perioperative care was significantly higher in the Animation Group. There is growing evidence that the use of animation as instructional material could improve efficiency and effectiveness. This was attributed to the fact that animation could help users mentally visualize the procedure of a task, thus reducing the cognitive load compared to static graphics or text materials [15]. According to the information processing theory of "Learning as a generative process," meaningful learning can be generated by actively combining stimuli with memory [23]. Furthermore, the participants could repeatedly watch the animation-assisted education material on their mobile devices, strengthening their memory recollection and enhancing their knowledge of the technique when required to perform the manual vibration method. Therefore, participants receiving the animation-assisted education showed better knowledge retention compared with participants receiving oral education.

Patients in the Animation Group showed a significantly lower chance of requiring atomization therapy than those in the Oral Group, though there was no significant difference in the signs of respiratory

TABLE 2 Analysis of correction rates of knowledge assessment questionnaire.

	Oral Group ($n = 88$) (%)	Animated Group ($n = 87$) (%)	χ^2 value	p value
Q1. What's the purpose of back patting? A. To prevent children from choking B. Because children are easy to suffer from lung infection after surgery C. I don't know	89.800	87.400	0.252	0.396
Q2. What's the accurate movement of back patting? A. With hollow palm B. With solid palm C. With whole fist	98.900	98.900	0.000	0.749
Q3. Which item can help sputum excretion? A. Fan B. Bottle C. Sputum cup	88.600	100.000	10.486	0.001*
Q4. Which is the best position during expectoration for children? A. Lying on his back B. Lying on his side C. Holding on his side	84.100	97.700	9.756	0.001*
Q5. Which is the best time for back patting? A. Before meals B. After meals C. After defecation	81.800	83.900	0.135	0.434
Q6. Which is the best duration of back patting? A. About 10 min each time B. About 20 min each time C. About 30 min each time	93.200	96.600	1.018	0.254
Q7. Which is the best frequency of back patting? 2–3 times a day 4–5 times a day 1–2 times a day	59.100	88.500	19.536	0.000*
Q8. Which of the following is wrong in back patting? A. From bottom to top B. From outside to inside C. First left then right	67.000	81.600	4.858	0.021*
Q9. Which is the best thickness of patients' clothes in back patting? A. With no cloth B. Wearing 1–2 cloth C. Wearing a little more	89.800	94.300	1.193	0.209
Q10. Which of the following is true? A. Don't pat to the bone B. Patting softly C. Patting before atomization	68.200	81.600	4.191	0.030*
Total accuracy rate	82.045	91.034	18.858	0.009*

Note: Pearson Chi-square test was conducted. *Significant at $p < 0.05$.

TABLE 3 Children's hospitalization days, treatments, and signs of pneumonia.

	Oral Group ($n = 88$)	Animated Group ($n = 87$)	p value
Hospitalization days (mean ± SD)	9.2 ± 3.1	9.0 ± 2.9	0.723
Duration of antibiotic treatment (mean ± SD)	8.6 ± 2.9	8.1 ± 2.4	0.215
Atomization therapy (%)			0.024*
Yes	14 (16)	5 (6)	
No	63 (72)	70 (81)	
Signs of pneumonia			
Fever >38.4°C (%)			0.584
Yes	53 (59.8)	48 (55.7)	
No	35 (40.2)	39 (44.3)	
Leukopenia (<4000/mm^3) or leukocytosis (>15,000/mm^3) (%)			0.242
Yes	18 (20.5)	12 (13.8)	
No	70 (79.5)	75 (86.2)	
Blur chest X-rays (%)			0.505
Yes	3 (3.4)	2 (2.3)	
No	85 (96.6)	85 (97.7)	

Note: *T*-test, Pearson Chi-square or Fisher exact test was conducted. *Significant at $p < 0.05$.

complications between the two groups. This indicates participants might have better performance on the manual vibration method for preventing atomization therapy and better airway management after pediatric neurosurgery in the Animated Group. Thus, detailed and representative animations may improve the effectiveness of task performance for family empowerment programs on perioperative care after neurosurgery. Previous studies have indicated that specific instructions are beneficial for the initial performance, whereas general instructions help with learning and knowledge transfer [23, 24]. Declarative information has been shown to be beneficial for correctly completing tasks at a faster rate, while adding motivating elements can ease users' tension and enhance their appreciation of the manual [25].

There were several limitations in our study. First, no significant difference was observed in total hospitalization days and duration of antibiotic treatment between the two groups. This might result from the fact that pediatric neurosurgeons prioritize course of disease in determining length of hospital say and duration of antibiotic treatment, limiting the generalizability of the results. Better management of airway by using animation-assisted nursing education programs might not be able to influence their clinical practice. A further limitation was that our study only evaluated the participants' knowledge and patient outcomes, but the extent to which participant have mastered over the manual vibration technique in both groups was unclear. Therefore, further studies are needed to assess the proficiency of the participants and the techniques applied in nursing education. Additionally, the reduced sample size of 175 participants may affect the generalizability of our findings and limit the statistical power to detect smaller effects. While we have taken measures to interpret the results cautiously and discussed this limitation in the manuscript, it remains imperative for future research to replicate our findings with larger and more diverse samples to enhance the robustness and external validity of the study. Finally, while our study encompassed patients with five distinct diagnoses, it does not encapsulate the entire spectrum of neurosurgery. As a result, the generalizability of our study's conclusions is limited to the specific patients included. Further research involving a more comprehensive range of diagnoses is warranted to enhance the applicability of our findings.

5 | CONCLUSION

An animation-assisted nursing education program that prepares pediatric caregivers for perioperative care by providing training in manual vibration method was found effective for enhancing caregivers' knowledge and

lowering the need for treatment of respiratory complications after surgery. Our findings provided useful information for further studies and procedures to investigate the use of animation-assisted nursing education programs in instructing caregivers to carry out family empowerment. Ultimately, patients will benefit from the improved treatment.

Animation-assisted nursing education for a family empowerment program is inexpensive, pragmatic, efficient, and potentially enhances the ability of a caregiver to comprehend important information related to perioperative care, which is necessary in accelerating postoperative recovery of child patients.

AUTHOR CONTRIBUTIONS

Yunfen Lv: Conceptualization; software; formal project administration; funding acquisition; writing—original draft; project administration. **Ziwei Zhao**: Investigation; validation; writing—original draft; data curation. **Xinyi Wu**: Investigation; validation; visualization; data curation. **Yao Wang**: Investigation; validation; visualization; data curation. **Shanshan Qiu**: Conceptualization; methodology; formal analysis, data curation; writing—original draft; writing—review and editing; visualization; supervision.

ACKNOWLEDGMENTS

We acknowledge all the families for their participation in this study and medical staff of the Pediatric Neurosurgery Department at Shanghai Children's Medical Center.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The study was approved by the Institutional Review Boards of Shanghai Children's Medical Center. The privacy rights of human subjects were always observed. The clinical trial registration number is ChiCTR2000033825 retrospectively registered.

INFORMED CONSENT

Written informed consent was obtained from each participant.

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How to cite this article: Lv Y, Zhao Z, Wu X, Wang Y, Qiu S. Animation-guided family empowerment program on perioperative care after neurosurgery: A randomized controlled trial for preventing respiratory complications. Health Care Sci. 2024;3:141–50. https://doi.org/10.1002/hcs2.93