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Factors influencing the perception of shunt devices in children after ventriculo-peritoneal shunts

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Abstract

Objective The impact of hydrocephalus on the emotional, cognitive, and social health of children is frequently overlooked when measuring clinical outcomes in children with hydrocephalus. The aim of this study was to determine factors that influence the subjective perception of the subcutaneous shunt devices in children with hydrocephalus after ventriculo-peritoneal shunts (VPS).

Methods A retrospective analysis was performed on a cohort of 86 pediatric patients who underwent VPS at the Department of Neurosurgery, Tongji Hospital, between January 2012 and July 2022. Clinical information such as gender, age at surgery, age at follow-up, post-shunt complications, postoperative shunt replacements or shunt revisions, adjustments for valve opening pressure(VOP), brands of shunt devices, family situation, and the patients' subjective perception of the subcutaneous shunt devices were collected by telephone follow-up.

Results Of the 86 children, 63 (73%) perceived the existence of the subcutaneous shunt devices (32% at the level behind the ear, 16% at the chest, 52% at the neck), among which 3 children were particularly sensitive and more anxious. The independent risk factors for the subjective perception of shunt devices were age at follow-up (≥ 7 years) and post-shunt complications with odds ratios of 3.860 ($P=0.02$) and 4.956 ($P=0.02$) respectively.

Conclusion In pediatric hydrocephalic patients who have undergone VPS, those aged seven years or older or who experienced post-shunt complications may exhibit a significant subjective perception of subcutaneous shunt devices. It is crucial for parents to be cognizant of this potentiality, and offer attentive care and thorough explanations to relieve any associated anxieties.

Keywords Pediatrics, Hydrocephalus, Ventriculo-peritoneal shunts, Influencing factors, Perception

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Introduction

Hydrocephalus is a condition that pertains to an anomaly in the physiology of cerebrospinal fluid (CSF), which is known to cause the abnormal dilation of the ventricular system and an increase in intracranial pressure in both adults and children [1, 2]. Ventriculo-peritoneal shunting (VPS) is the most commonly employed approach and functions to redirect CSF from the ventricles to the peritoneal cavity. Alternative distal sites such as the right atrium of the heart and the pleural cavity are occasionally utilized [3, 4]. Most pediatric VPS patients require lifelong medical care and support, and any episode of shunt failure or infection could significantly impact the functional and cognitive outcomes of survivors [5].

During routine outpatient consultations for pediatric VPS patients, physicians are frequently asked by the patients and their parents about the care of the subcutaneous placement of the shunt devices, this excessive attention may place a burden on the child. It has been reported that children with hydrocephalus seem to exhibit higher levels of both internalizing symptoms, such as anxiety, depression, and somatization, and externalizing symptoms, including hyperactivity, aggression, and conduct problems, when compared to the general population [6]. Although many studies have examined the physical outcomes of shunted children with hydrocephalus, few studies have focused on the subjective perception of the subcutaneous shunt devices in children after VPS and the cognitive or psychological risks they may cause [7, 8]. The current study is the first to retrospectively explore the factors influencing the subjective perception of the subcutaneous existence of shunt devices by pediatric patients with hydrocephalus after VPS, which might contribute to better care and alleviation of the related anxiety.

Clinical materials and methods

The target population of this study consists of children with hydrocephalus who are at least 3 years old at the time of follow-up and at least 1 year after VPS(a 3-year-old child is capable of independently expressing their needs and can accurately communicate any discomfort in their body to their parents) at the Department of Neurosurgery, Tongji Hospital, between January 2012 and July 2022. Additionally, patients who were considered not to have self-awareness by the Developmental Profile-II (DP-II) assessment [9] or who had their shunt devices removed after surgery due to mechanical impairment were excluded from the study. The study was approved by the institute's ethics committee. Various clinical data were collected through a telephone follow-up, such as the children's gender, age at surgery, age at follow-up, post-shunt complications, postoperative shunt replacements or shunt revisions, adjustments of valve opening pressure (VOP), brands of shunt devices, family situation, and the patient's perception of shunt devices.

Age classification

In order to identify meaningful age of follow-up segment thresholds, we classified the children into two groups based on age and conducted a univariate analysis to explore the relationship between different age segments and children's perception of the shunt. Our results showed that when the age threshold was set at 7 years, the effect of age on shunt perception became statistically significant.

Boundary of shunt touch frequency

Because children's psychosocial health is difficult to assess due to age and cognitive issues, we used the Hydrocephalus Outcome Questionnaire (HOQ) [10]. The HOQ has 51 items, primarily used as a parental proxy evaluation, with 24 of them for Social-Emotional Health (refer to Appendix). The HOQ is scored on a scale from 0 to 1, with higher scores indicating higher quality-of-life. We performed emotional-related items scores for the pediatric patients in this study, we observed that children with a shunt touch frequency exceeding 1–2 times per week had significantly lower emotional health scores. We used the average score as a cutoff point to stratify the children into two groups and subsequently conducted a correlation analysis using the chi-square test with the subgroup of children who had a shunt touch frequency greater than 1–2 times per week.

Finally, we found that a shunt touch frequency greater than 1–2 times per week may serve as a meaningful threshold for assessing children's perception of the shunt and the potential emotional health risks. Interestingly, we also observed that these children used to ask about or grumble about the existence of a shunt, therefore, we thought that children who touched the shunt ≥ 1–2 times a week and frequently mentioned the shunt cared more about the shunt than other children and were more likely to have anxiety or develop psychological disorders in their lives, thus, we divided the patients into perceptual and non-perceptual groups based on this boundary.

Children with the following characteristics were considered to perceive a sensation of the subcutaneous shunt devices: (1) the child touched the shunt devices at the body surface (at the level behind the ear, at the chest, or at the neck) at least 1–2 times a week; (2) and the child frequently asked about or complained about the presence of a shunt to parents.

Evaluation of Scar tension perception

There is one possible scenario that the neck is the site of greatest scar tension and it is the tightness of the scar rather than the shunt itself which is being perceived.

Parallel questioning of the children and their parents revealed that children at peak growth did not show an increased frequency of palpation compared to other children, and the child denied the sensation of pain at the site where the shunt was placed, which could be distinguished from the occurrence of localized pain in the patient due to irritation of the cutaneous nerves by the shunt. Therefore, it was the presence of the shunt that was felt by the child and not the tension of the scar or the irritation pain of the cutaneous nerves. To further verify our conjecture, we followed up five children who had undergone shunt removal and did not see the children touching the neck shunt after removal according to parental observation, which could exclude the factor of neck scar tension on the perception of the shunt by the children.

Statistical analysis

Continuous measurement data were presented as mean ± standard deviation, and *t*-test was used for statistical analysis between groups if the data with homogeneity of variance is normally distributed; discontinuous count data are expressed as rate or composition ratio, and the four-grid table χ^2 test was used for comparison between groups; chi-square test was used for the correlation analysis of categorical variables. Univariate logistic regression models then were applied to explore factors for perception for the shunt. Variables found to be statistically significant on the univariate analyses were entered into a stepwise logistic regression model for multivariate analysis ($\alpha = 0.05$; $\beta = 0.10$). Differences were considered statistically significant at $P < 0.05$. All analyses in the present study were performed using SPSS26.0.

Results

Boundary of shunt touch frequency

Emotional health-related items were scored for a cohort of 86 children, yielding an average score of 0.71 ± 0.15. Correlation analysis of shunt touch frequency and emotional health scores revealed a Spearman correlation coefficient of 0.472 with $p < 0.001$, indicating a statistically significant association between a higher frequency of shunt touch and lower emotional health scores on the HOQ.

Patient characteristics

A total of 86 patients were enrolled, of whom 63 perceived the existence of their shunt devices (73%). Three of the patients were more sensitive to shunt devices and more anxious than the other children, touching the subcutaneous shunt devices at least 4–5 times a week at the body surface. The average age at surgery was 1.52 ± 1.42, the average age at follow-up was 7.66 ± 3.35, and all of them used programmable valve located behind the ear. Of all the 86 children, 69 underwent VPS due to congenital hydrocephalus, 7 hydrocephalus after cerebral hemorrhage, 7 hydrocephalus after tumor removal, 2 hydrocephalus after infection and 1 traumatic hydrocephalus. There were 57 males (66%), 69 patients under 3 years of age at the time of surgery (80%), and 47 patients ≥ 7 years of age at the time of follow-up (55%). The post-shunt complication rate was 41%, including 7 cases of intracranial infections (20%), 6 shunt displacements (17%), 6 shunt blockages (17%), 5 shunt dislodgements (14%), 6 subdural effusions (17%), 3 epidural haematoma(9%), 1 epilepsy(3%) and 1 eye strabismus(3%). 58 patients underwent post-shunt adjustments of VOP, 16 of whom were adjusted once (28%), 17 twice (29%), 17 three times (29%), and 8 four or more times (14%). 13 patients required post-operative shunt replacements or revisions (15%).

Univariate analysis of factors affecting the perception for shunts after VPS in children with hydrocephalus

The univariate results for the potential factors affecting the perception of shunt devices after VPS in children with hydrocephalus are summarized in Table 1. It is worth noting that age at follow-up, gender, and post-shunt complications were associated with the perception of shunt devices ($P < 0.05$). Conversely, age at surgery, post-operative shunt replacements or revisions, adjustments of VOP, brands of shunt devices, and family situation were not associated with the perception of shunt devices in children after VPS ($P > 0.05$).

Multivariate logistic regression analysis of factors affecting the perception for shunts after VPS in children with hydrocephalus

The multivariate logistic regression for potential factors affecting the perception of shunt devices in children with hydrocephalus after VPS is summarized in Table 2. The factors with statistically significant differences in the univariate analysis were included in the multivariate logistic regression analysis. The identified independent factors included the age ≥ 7 years at follow-up (OR 3.860, 95% CI 1.236–12.057, $P = 0.02$), and the presence of post-shunt complications (OR 4.956, 95% CI 1.256–19.548, $P = 0.02$), with an increased risk of perceiving the existence of shunt devices in children with hydrocephalus after VPS. Gender was not statistically significant ($p > 0.05$). 11 of the 39 individuals younger than 7 years old had post-shunt complications, 10 of whom felt the presence of a shunt; 23 of the 47 individuals older than or equal to 7 years old had post-shunt complications, 22 of whom had a sense of the presence of the shunt. Post-shunt complications seem to show a stronger impact than age.

Table 1 Univariate analysis of the perception of shunt devices after VPS[1] in children with hydrocephalus

Influencing Factors	Perception group (*n*=63),n(%)	Non-perception group (*n*=23),n(%)	t/χ^2 value	*P*-value
Gender			6.006	0.014
Male	37 (59)	20 (87)		
Female	26 (41)	3 (13)		
Age at surgery			0.895	0.34
<3 years old	49 (78)	20 (87)		
≥3 years old	14(22)	3 (13)		
Age at follow-up			10.336	0.001
<7 years old	22 (35)	17 (74)		
≥7 years old	41 (65)	6 (26)		
Post-shunt complications			9.949	0.002
Yes	32 (51)	3 (13)		
No	31 (49)	20 (87)		
Post-shunt adjustments of VOP[1]			0.618	0.43
Yes	44 (70)	14 (61)		
No	19 (30)	9 (39)		
Postoperative shunt replacements or revisions			2.837	0.09
Yes	12 (19)	1 (4)		
No	51 (81)	22 (96)		
Family situation			0.836	0.36
Rural	26 (41)	7 (30)		
City	37 (59)	16 (70)		
Brands of shunts			1.01	0.32
Codman	59 (94)	20 (87)		
Aesculap	4 (6)	3 (13)		

[1]ventriculo-peritoneal shunts

[1]valve opening pressure

Table 2 Multivariate logistic regression analysis of the perception of shunt devices after VPS in children with hydrocephalus

Influencing Factors	β value	SE value	Wald χ^2 value	*P*-value	OR	95% CI
Age at follow-up	-1.351	0.581	5.404	0.02	3.860	1.236–12.057
Post-shunt complications	1.601	0.700	5.226	0.02	4.956	1.256–19.548
Gender	-1.247	0.714	3.047	0.08	0.287	0.071–1.165

Discussion

Hydrocephalus, a prevalent neurological disorder, is characterized by the gradual buildup of CSF within the intracranial cavity, leading to heightened intracranial pressure, ventricular enlargement, and subsequent brain damage. The deployment of ventriculoperitoneal shunts, facilitated by the development of valve systems and the availability of new biocompatible materials, has become the standard mode of treatment for individuals afflicted with hydrocephalus [11]. However, in addition to suffering potential shunt-related complications, children with hydrocephalus also frequently experience related emotional and social health disturbances. These aspects of health can be challenging to measure and quantify in a reproducible and valid manner not only from the pediatric patients, but also from their family members [12, 13]. During routine outpatient consults for pediatric VPS patients, physicians are frequently asked by the patients and their parents about the care of the subcutaneous placement of the shunt devices. Indeed, the reservoir, regulator, and associated tubing are buried under the skin behind the ear, and the tubing below the regulator is placed in a "subcutaneous tunnel" that reaches the umbilicus. Therefore, a slightly elevated tube can be felt under the skin, and the protruding reservoir and regulator can usually be felt behind the child's ear. This subjective perception of the existence of shunt devices may contribute to anxiety and psychological problems. In our study, a total of 63 patients who underwent VPS felt the presence of shunt devices (73%). Among them, three children not only touched the shunt more than 4–5 times a day, but also expressed strong resistance through crying and fussing, as reported by their parents. Additionally, their HOQ emotional health scores were below average, specifically 0.58, 0.62, and 0.63. These children are considered to have developed anxiety. Anxiety is just one of the emotional disorders that may occur in children, other psychological disorders, such as depression, fear, and obsessive-compulsive disorder may also arise. These disorders can range from mildly affecting daily life to

severely impacting life itself. Therefore, these psychological conditions also require attention.

The age of surgery was found to have no association with the perception of shunt devices, while the age at follow-up exhibited a correlation with an increased perception of the shunt devices. A recent nationwide study conducted in Denmark revealed that merely 69.5% of hydrocephalic patients could attend school on time, with a delay of one or two years compared to their peers, and this gap in school readiness is generally unaffected by the age at surgery or the number of surgeries undergone [14]. Previous research has also demonstrated that hydrocephalic children with a normal IQ are prone to underperforming at school due to psychological and behavioral disorders that negatively impact their academic performance [15]. Our study indicated that children over the age of 7 were more likely to develop a significant awareness of the existence of shunt devices, it seems reasonable that children of this age are becoming more self aware and involved in their bodies, which might explain greater focus and curiosity regarding their shunt, however, this may increase their awareness of physical limitations and lead to social, psychological, and emotional impairments. Our second finding is that children's perception of the shunt is associated with post-shunt complications. Regrettably, there is currently no research on the psychological impact of VPS complications in children. However, studies have shown that children with hydrocephalus are at a higher risk of developing anxiety [16]. Research in pediatric psychology also suggests that if surgery involves a prolonged recovery period or if complications arise, the risk of psychological impact may increase. A prolonged recovery period can lead to feelings of loneliness, anxiety, or depression in children, while complications further exacerbate their sense of inadequate coping ability. Therefore, it is crucial to consider postoperative complications as a factor when evaluating the impact on children's anxiety. Obviously, the care provided by parents to the child is crucial, it is as follows: (1)Parents should patiently explain the function of the shunt to their child, helping them understand that it is crucial for safeguarding their life and does not pose any additional harm to their body. The child should be encouraged to adapt to its presence; (2)Parents should avoid overprotecting their child and, psychologically, treat them as they would a healthy child. It is important to help the child develop a healthy sense of self-awareness and encourage them to perform tasks within their abilities. This approach can boost their self-confidence. Parents should also promote social interactions with peers to reduce excessive dependence on family members; (3)If the child shows signs of anxiety, parents should engage in open communication to help alleviate their anxious feelings and ease symptoms of restlessness. If the child's anxiety is severe, parents might be able to consider seeking professional psychological counseling at a reputable healthcare facility. These were especially significant in pediatric patients after VPS.

This research aimed to investigate, for the first time, the perception of shunt devices in pediatric patients after VPS surgery. Specifically, this study sought to analyze the influencing factors that might contribute to the subjective perception by the patients. The awareness of the subcutaneous shunt devices and related anxieties could potentially affect their social performance. The outcomes of this study may serve as a reference for clinicians at the postoperative care and follow-up of pediatric patients who have undergone VPS surgery. However, it is regrettable to note that several limitations were encountered in this study. Firstly, the study was conducted retrospectively and the data were limited to a single center. Secondly, some variables that may be relevant to the perception of shunt devices, such as patients' symptoms and length of hospital stay, were not included in the analysis. In order to address these limitations, a multicenter study that incorporates a larger patient cohort and a broader range of variables is recommended.

Conclusion

Most pediatric patients could perceive the presence of shunt devices post-surgery, only a few had related anxiety. The likelihood of more intense subjective perception and related anxiety may increase in patients at school age and with post-shunt surgery complications. Parents and clinicians should be aware of the likelihood and afford timely psychological care.

Abbreviations

VPS	Ventriculo-peritoneal shunt
CSF	Cerebrospinal fluid
VOP	Valve opening pressure
HOQ	Hydrocephalus Outcome Questionnaire

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12883-025-04109-4.

Supplementary Material 1

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Author contributions

WLJ, CZR, WF and ZK conceived the idea and conceptualised the study. ZK, DMH and GZY collected the data. WLJ, CZR and XW analysed the data. WLJ, ZXL, WF and DMH drafted the manuscript, then SJX, XW, WF and GZY reviewed the manuscript. All authors read and approved the final draft.

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Data availability
All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate
This study was conducted with approval from the Ethics Committee of Tongji Hospital. This study was conducted in accordance with the declaration of Helsinki. Due to the retrospective nature of the study, the requirement of patient consent for inclusion was waived by the Ethics Committee of Tongji Hospital.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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