

Emergency Department Presentations of Pediatric Patients With Ventriculoperitoneal Shunts: Is Every Presentation a Shunt Malfunction?

Atakan Besnek

Ankara Etlik City Hospital

Mehmet Kılıç

Şanlıurfa Training and Research Hospital

Bahri Ünal

Şanlıurfa Training and Research Hospital

Ümit Zeydoğlu

Kayseri Training and Research Hospital

Barış Erdoğan

`dr.baris.erdogan@gmail.com`

Stanford University

Research Article

Keywords: ventriculoperitoneal shunt, hydrocephalus, pediatric emergency department, computed tomography, defensive medicine, pediatric radiation safety

Posted Date: June 30th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-9973902/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Background

Pediatric patients with ventriculoperitoneal (VP) shunts presenting to the emergency department (ED) are frequently evaluated under a presumptive diagnosis of shunt malfunction, prompting routine cranial computed tomography (CT) and neurosurgical consultation. The true proportion of these visits that involve shunt-related pathology has not been adequately quantified.

Methods

We retrospectively reviewed 160 pediatric patients with prior VP shunt placement who presented to the ED of a regional tertiary referral hospital and were evaluated by the neurosurgery service between 2019 and 2023. Patients were classified according to whether shunt-related pathology requiring revision was identified during the study period. Demographic data, hydrocephalus etiology, acute diagnoses recorded across ED visits, number of CT examinations, and hospital admission were analyzed. Between-group comparisons used Pearson χ^2 , Fisher exact, and Mann-Whitney U tests. Univariable odds ratios (ORs) with 95% confidence intervals (CIs) were calculated for acute diagnoses.

Results

Among 160 patients (53.1% male; median age, 4.0 years), shunt-related pathology was identified in only 43 (26.9%); the remaining 117 patients (73.1%) presented for acute pediatric conditions unrelated to the shunt. The most common presenting complaints were upper respiratory tract infection (83.8%), acute gastroenteritis (32.5%), lower respiratory tract infection (32.5%), and seizure (24.4%). Patients underwent a median of 2 (interquartile range [IQR], 1–3) CT examinations. The number of CT examinations did not differ significantly between groups ($P = 0.071$). Among acute presenting complaints, only seizure was significantly more frequent in the shunt-related pathology group (37.2% vs 19.7%; $P = 0.037$).

Conclusions

In this patient-level cohort, most pediatric VP shunt patients presenting to the ED did not have revision-confirmed shunt-related pathology. Routine cranial CT and neurosurgical consultation in all such patients impose unnecessary radiation exposure and health system burden. Seizure was associated with shunt-related pathology but did not reliably exclude it when absent. These findings support prospective validation of selective, symptom-guided ED pathways that balance early detection of shunt malfunction with pediatric radiation safety.

Background

Hydrocephalus is characterized by abnormal accumulation of cerebrospinal fluid (CSF) with ventricular dilation and remains an important cause of pediatric morbidity and mortality, particularly in low- and middle-income countries [1]. Ventriculoperitoneal (VP) shunting, the primary treatment, regulates intracranial pressure by diverting CSF to the peritoneal cavity. Although its efficacy is established, pediatric shunt management is more challenging than in adults, with notably higher rates of obstruction and infection [2].

Approximately 25% to 40% of VP shunts malfunction within the first year and up to 56% to 80% fail within 10 years [3, 4]. Unrecognized shunt failure can have severe consequences including death [5], and in the United States alone, approximately 17,000 emergency department (ED) visits for VP shunt malfunction were reported in 2017 [6]. This high complication risk places shunt malfunction at the top of the differential when these children present to the ED.

However, the classic features of shunt failure—headache, nausea, vomiting, altered mental status, irritability, and seizure—overlap broadly with common benign childhood conditions such as upper respiratory tract infection (URTI), gastroenteritis, and febrile illness [5]. In practice, this prompts many clinicians to proceed directly to cranial CT and neurosurgical consultation rather than performing a careful symptom inventory and neurologic examination [7]. The reflex is further reinforced by high patient volumes, stressful working conditions, and concern about malpractice [8].

The proportion of ED visits by children with VP shunts that are truly shunt-related versus attributable to other pediatric causes has not been adequately quantified. Although prior studies have focused on specific etiologies such as spina bifida or myelomeningocele [9], comprehensive data across all VP shunt patients regardless of etiology remain limited—a gap that hinders identification of patients who truly require advanced imaging.

The implications of this practice are nontrivial. Cumulative ionizing radiation exposure increases long-term malignancy risk in pediatric patients [10, 11], and unnecessary consultations impose substantial workload on neurosurgical services. Whether systemic clinical evaluation can adequately triage these patients remains insufficiently addressed.

This study aimed to determine the true frequency of shunt-related pathology among pediatric VP shunt patients presenting to the ED, characterize the presentation profile, and identify acute complaints that should raise clinical suspicion for shunt-related pathology.

Methods

Study design and ethics

This was a retrospective cohort study reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines. The study was approved by the Harran University Ethics Committee (Approval No: HRÜ/23.03.08) and was conducted in accordance with the

principles of the Declaration of Helsinki. Individual patient consent was waived by the ethics committee owing to the retrospective nature of the study.

Study setting and patient selection

The study site is a regional tertiary training and research hospital that serves as the sole referral center for its catchment area and incorporates the obstetrics center and pediatric and neonatal intensive care units. It is located in a province with one of the highest pediatric populations and birth rates in Turkey. Consequently, most pediatric patients with VP shunts in the region are followed at this institution.

Between 2019 and 2023, pediatric patients with prior VP shunt placement who presented to the ED and were evaluated by the neurosurgery service were screened. A total of 160 patients with sufficient demographic, clinical, imaging, and outcome data were included. Patients with insufficient data to determine shunt revision status, ED diagnoses, or CT utilization were excluded. Because inclusion required neurosurgical consultation, the cohort represents ED presentations that raised sufficient concern to trigger neurosurgical assessment and not all ED visits by children with VP shunts.

Data collection and group definitions

Clinical data were obtained from the hospital information management system. External referral data, discharge summaries, and imaging records were retrieved through the national electronic health record system where available. Recorded variables included age, sex, hydrocephalus etiology, number and date of VP shunt placements, hospital admission, number of ED presentations, and number of cranial CT examinations performed during ED care.

Acute diagnoses recorded during ED visits were classified according to ICD-10 coding. Diagnoses analyzed included seizure, nausea/vomiting, fever, URTI, acute gastroenteritis, lower respiratory tract infection (LRTI), soft tissue disorder, urinary tract infection (UTI), otitis, pneumonia, falls, burns, and other rare diagnoses. Because patients could present more than once during the study period, each diagnosis was summarized at the patient level as present if it was recorded during at least one ED visit. The number of visits with each diagnosis was also tabulated. Therefore, the complaint analysis reflects diagnoses recorded across ED care episodes rather than mutually exclusive index-visit chief complaints.

Because the entire study population comprised patients with chronic hydrocephalus and VP shunts, ICD-10 code G91 (hydrocephalus) was frequently recorded in ED files. This code reflects the chronic underlying condition rather than an acute presentation and was not analyzed as an acute ED diagnosis.

The primary outcome was shunt-related pathology requiring surgical revision during the study period. The shunt-related pathology group comprised patients who underwent shunt revision for suspected or confirmed malfunction or infection. The no shunt-related pathology group comprised patients without shunt revision during the study period, whose ED presentations were attributed to acute conditions

unrelated to shunt failure. This outcome definition identifies revision-confirmed shunt pathology but may not capture nonoperative or externally managed shunt-related events.

Statistical analysis

Analyses were performed with SPSS version 29.0 (IBM Corp, Armonk, NY). Normality of continuous variables was assessed with the Shapiro–Wilk test. Continuous variables with non-normal distribution are presented as median (IQR) and compared between groups using the Mann–Whitney U test. Categorical variables are presented as frequency and percentage and compared using the Pearson χ^2 test or Fisher exact test, as appropriate. For clinical complaints significantly associated with shunt-related pathology, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated. Statistical significance was set at $P < 0.05$.

Results

Demographic and clinical characteristics

Of 160 patients, 53.1% ($n = 85$) were male. Median age was 4.0 years (IQR, 2.0–5.8). Hydrocephalus etiology was congenital in 37.5%, myelomeningocele in 30.0%, and IVH-related in 13.1%. The overall hospital admission rate was 70.6% ($n = 113$). Patients presented to the ED a median of 5.0 times (IQR, 2.0–15.0) during the study period and underwent a median of 2.0 cranial CT examinations (IQR, 1.0–3.0) during ED care. Baseline characteristics are summarized in Table 1.

Table 1
Baseline characteristics of the study population (N = 160)

Variable	Category	n / Median	%
Sex	Male	85	53.1
	Female	75	46.9
Age, y	Median (IQR)	4.0 (2.0–5.8)	—
Hydrocephalus etiology	Congenital	60	37.5
	Myelomeningocele	48	30.0
	IVH	21	13.1
	Meningitis	9	5.6
	Trauma	8	5.0
	Intracranial mass	7	4.4
	Other	7	4.4
Hospital admission	No	47	29.4
	Yes	113	70.6
Number of ED presentations	Median (IQR)	5.0 (2.0–15.0)	—
Number of CT scans in ED	Median (IQR)	2.0 (1.0–3.0)	—
Time since most recent shunt placement/revision, mo	Median (IQR)	1.0 (1.0–6.0)	—
Number of VP shunt placements	Median (IQR)	1.0 (1.0–2.0)	—
Revision-confirmed shunt-related pathology	No	117	73.1
	Yes	43	26.9
<i>IQR, interquartile range; IVH, intraventricular hemorrhage; VP, ventriculoperitoneal; CT, computed tomography; ED, emergency department.</i>			

Shunt-related pathology requiring revision was identified in 43 patients (26.9%). The remaining 117 patients (73.1%) did not undergo shunt revision and had ED diagnoses attributed to non-shunt-related acute pediatric conditions.

Acute diagnoses recorded during ED visits

Acute diagnoses recorded across ED visits are shown in Table 2. The most common diagnosis was URTI, recorded in 83.8% of patients, with a median of 3 URTI-related visits among affected patients. Acute

gastroenteritis and LRTI were each recorded in 32.5% of patients. Seizure was documented in 24.4% of patients. Diagnoses classically overlapping with shunt malfunction—seizure, nausea/vomiting, and fever—were less frequent than respiratory and gastrointestinal diagnoses.

Table 2
Emergency department presenting complaints

Presenting complaint	n	%	Visits, median (IQR)	Min–Max
Upper respiratory tract infection	134	83.8	3 (1.0–7.3)	1–94
Acute gastroenteritis	52	32.5	2 (1.0–4.0)	1–18
Lower respiratory tract infection	52	32.5	3 (2.0–4.0)	1–52
Seizure	39	24.4	2 (1.0–2.0)	1–16
Soft tissue disorder	23	14.4	3 (2.0–4.0)	1–15
Nausea/vomiting	21	13.1	2 (1.0–2.5)	1–3
Fever	15	9.4	1 (1.0–3.0)	1–4
Urinary tract infection	12	7.5	1 (1.0–3.5)	1–8
Otitis	4	2.5	2.5 (2.0–3.0)	2–3
Pneumonia	4	2.5	1 (1.0–1.0)	1–1
Falls	2	1.3	1 (1.0–1.0)	1–1
Burns	2	1.3	1 (1.0–1.0)	1–1
Other (each n = 1)*	7	4.4	—	—
*Other category includes (n = 1 each): testicular torsion, cardiac arrest, cerebral palsy, septicemia, acute bronchitis, and meningitis. IQR, interquartile range.				

Between-group comparison

Patients with and without shunt-related pathology were compared with respect to demographic variables, clinical course, CT utilization, and etiology (Table 3). No significant between-group differences were observed for sex ($P = 0.815$), age ($P = 0.560$), total number of ED presentations ($P = 0.823$), time since most recent shunt placement/revision ($P = 0.406$), or hydrocephalus etiology ($P = 0.455$). The number of CT examinations was numerically higher in the shunt-related pathology group but did not reach statistical significance (median, 2.0 vs 1.0; $P = 0.071$). Hospital admission was more frequent in the shunt-related pathology group (100.0% vs 59.8%; $P < 0.001$), an expected finding because revision-confirmed shunt pathology generally required inpatient management.

Table 3
Demographic and clinical characteristics according to shunt-related pathology status

Variable	No pathology (n = 117)	Pathology (n = 43)	P value
Sex – Male, n (%)	61 (52.1)	24 (55.8)	0.815
Sex – Female, n (%)	56 (47.9)	19 (44.2)	
Age, y, median (IQR)	4.0 (2.0–5.0)	4.0 (3.0–6.0)	0.560
Number of ED presentations, median (IQR)	5.0 (2.0–16.5)	5.0 (3.0–12.0)	0.823
Number of CT scans in ED, median (IQR)	1.0 (1.0–3.0)	2.0 (1.0–3.0)	0.071
Time since most recent shunt placement/revision, mo, median (IQR)	1.0 (1.0–1.0)	1.0 (1.0–1.0)	0.406
Hospital admission, n (%)	70 (59.8)	43 (100.0)	< 0.001
Etiology – Congenital, n (%)	41 (35.0)	19 (44.2)	0.455
Etiology – Myelomeningocele, n (%)	33 (28.2)	15 (34.9)	
Etiology – IVH, n (%)	19 (16.2)	2 (4.7)	
Etiology – Other, n (%)	24 (20.5)	7 (16.3)	
Pearson χ^2 test; Mann–Whitney U test. The 7 etiology categories were tested jointly. IQR, interquartile range; IVH, intraventricular hemorrhage; ED, emergency department; CT, computed tomography.			

Acute diagnoses associated with shunt-related pathology

Among the acute diagnoses analyzed, only seizure was significantly associated with shunt-related pathology (37.2% vs 19.7%; OR, 2.42; 95% CI, 1.12–5.22; P = 0.037) (Table 4; Fig. 1). No statistically significant association was found for URTI, LRTI, acute gastroenteritis, nausea/vomiting, fever, soft tissue disorder, or UTI. The diagnostic performance of seizure was limited as a stand-alone screening marker: sensitivity was 37.2%, specificity 80.3%, PPV 41.0%, and NPV 77.7%. Thus, seizure increased the probability of shunt-related pathology when present but could not exclude shunt-related pathology when absent.

Table 4
Association of ED presenting complaints with shunt-related pathology

Presenting complaint	No pathology, n (%)	Pathology, n (%)	P value	Interpretation
Seizure*	23 (19.7)	16 (37.2)	0.037 [‡]	↑ Red flag
Nausea/vomiting	13 (11.1)	8 (18.6)	0.327 [‡]	Inconclusive
Soft tissue disorder	21 (17.9)	3 (7.0)	0.132 [‡]	Inconclusive
Fever	11 (9.4)	5 (11.6)	0.905 [‡]	Nondiscriminatory
Urinary tract infection	8 (6.8)	4 (9.3)	0.735 [‡]	Nondiscriminatory
Acute gastroenteritis	39 (33.3)	10 (23.3)	0.302 [‡]	Nondiscriminatory
Lower respiratory tract infection	43 (36.8)	13 (30.2)	0.562 [‡]	Nondiscriminatory
Upper respiratory tract infection	101 (86.3)	33 (76.7)	0.224 [‡]	Nondiscriminatory

[‡] Pearson χ^2 test; [§] Fisher exact test. *Diagnostic performance of seizure: sensitivity 37.2%, specificity 80.3%, positive predictive value 41.0%, negative predictive value 77.7%. ED, emergency department.

Discussion

This retrospective cohort study shows that most pediatric VP shunt patients presenting to the ED and evaluated by neurosurgery did not have revision-confirmed shunt-related pathology during the study period. Among 160 patients, 26.9% underwent shunt revision, whereas 73.1% had no revision-confirmed shunt pathology. These findings support a more nuanced ED approach: clinicians must maintain a low threshold for identifying dangerous shunt malfunction, but the presence of a VP shunt should not automatically override systematic assessment for common pediatric illnesses.

The patient-level nature of the analysis is important. Our findings should not be interpreted as showing that exactly three-quarters of all ED visits are unrelated to the shunt. Rather, they indicate that, among children with VP shunts who presented to the ED and were referred for neurosurgical evaluation, most patients did not ultimately require shunt revision. Future visit-level studies should evaluate each ED presentation as an index event and determine whether revision occurred during that visit or within a prespecified follow-up interval.

Seizure was the only acute diagnosis significantly associated with shunt-related pathology. However, its diagnostic performance was imperfect: sensitivity was 37.2%, meaning that most patients with revision-confirmed shunt pathology did not have seizure recorded, while PPV was 41.0%. Accordingly, seizure should be interpreted as a clinically relevant warning feature rather than a stand-alone diagnostic test. The distinction between new-onset seizure, breakthrough seizure in known epilepsy, febrile seizure, and

seizure related to underlying neurologic comorbidity could not be reliably assessed in this retrospective dataset and should be captured prospectively.

Large-scale studies of pediatric ED visits identify URTI, fever of unknown origin, gastroenteritis, and pneumonia as the most common presenting reasons [12–14]. In our cohort, URTI (83.8%), gastroenteritis (32.5%), and LRTI (32.5%) led the list—a pattern that closely mirrors that of the general pediatric population. A child with a VP shunt is ultimately a child, most often presenting for the same viral infections and systemic illnesses as peers without shunts.

The overall admission rate (70.6%) substantially exceeds the rate of shunt-related pathology (26.9%); even within the no-pathology group, 59.8% were admitted. Children with neurologic disorders have a 5- to 7-fold higher risk of hospitalization for respiratory infections than the general pediatric population [15], consistent with our findings. Longer initial hospital stays and comorbidities such as bronchopulmonary dysplasia also increase admission rates in patients with VP shunts [16].

The clinical presentation of shunt malfunction is shaped by signs of increased intracranial pressure: in older children, severe and progressive headache, nausea and vomiting, visual blurring, and altered mental status; in infants and young children, irritability, feeding difficulty, lethargy, and increased fontanelle bulging. Unexplained seizures—particularly new-onset or breakthrough seizures—are a strong warning sign [5]. Our data confirm seizure as the sole statistically significant discriminator among the complaints captured in retrospective ED records; nausea/vomiting ($P = 0.327$) and fever ($P = 0.905$) did not differ between groups, underscoring the need for prospective evaluation of other classic findings.

Patients underwent a median of 2 CT examinations across visits, yet the marginal association between CT use and shunt-related pathology ($P = 0.071$) suggests limited diagnostic discrimination. Cohen et al [17] reported 2.6 CTs per patient over 9 months in children with VP shunts. A multicenter study showed that institutional shunt volume was not associated with rates of emergent CT use or revision [18]. Hulsbergen et al demonstrated that routine cranial imaging after pediatric shunt revision provides limited clinical utility [19].

The long-term risks of unnecessary CT in pediatric patients are well documented. An Australian cohort of 680,000 children showed a 24% higher overall cancer incidence and a 44% higher brain tumor incidence after CT [20], and a large UK cohort showed that 2 to 3 cranial CTs before age 22 nearly tripled the risk of brain tumor [21]. Radiation-free rapid brain MRI provides diagnostic value comparable to CT in children with VP shunts when clinically feasible [11].

Based on these findings and the existing literature, a selective rather than reflexive approach is warranted. Systemic clinical evaluation should precede radiologic testing. Red flags warranting suspicion of shunt-related pathology include seizure (particularly new-onset or breakthrough seizure), severe or progressive headache or projectile vomiting, altered mental status, fontanelle bulging or increased head circumference in infants, restricted eye movements, redness or tenderness along the shunt tract, and Cushing triad. Patients with none of these features and a clear benign acute etiology

may be observed clinically. High-suspicion patients should follow a stepwise imaging algorithm, beginning with shunt-series radiographs and progressing to rapid MRI or CT. Febrile patients require specific evaluation for shunt infection. Prospective, multicenter validation of this approach is essential to preserve pediatric radiation safety and optimize health system resource use.

Limitations

This study has several limitations. First, it is a single-center retrospective cohort study; however, our institution is the sole pediatric referral hospital for the region, which partially mitigates this limitation. Second, to minimize the data-loss inherent to retrospective designs, we used both the hospital information management system and the e-Nabız national health record system, although some data may still have been incomplete. Third, the raw data did not contain sufficient discriminatory information to subclassify shunt-related pathology (malfunction vs infection), as these were coded as a combined variable, and CSF analysis (cell count, protein, glucose, culture) and microbiologic data could not be reliably retrieved retrospectively for all patients. Because the clinical management, imaging preferences, and prognosis differ between malfunction and infection, this distinction is clinically important; prospective studies should systematically collect CSF analysis and microbiologic data to enable this distinction. Fourth—and methodologically important—certain classic warning signs of shunt malfunction (headache, altered mental status, irritability, fontanelle bulging, lethargy, and abnormal eye movements) were not coded separately in ED records and could not be analyzed retrospectively, although seizure, nausea/vomiting, and fever were captured by distinct ICD-10 codes. This limited systematic evaluation to seizure and a few other specific complaints. Fifth, although ICD-10–based screening provides objective ascertainment, multiple-code assignment of the primary complaint in some patients is a potential limitation. Sixth, the external validity of the proposed suspicion framework has not been tested in an independent cohort; prospective validation studies of the clinical red flags are warranted. Finally, the absence of a control group (children of similar age without VP shunts) limits direct comparison with the general pediatric population.

Conclusions

In this patient-level cohort of pediatric VP shunt patients presenting to the ED and evaluated by neurosurgery, approximately one-quarter had revision-confirmed shunt-related pathology. Respiratory and gastrointestinal diagnoses were common, highlighting that many presentations reflect general pediatric illness rather than shunt failure. Seizure was associated with shunt-related pathology but had limited sensitivity and should be interpreted as a warning feature, not a definitive screening tool. These findings support prospective validation of selective, symptom-guided ED pathways that combine systemic clinical evaluation, neurologic red flags, and judicious imaging to protect children from both missed shunt malfunction and unnecessary radiation exposure.

Abbreviations

CT
computed tomography
CSF
cerebrospinal fluid
ED
emergency department
ICD
International Classification of Diseases
IQR
interquartile range
IVH
intraventricular hemorrhage
LRTI
lower respiratory tract infection
NPV
negative predictive value
PPV
positive predictive value
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
UTI
urinary tract infection
URTI
upper respiratory tract infection
VP
ventriculoperitoneal

Declarations

Ethics approval and consent to participate

The study was approved by the Harran University Ethics Committee (Approval No: HRÜ/23.03.08) and was conducted in accordance with the principles of the Declaration of Helsinki. Individual patient consent was waived by the ethics committee owing to the retrospective nature of the study and the use of de-identified data.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Contribution

B.E. and A.B. conceived and designed the study. M.K. and B.Ü. performed patient identification, clinical follow-up, and data acquisition. B.E., A.B., and Ü.Z. interpreted data and performed statistical analyses. Ü.Z. and A.B. conducted the literature review. B.E. drafted the manuscript; all authors provided critical revisions for important intellectual content. All authors read and approved the final manuscript.

Acknowledgements

Not applicable.

Availability of data and materials

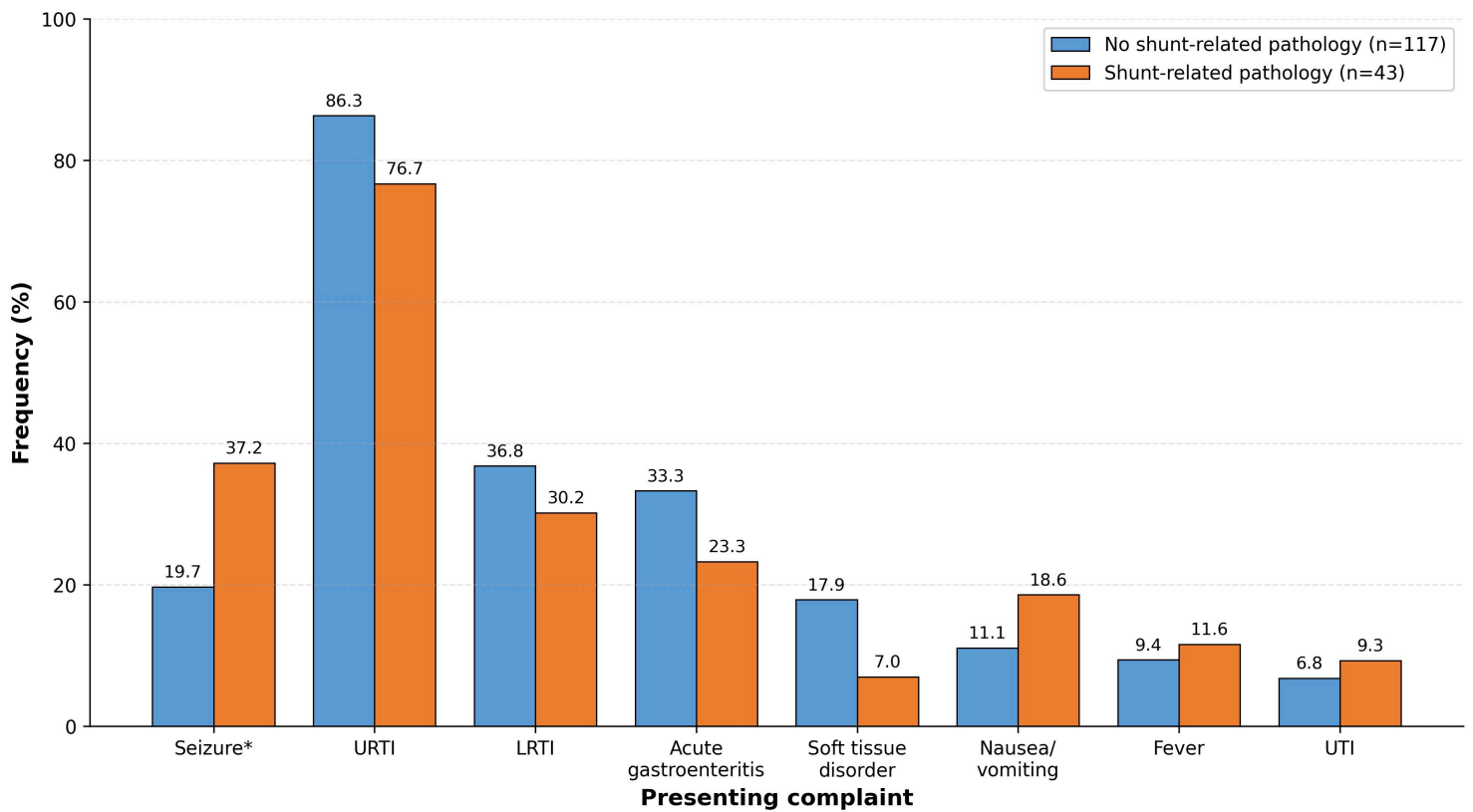
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

References

1. Dewan MC, Rattani A, Mekary R, et al. Global hydrocephalus epidemiology and incidence: systematic review and meta-analysis. *J Neurosurg*. 2019;130(4):1065–79.
2. Miranda P, Simal JA, Menor F, et al. Initial proximal obstruction of ventriculoperitoneal shunt in patients with preterm-related posthaemorrhagic hydrocephalus. *Pediatr Neurosurg*. 2011;47(2):88–92.
3. Madikians A, Conway EE. Cerebrospinal fluid shunt problems in pediatric patients. *Pediatr Ann*. 1997;26(10):613–20.
4. Gonzalez DO, Mahida JB, Asti L, et al. Predictors of ventriculoperitoneal shunt failure in children undergoing initial placement or revision. *Pediatr Neurosurg*. 2017;52(1):6–12.
5. Lee TT, Uribe J, Ragheb J, et al. Unique clinical presentation of pediatric shunt malfunction. *Pediatr Neurosurg*. 1999;30(3):122–6.
6. Hari-Raj A, Malthaner LQ, Shi J, et al. United States emergency department visits for children with cerebrospinal fluid shunts. *J Neurosurg Pediatr*. 2021;27(1):23–9.

7. Kurwale NS, Agrawal D. Phase-contrast MRI of intracranial shunt tube: a valuable adjunct in the diagnosis of VP shunt malfunction. *Clin Neurosurg*. 2011;58:138–42.
8. Glerum KM, Selbst SM, Parikh PD, Zonfrillo MR. Pediatric malpractice claims in the emergency department and urgent care settings from 2001 to 2015. *Pediatr Emerg Care*. 2021;37(7):e376–9.
9. Riddle S, Meinzen-Derr J, Tabangin M, et al. Emergency department utilization among pediatric spina bifida patients. *J Pediatr Rehabil Med*. 2019;12(4):375–81.
10. Miglioretti DL, Johnson E, Williams A, et al. The use of computed tomography in pediatrics and the associated radiation exposure and estimated cancer risk. *JAMA Pediatr*. 2013;167(8):700–7.
11. Koral K, Blackburn T, Bailey AA, et al. Strengthening the argument for rapid brain MR imaging in children with shunted hydrocephalus. *AJNR Am J Neuroradiol*. 2012;33(10):1851–4.
12. Wier LM, Yu H, Owens PL, Washington R. Overview of children in the emergency department, 2010. *HCUP Statistical Briefs*. Rockville, MD: Agency for Healthcare Research and Quality; 2006.
13. Yoong SYC, Ang PH, Chong SL, et al. Common diagnoses among pediatric attendances at emergency departments. *BMC Pediatr*. 2021;21(1):172.
14. Massin MM, Montesanti J, Gerard P, Lepage P. Spectrum and frequency of illness presenting to a pediatric emergency department. *Acta Clin Belg*. 2006;61(4):161–5.
15. Havers F, Fry AM, Chen J, et al. Hospitalizations attributable to respiratory infections among children with neurologic disorders. *J Pediatr*. 2016;170:135–41.
16. McGrath-Morrow SA, Ahn ES, Collaco JM. Respiratory outcomes after initial hospital discharge in children with ventricular shunts and bronchopulmonary dysplasia. *Pediatr Pulmonol*. 2017;52(10):1323–8.
17. Cohen JS, Jamal N, Dawes C, et al. Cranial CT utilization for suspected VP shunt malfunction in a pediatric emergency department. *J Emerg Med*. 2014;46(4):449–55.
18. Florin TA, Aronson PL, Hall M, et al. Emergency department use of computed tomography for children with ventricular shunts. *J Pediatr*. 2015;167(6):1382–8.
19. Hulsbergen AFC, Siddi F, McAvoy M, et al. The low utility of routine cranial imaging after pediatric shunt revision. *J Neurosurg Pediatr*. 2022;29(3):276–82.
20. Mathews JD, Forsythe AV, Brady Z, et al. Cancer risk in 680,000 people exposed to computed tomography scans in childhood or adolescence. *BMJ*. 2013;346:f2360.
21. Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours. *Lancet*. 2012;380(9840):499–505.

Figures



* $P < .05$ (statistically significant). All other comparisons $P \geq .132$.

Figure 1

Distribution of emergency department presenting complaints by presence of shunt-related pathology. Only seizure was significantly more frequent in patients with shunt-related pathology (37.2% vs 19.7%; $P = 0.037$). All other comparisons were not statistically significant ($P \geq 0.132$). URTI, upper respiratory tract infection; LRTI, lower respiratory tract infection; UTI, urinary tract infection.