

## **Abstract**

**Introduction:** Children whose ventricles do not change during shunt malfunction are a diagnostic dilemma. This study identifies risk factors for unchanged ventricular size at shunt malfunction.

**Methods:** This retrospective 1:1 age-matched case-control study identified children with shunted hydrocephalus who underwent shunt revision with intraoperative evidence of malfunction at one of the three participating institutions from 1997-2019. Cases were defined as patients with a change in the frontal-occipital horn ratio (FOR) between malfunction and baseline of  $< 0.05$ , while controls included FOR changes  $\geq 0.05$ . The presence of infection, abdominal pseudocyst, pseudomeningocele, wound drainage, and lack of baseline cranial imaging at the time of malfunction warranted exclusion.

**Results:** Of 450 included patients, 60% were male, 73% were Caucasian, 67% had an occipital shunt, and median age was 4.3 [IQR 0.97, 9.21] years at malfunction. On univariable analysis, unchanged ventricles at malfunction were associated with a: frontal shunt (41% vs 28%,  $p<0.001$ ), programmable valve (17% vs 9%,  $p=0.011$ ), non-siphoning shunt (85% vs 66%,  $p<0.001$ ), larger baseline FOR ( $0.44 \pm 0.12$  vs  $0.38 \pm 0.11$ ,  $p<0.001$ ), no prior shunt infection (87% vs 76%,  $p=0.003$ ), and no prior shunt revisions (68% vs 52%,  $p<0.001$ ). On multivariable analysis with collinear variables removed, patients with a frontal shunt (OR 1.67 [95% CI: 1.08, 2.70],  $p=0.037$ ), programmable valve (OR 2.63 [95% CI: 1.32, 5.26],  $p=0.007$ ), non-siphoning shunt at malfunction (OR 2.76 [95% CI: 1.63, 4.67],  $p<0.001$ ), larger baseline FOR (OR 3.13 [95% CI: 2.21, 4.43],  $p<0.001$ ), and no prior shunt infection (OR 2.34 [95% CI: 1.27, 4.30],  $p=0.007$ ) were more likely to have unchanged ventricles at malfunction.

**Conclusion:** In a multicenter cohort of children with shunt malfunction, those with a frontal shunt, programmable valve, non-siphoning shunt, baseline large ventricles, and no prior shunt infection were more likely than others to have unchanged ventricles at shunt failure.