Table 1: A Summary of the Causes of Shunt Malfunction[1,6,9,10]

Type of Malfunction	Timing	Clinical features/ Signs	Location	Cause	Imaging	Management
Obstruction	At any point in lifespan of CSF shunt	Signs of raised ICP e.g. nausea & vomiting, CN palsies	Ventricular catheter tip Shunt valve Distal catheter (less common)	Occlusion by in-growth of choroid plexus Occlusion by blood and debris Adhesions, scarring, torsion/kinking of distal shunt	CT head: hydrocephalus Shunt series may be normal	Manometry: may show sluggish/absent pressures if occlusion is at or distal to the valve Surgical revision of CSF shunt
Mechanical Shunt Failure						
Shunt fracture	Late (years after insertion)	Mildly elevated ICP Pain, erythema and swelling at fracture site	Most common location along shunt is near the clavicle or adjacent to lower ribs	Degradation of shunt material due to debris, local reactions and infections. Tethering of shunt by scar tissue; increased risk of shearing	Shunt series: may show a gap between two segments of a shunt	Surgical correction or exploration if shunt fragments are retained. May need to consider alternative tract
Disconnection	Early	Signs of raised ICP Palpable fluid accumulation along length of shunt	Catheter-valve connection Valve-distal tubing connection	Idiopathic; poorly secured with sutures, poor positioning	Shunt series - may show a gap in the tubing at points of connection between catheter and valve or valve and distal tubing CT head may show dilated ventricles	Surgical correction
Migration	Early	Signs of raised ICP Palpable change in position of the shunt	Chest wall Peritoneal entry site	Adequately placed shunt has moved out of original trajectory to suboptimal draining site	Comparison of CT with previous images	Surgical repositioning
Misplacement (into brain parenchyma, choroid plexus or omentum)	Early	Signs of raised ICP or abdominal discomfort (with distal misplacement) Risk of infection/ hemorrhage	Proximal or distal catheter	Idiopathic; incomplete evaluation of anatomy and improper insertion of the shunt or use of inadequate apparatus	CT head may show dilated ventricles after some delay. CT abdomen CXR for misplaced ventriculo-atrial catheter	Surgical revision

(*continued*)

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Type of Malfunction	Timing	Clinical features/ Signs	Location	Cause	Imaging	Management
Loculation	Late	Signs of ICP		Inadequate drainage of CSF due to extra non-communicating fluid-filled compartments	Iohexol intraventricular dye study	Insertion of additional drainage system
Overdrainage						
Extra axial fluid collection	Early	Sunken fontanelles, microcephaly and over-riding sutures in young children Nausea, vomiting, and lethargy	Ventricular system	Excess removal of CSF	CT head Extra-axial fluid collection around brain, risk of subdural hematomas	Conservative if small with no risk of herniation. Replacement with more resistant valve. Burr hole to relieve pressure.
Slit ventricle syndrome	Late	Sunken fontanelles, microcephaly and over-riding sutures in young children Signs of ICP Symptoms worse when upright	Ventricular system	Excess removal of CSF. Ventricles collapse around the proximal catheter due to increased distal negative pressure.	Small ventricles on CT head	Shunt revision
Infection						
Shunt Infection	Early (within 2 months of shunt placement)	Irritability, lethargy, pain Fever (nonspecific) Manifestation of infection on skin, and subcutaneous structures: Skin breakdown and peritoneal infection		Early shunt infections *S. epidermidis* *S. aureus* Late shunt infections (6 months) Gram negative infections	CT head/ shunt series The CT head may show dilated ventricles or, in rare cases, additional fluid collections e.g. with severe localized empyema Shunt aspirated and fluid sent for microbiology and culture	Surgical revision/ extraventricular drainage catheter Externalization of infected distal tubing Consider broad-spectrum antibiotic coverage e.g. vancomycin and cefotaxime