Imaging CSF Shunts and their Complications

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CSF Physiology

- Choroid plexus produces 400-600 mL per day of cerebrospinal fluid (CSF), with 150mL present at any given time (125 mL subarachnoid + 25 mL intraventricular)
CSF absorbed by arachnoid villi and lymphatics
- **Monro-Kellie doctrine**: a dynamic pressure-volume equilibrium exists within the rigid skull between the brain parenchyma, blood, and CSF
- Hydrocephalus (↑CSF volume) alters this intracranial pressure-volume equilibrium. Examples:

Communicating

CSF can exit the ventricular system but cannot be absorbed

subarachnoid hemorrhage

leptomeningeal carcinomatosis

Non-communicating (obstructive)

CSF cannot exit the ventricular system

colloid cyst

tectal glioma

Abnormal CSF dynamics

normal pressure hydrocephalus (NPH)

choroid plexus papilloma (may also be obstructive)

CSF Shunts

- CSF shunts attempt to restore the pressure-volume equilibrium
Fixed shunt valve (FSV) – fixed flow rate

(note the lack of a rotatory dial)

Programmable shunt valve (PSV) – adjustable flow rate using an external codified magnetic tool; ideal for NPH, complex hydrocephalus (Dandy-Walker, Chiari)

Sophysa Polaris

pumping reservoir

Cephalad marker (curvilinear line)

ball-in-cone spring valve

rotatory dial (changes flow rate)

*Each PSV manufacturer has a unique rotatory dial and radiopaque markers (refer to user guide). [Aesculap PSV not shown]

Codman Certas

Medtronic Strata

Codman Hakim

Shunt courses

- Ventriculoperitoneal (VP)
- Ventriculoatrial (VA)
- Ventriculopleural (VPL)
- Lumboperitoneal (LP)

Imaging evaluation of shunts

- **XR shunt series**: AP+lateral views along shunt course
Assess shunt integrity (fracture, disconnection, kinking)
- **NM scintigraphy**: ≤ 0.4mL [^{99m}Tc-pertechnetate, ^{99m}Tc-DTPA, or ¹¹¹In-DTPA (0.25-1.5 mCi)] into reservoir, supine position, obtain initial flow and delayed planar images
Differentiate proximal/distal limb obstruction, locate site of leak or obstruction
- **US**: targeted evaluation
Evaluate for loculations/pseudocyst
- **CT**: cross-sectional view of area of interest
Assess ventricle size, complications along shunt course
- **MR**: single-shot T2 of ventricles
Assess ventricle size without radiation, limited evaluation of shunt valve itself (susceptibility artifact)

Potential MRI interactions with shunts

Shunt type	MR field strength*	Performance	Screening radiograph after MR exam
FSV	Conditional at 1.5/3T	Not affected	Not required
PSV	Conditional at 1.5/3T	Potential adjustment of flow rate ¹	Recommend radiograph (or interrogation with magnet device) to check settings

*Refer to manufacturer guide for spatial gradient magnetic field and specific absorption rate limits. Do not place local transmit coils over valve.
¹The *Sophysa Polaris* PSV has not demonstrated inadvertent valve setting changes by high magnetic field strengths of up to 3T, although the similarly appearing *Sophysa SM8* and other PSVs may be altered.

CSF shunt complications

- Approximately 1/3rd of all shunts fail within 1 year of placement

Post-op hemorrhage

Malpositioned tip at right internal capsule

Shunt fracture

CSF peritoneal pseudocyst

Radioisotope leak to occipital/neck soft tissues

Pseudomonas shunt infection (from RUQ abscess, edema along shunt tract)

Overshunting (slit-like ventricles + new subdural hygromas)

Other complications: shunt migration, kinking, ventricular loculation, ascites (VP), pleural effusion (VPL), pulmonary arterial hypertension (VA), thromboembolic disease (VA), tricuspid valve injury (VA)

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Nothing to disclose

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