Radiological evaluation of ventriculoperitoneal shunt systems

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Learning objectives

To present important aspects in the radiological evaluation of ventriculoperitoneal shunt systems.

Background

Introduction:

Ventriculoperitoneal shunts are implanted for the treatment of hydrocephalus. In hydrocephalus intracranial pressure is increased above the normal (approximately 12 cm H$_2$O) [1]. Occlusive and communicating forms of hydrocephalus can be differentiated. As a special form hydrocephalus e vacuo should be mentioned, this form is usually not treated neurosurgically. Among the typical causes of hydrocephalus are subarachnoid hemorrhage, menigitis, craniocerebral injury and intracranial tumour. Among the causes of infantile hydrocephalus are aqueductal stenosis, Dandy-Walker-malformation or Arnold-Chiari-malformation Typ I and II [2].

Surgical Technique:

Different neurosurgical techniques are applied. Commonly the ventricular catheter is placed in the frontal horn of the lateral ventricle of the non-dominant hemisphere through a frontal burr hole. Alternatively an occipital burr hole can be used as an insertion site. If existent valves, gravitation compensation devices / antisiphon devices and reservoirs are placed subgalealy in the descending portion of the shunt in a lateral or retroauricular position. The different catheter portions are linked by connectors. The catheter is commonly advanced subcutaneously to the right or middle epigastrium, where it is placed intraperitonealy, in small children with approximately 30 cm length of intraperitoneal tubing to allow for continued growth [1, 4].

Valve components:

Various valves (including valves with a fixed opening pressure, valves with programable opening pressure and gravitation dependent valves), connectors and catheters are in use.

Miscellaneous differential-pressure actuated system are in use, including ball valve, slit valve and membraneous valve mechanisms. These differ not only in their liability to be agglutinated by protein or blood components, but also in their response to pressure changes, resulting in different frequencies of over-drainage syndroms.
Gravitation actuated devices allow different pressure settings depending on the body position. Additional pressure stages of approximately 15-60 cm H₂O lead to an increased drain resistance in upright position.

**Imaging findings OR Procedure details**

**Radiological assessment:**

When patients with a ventriculoperitoneal shunt present with neurological or even unspecific clinical symptoms, imaging is often performed to evaluate the integrity of the system.

Conventional radiological imaging is often performed to identify components, check the valve setting and for further assessment in cases of assumed malfunction. Plain x-rays to visualize the entire shunt are obtained (AP & lateral skull x-ray, AP chest x-ray and AP abdominal x-ray, sometimes even lateral abdominal x-ray). The valve should lie against the film for the lateral skull x-ray.

Cranial CT is often performed to additionally assess the width of the ventricles. Furthermore the exact position of the ventricular catheter can be evaluated. Ultrasound can be used for further evaluation of the intraperitoneal catheter, the last resort should be an abdominal CT for exact evaluation of the catheter position and structures adjacent to the catheter.

For certain clinical questions MRI can become necessary in ventriculoperitoneal shunt patients.

**Imaging findings of possible complications:**

Various direct complications can be assessed by imaging. Obstruction of the proximal part, the valve mechanism or the distal part may lead to enlargement of ventricles in CT. Disconnection of catheter parts (often associated with dislocation of the two ends) usually occurs at the connectors but can occur anywhere else following breakage of shunt components. Catheters can dislocate with growth as they might become to short (Figure 1-3). Hardware erosion through the skin, which can indicate allergy, is rarely reported. Misplacement of shunt components can be evaluated to some extent using plain x-ray, however often CT is performed for exact assessment of the position (Figure 4). Along the whole course of the shunt misplacement can occur. Placement of the distal catheter in the stomach or an inguinal hernia has been reported (Figure 5). Residual shunt components can remain following revision surgery in all parts of the course of the shunt. Imaging of the abdomen can show signs of complications such as volvulus, infection or perforation. Shunt failure caused by meteorism has been reported [3].

**Identification of valves and MRI compatibility:**
Identification of the valve type based on the plain x-ray information can be supported by patient history, shunt pass and medical documents. Synopses on commonly used systems can be found in the literature [1]. When information on rarely used types is necessary, it can usually be found in the internet.

Concerning the currently relevant information on the MRI compatibility of the systems we refer to the manufacturer’s data. However a comprehensive overview on the various systems can be found in the handbook of MRI safety by Shellock [4].

A valve adjustment mechanism based on magnetic force transmission is the reason for the sensitivity to magnetism. This mechanism is used as the subcutaneously located valves can this way be readjusted externally. If a valve is placed in a magnetic field, the valve setting determining the drain resistance can be changed. Innovative valve systems try to avoid this problem using magnetically adjustable valves that have to be unlocked using external mechanical pressure first.

Images for this section:

Fig. 1: Temporal dislocation of the ventricular catheter at the connector in a young patient (A) Cranial CT shows the course of the ventricular catheter (B)
Fig. 2: Chest X-ray in a patient who received multiple follow-up studies due to cardiovascular surgery, note the disconnection of the catheter at the connector.
**Fig. 3:** Tear of the abdominal catheter with dislocation of the ends, no connector can be seen.

**Fig. 4:** Ventricular catheter placed on the left side. The tip surmounts the midline (A). The puncture reservoir, adjustable valve and gravitation compensation device can be depicted on the lateral view (B). Cranial CT shows exact position of the ventricular catheter (C).
**Fig. 5:** Abdominal x-rays show an atypical position of the abdominal catheter. Projection of catheter parts on stomach and esophagus (A, B). CT secures the intragastral misplacement (C). 3D-Volume Rendering of the catheter course (D).
Conclusion

Imaging can provide valuable information on the type of shunt system, the MRI compatibility, the pressure setting and causes of malfunction in the evaluation of ventriculoperitoneal shunt systems.

Personal Information

References


