Radionuclide shuntography for cerebrospinal fluid shunt malfunction diagnosis

- Radionuclide shuntography for cerebrospinal fluid shunt flow evaluation in adults
- Clinical value of radionuclide shuntography by qualitative methods in hydrocephalic adult patients with suspected ventriculoperitoneal shunt malfunction
- Evaluation of shunt function in hydrocephalic patients with the radionuclide 99mTc-pertechnetate
- The complementary role of plain radiographs and radionuclide shuntography in evaluating CSF-VP shunts

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Radionuclide shuntography is a imaging technique used to assess the patency and function of cerebrospinal fluid shunts in patients who have undergone shunt placement to treat conditions such as hydrocephalus.

Here's how radionuclide shuntography works for diagnosing CSF shunt malfunction:

Radiotracer Injection: A small amount of a radioactive substance, known as a radiotracer (usually technetium-99m or indium-111), is injected into the CSF reservoir or shunt valve. This radiotracer is tagged to molecules that are actively transported in the CSF.

Imaging: After the injection, the patient undergoes a series of nuclear medicine imaging scans, typically involving single-photon emission computed tomography (SPECT) or gamma camera imaging. These scans track the movement of the radiotracer as it flows through the CSF system.

Evaluation: The images obtained during the scan are analyzed to assess the flow of CSF through the shunt system. The radiotracer should follow a normal pattern, moving from the shunt reservoir or valve through the shunt tubing and into the designated drainage site (e.g., peritoneal cavity or heart atrium). Abnormalities in the tracer flow, such as blockages or shunt malfunction, can be detected through this imaging process.

Diagnosis: If the radionuclide shuntography shows normal flow patterns, it suggests that the CSF shunt is functioning properly. However, if the scans reveal irregularities, it may indicate a shunt malfunction. The exact nature of the malfunction (e.g., obstruction, disconnection, overdrainage, underdrainage) can often be determined based on the observed flow patterns and the location of the abnormality.

Radionuclide shuntography is a valuable diagnostic tool for identifying CSF shunt malfunctions, as it provides real-time functional information about the shunt system. This helps healthcare providers make informed decisions about whether shunt revision or replacement is necessary.

It's important to note that while radionuclide shuntography is a useful diagnostic tool, it is typically reserved for cases where other clinical assessments and imaging studies (e.g., CT scans, MRI) have not provided conclusive evidence of shunt malfunction. Additionally, the procedure involves exposure to radiation, so the risks and benefits must be carefully considered for each individual patient.

Nandoliya et al. retrospectively reviewed all RS studies performed between November 2003 and June 2022. Patients with shunted hydrocephalus who were ≥ 18 years of age were included. Patients undergoing RS for evaluation of Ommaya reservoirs were excluded. Demographics, hydrocephalus etiology, presenting symptoms, study results, subsequent management, complications, and intraoperative diagnoses were recorded. Chi-square tests were reported for categorical variables and standard 2 × 2 contingency methods were used for sensitivity/specificity analysis.

They identified 211 RS procedures performed in 142 patients. The mean age at procedure was 55.6 ± 20.9 years (mean ± SD). Normal pressure hydrocephalus was the most common hydrocephalus etiology (37.0%), followed by congenital malformations (26.1%) and idiopathic intracranial hypertension (15.6%). Successful radionuclide injection was achieved in 207 studies (98.1%). Shunt patency was confirmed in 63.8% of successful injections, whereas malfunction was demonstrated in 27.1% and abnormally slow flow was seen in 9.2%. RS studies demonstrating shunt malfunction were more likely to result in subsequent revisions than were studies showing patency (86.6% vs 2.9%; $p < 0.0001$). The overall sensitivity and specificity of RS for detecting shunt malfunction was 92.3% and 96.2%, respectively. The median follow-up time was 29 months, with 151 cases having ≥ 6 months of follow-up. There were no complications or infections attributable to RS in this cohort.

RS is a useful and safe tool in the workup of shunt malfunction [1)]

Adult patients who underwent Tc-99m diethylenetriamine pentaacetic acid shuntographic scans at Far Eastern Memorial Hospital between August 2005 and December 2015 were included. Shuntographic results were visually evaluated in a simple qualitative manner: prompt flow that reached the peritoneum on 30-minute early images and diffuse peritoneal tracer distribution on 2-hour delayed images were interpreted as nonobstructive shunt flow. Partial dysfunction was diagnosed as scintigraphic findings between no obstruction and complete obstruction (where complete malfunction indicated no peritoneal distribution on delayed images). The results were correlated with the clinical outcomes and surgical results within 30 days. Diagnostic sensitivity (Se), specificity (Sp), positive predictive value (PPV), negative predictive value (NPV), and overall accuracy were also calculated. A total of 93 scans in 69 patients with suspected V-P shunt malfunction were analyzed. Sixty-two scans were interpreted as abnormal, including complete (n = 26, 41.9) distal obstruction, partial (n = 35, 56.5) distal dysfunction, and miscellaneous (n = 1, 1.6, cerebrospinal fluid leak). The Se and Sp were 83.0% and 55.0%, respectively, and PPV, NPV, and accuracy were all 71.0%. Twenty-five patients (28 scans) underwent surgical revision, and the results were highly concordant with the imaging findings (Se, 92.0%; Sp, 100.0%; PPV, 100.0%; NPV, 60.0%; and accuracy, 92.9%). Radionuclide shuntography provides useful information in adult patients with V-P shunt malfunction and could be used to guide further surgical intervention [2)].

The radiopharmaceutical (Tc-99m diethylenetriaminepentaacetic acid) was injected via the reservoir for VP shunt and via lumbar puncture needle in subarachnoid space for LP shunt, then serial image in the head and abdominal area. The normal function of VP and LP shunt usually rapid spillage of the radioactivity in the abdominal cavity diffusely. The patent proximal tube VP shunt demonstrates ventricular reflux. The early image of patent LP shunt reveals no activity in the ventricular system contrast to distal LP shunt reveals early reflux of activity in the ventricular system. The completed distal VP and LP shunt obstruction show absence of tracer in the peritoneal area or markedly delayed appearance of abdominal activity. The partial distal VP and LP shunt obstruction recognized by slow transit or accumulation of tracer at the distal end or focal tracer in the peritoneal cavity near the tip of distal shunt. The images of the normal and abnormal CSF shunt as describe before are present in the full paper. Radionuclide CSF shuntography is a reliable and simple procedure for assessment shunt patency [3].

In most cases of shunted hydrocephalus, shunt malfunction is evaluated by clinical examination and neuro-imaging. However if there is a discrepancy between neurological examination and imaging, additional shuntography can be helpful in the evaluation of the shunt function. In our clinic, radionuclide-imaging shuntography using (99m)technetium-pertechnetate was performed in 85 children between 1992 and 1995. The results of shuntography were evaluated visually and from time-activity curves. Shuntography had a sensitivity of 96%, a specificity of 89%, and an accuracy of 93%, proved either by surgery or by clinical follow-up for 2-5 years. Corresponding to these results, we recommend the use of shuntography in cases with an uncertain shunt function before surgical [4].

Cerebrospinal fluid-ventriculoperitoneal shunts are often used in the treatment of hydrocephalus in children. Many complications can arise that may lead to shunt malfunction, including detachment of the distal limb of the shunt. A case is presented where such a complication occurred with distal migration of the detached tubing into the abdomen, which resulted in a patent subcutaneous tract through which cerebrospinal fluid could drain. The need for radiographic correlation at the time of radionuclide shuntography is stressed [5]

1)
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