Evaluation of MR Cisternography in Diagnosis of Cerebrospinal Fluid Fistula

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Purpose : *To study the clinical usefulness and sensitivity of MR cisternography as noninvasive study in the diagnosis of CSF fistula in patients with clinical diagnosis CSF rhinorrhea or otorrhea.*
Method : *Thirty-five patients with clinically diagnosed CSF leakage were examined for site of dural tear with MR cisternography with additional plain high-resolution CT in some cases from Jan. 1999 to Dec.2002. The MR imaging technique was performed as a heavily T2 weighted fast spin echo study with fat suppression in axial, coronal and sagittal projections. Criteria for positive results were demonstrable fistular tract connecting subarachnoid space to paranasal sinus/petrous bone, and/or dural discontinuity, and/or bone defect with pneumocephalus, and/or presence of brain herniation. Eighteen of the patients subsequently had exploratory surgery for fistula. Sensitivity analysis of the surgical results was compared with the findings at MR cisternography.*
Result : *MR cisternography showed significant correlation with surgical findings with sensitivity of 89%. Additional high resolution CT were complete agreement with site of fistular tract. The pathogenesis of CSF leakage was related to trauma (86%). The commonly found dural/bony defect and location of connecting fistular tract were cribriform plate and ethmoid sinus of 58%, 55% respectively.*
Conclusion : *In the presence of clinically diagnosed CSF leakage, the combination of MR cisternography and plain high-resolution CT are highly accurate in locating the site and extent of CSF fistula and should be considered a viable noninvasive alternative to CT cisternography and Tc-99m-DTPA cisternography.*

Keywords : *CSF fistula, CSF rhinorrhea, CSF otorrhea, MR cisternography*

J Med Assoc Thai 2004; 87(12): 1471-6
Full text. e-Journal: *http://www.medassocthai.org/journal*

CSF fistula has been a diagnostic challenge. Radiologic localization of cranial CSF fisula can be difficult but it is essential for successful surgical repair, thereby eliminating the chance of negative or recurrent exploration. Accurate preoperative localization has become important since the newer minimally invasive surgical technique especially nasal endoscopic surgery is used for treatment of CSF fistula and the field of view is limited.

Numerous diagnostic studies have been used for over two decades, CT cisternography has been considered the most reliable and accurate method of diagnostic CSF fistula[1], however, this technique is invasive, time consuming, and is contraindicated in patients with active meningitis.

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Radionuclide cisternography using Tc-99m-DTPA via the lumbar puncture is also sensitive for detecting CSF leakage but it does not provide the precise localization[2].

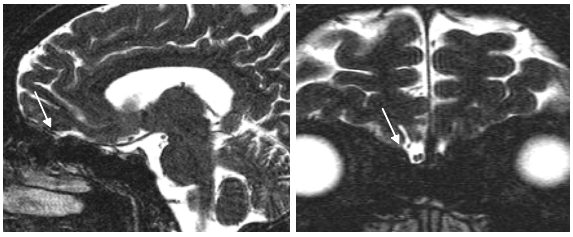
MR cisternography is a noninvasive and accurate diagnostic imaging technique. This technique does not involve the use of contrast material or spinal puncture. It can detect CSF fistula by inherent bright signal of CSF in T2 weighted images with suppression and substraction of adjacent background tissue signal by means of a fast spin-echo protocol with fat supression[3]. Coronal unenhanced thin-section CT is also valuable, noninvasive technique that depicts small bony defect at the site of CSF leak. The combination of these techniques is safe, less time-consuming and highly accurate in locating the site and extent of CSF fistula and should considered a viable alternative for CT cisternography[4].

Material and Method

A total of 35 MR cisternographic studies were performed in 35 patients with the diagnosis of CSF leakage during the period from Jan 1999 to Dec 2002 at Ramathibodi Hospital. The patient ranged in age from 3 to 68 years (mean age, 36 years) and included 20 males and 15 females. Criteria for clinically diagnosed CSF leakage were 1) the presence of clear fluid leaking from the nose or ear, 2) if the fluid containing blood or a mixture of CSF and nasal discharge, simple test was used by placing nasal discharge into the hankerchief with positive "bull's eye sign"[5]. Most of the patients were sent for a quantitative measurement of glucose content which were 05-0.67 that of the serum glucose concentration.

Most of the patients were examined with a 1.5 Tesla superconductive magnet (Signa, General Electric) with 9.1 X Advantage software and a standard head coil. A fast spin-echo heavily T2 weighted sequence with fat suppression was used with parameters of 8000-10000/200/4 (TR,TEeff/excitations), echo train length of 16, a 512x 256 matrix, no phase wrap option, 3-mm-thick interleaved contiguous sections and 20-24 cm field of view. Twenty sections were acquired to cover the area required including paranasal sinuses or petrous bones in axial, coronal an sagittal projections. Additional high resolution thin-section coronal CT in bone algorithm in 8 patients.

The MR cisternographic examinations were interpreted only with the knowledge of clinical history including CSF rhinorrhea or otorrhea. Criteria for diagnosis of fistula were 1) presence of continuous high T2 signal from the subarachnoid space to the paranasal sinuses or petrous bone and/or 2) presence of discontinuity of the dural line, (Fig. 1) and /or 3) presence of bone defect with air communicating from the paranasal sinuses to the intracranium, (Fig. 2) and/or 4) presence of brain herniation into the sinuses or petrous bone (Fig. 3). MR cisternography was considered negative for CSF fistula if a definite dark dural line was seen completely separating CSF of the cranial cavity from the high signal fluid in the paranasal sinuses or petrous bone and no evidence of a fistular tract was found. (Fig. 4) Results of surgery were classified as positive if one or more CSF fistulae were identified or localized and negative if no fistula was found and was used as a reference of standard. Surgical criteria for diagnosis of CSF fistula at craniotomy was presence of violation of the dura and osseous defect. At nasal endoscopy, a CSF fistula was diagnosed when an osseous defect of the sinus was identified with an accompanying dural defect with presence of clear fluid and with or without the presence of herniated brain tissue.



A B

Fig. 1 Positive MR cisternography in a patient with post-traumatic CSF rhinorrhea sagittal. (A) and Coronal (B) MR cisternogram shows hypersignal T2 fistular tract connecting subarachnoid space and the right ethmoid sinus (long white arrows in A and B), confirmed at surgery.

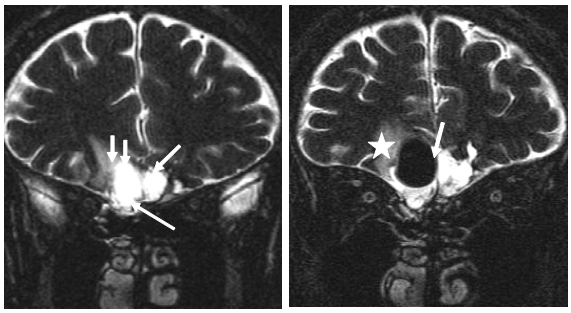


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Fig. 2 Coronal MR cisternography of a patient with post-traumatic right CSF rhinorrhea revealed moderate bilateral subfrontal encephalomalacia (small white arrows in A and B) with evidence of hypersignal CSF through the torn dura (thin white arrow in A). Also seen is pneumocephalus (white star in B) indicating fracture base of skull connecting the anterior cranial fossa with the paranasal sinuses.

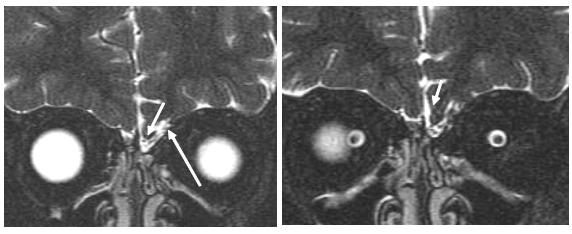

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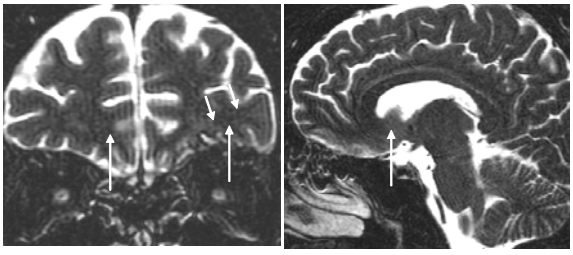
Fig. 3 Positive MR cisternography in a patient with post-traumatic left CSF rhinorrhea.
A,B. Coronal MR cisternogram shows bony/dural defect at the left cribriform plate, fistular tract (long white arrow in A) and herniation of the gyrus rectus into the left anterior ethmoid sinus (short white arrows in A and B).



A B

Fig. 4 Negative MR cisternography in a patient with post-traumatic right CSF rhinorrhea which was improved with medical treatment.
A,B. Coronal and sagittal MR cisternogram shows clear seperation of CSF fluid beneath right frontal lobe and air in the right ethmoid sinus by a dark intact dural line (long white arrows in A and B). Contusion of the inferior left frontal lobe is observed (short white arrows in A).

Results

Of the 35 patients, twenty- five presented with CSF rhinorrhea, five with CSF otorrhea, four with recurrent meningitis and one with hemotympanum. Review of the clinical charts indicated that precipitating events for CSF leakage were related to trauma in 86% and non traumatic in 14% (Table 1). Of the patients who experienced surgery relating precipitating events, ten had undergone craniotomy, two had undergone transphenoidectomy for pituitary tumor removal, one had undergone endoscopic sinus surgery and two had undergone various neurosurgical procedures. The congenital anomaly occurred in one child with Mondini's deformity.

Of the 35 patients included in the present study, six revealed no evidence of dural tear at MR cisternography despite histories of CSF leakage. None of these patients underwent subsequent imaging or intervention. All of these patients were treated conservatively. Four of six had no evidence of CSF leakage at the time of clinical follow-up. The remaining two had continuity of the CSF leakage.

MR cisternography depicited CSF positive result in twenty-nine patients, accounting for 83% of the group. The fistular tracts were identified. The presence of dural discontinuity, osseous defects, herniated brain parenchyma were found in twenty-four, fifteen and three respectively. Pneumocephalus was found in five. The fistular tracts were connecting into the ethmoidal, frontal, sphenoid sinuses and in the petrous bone (Table 2). The most common sites of dural defect/osseous defect was the cribriform plate, followed by tegmen tympani, planum sphenoidale, the sphenoid sinus, junction of the cribriform plate and fovea ethmoidalis in orderly frequency (Table 3). In seven patients, additional high-resolution CT showed bone defects six of which completely agreed with MR cisternography result. Only one patient had additional bone defect without evidence of CSF leakage.

Eighteen of the twenty-nine positive MR patients underwent surgical repair, sixteen of them via craniotomy and the remaining two via endoscopic nasal surgery, all of them were found to have dural defects or fistular tracts revealed by MR cisternogram. For sixteen of eighteen patients, the site of CSF leak was identified by direct visualization of the dural/bone defect or clear fluid leakage from the subarachnoid space which correlated with positive findings in MR cisternogram. In two patients, the sites of leakage were not found due to severe adhesion from previous surgery in which a subsequent CSF leakage developed. The CSF leakage stopped immediately after surgery in fifteen patients. The sensitivity of the examination was calculated for surgically proved cases = 89%. Speci-

Table 1. Pathogenesis of clinically diagnosed CSF leakage in 35 patients

	No. of patients (n=35)
Trauma	30
Noniatrogenic	15
Iatrogenic	15
Nontraumatic	5
Spontaneous	4
Congenital	1

Table 2. Location of connecting fistular tract from subarachnoid space

	No. of patients (n=29)
Ethmoid sinus	16
Frontal sinus	3
Sphenoid sinus	4
Petrous bone	4

Table 3. Sites of documented dural/bony defect

	No. of patients (n=24)
Cribriform plate	14
Junction of cribriform plate and foveal ethmoidalis	2
Planum sphenoidale	3
Sphenoid sinus	2
Tegmen tympani	4

ficity could not be determined because there were no true-negative results for the patients.

In eleven of the twenty-nine patients, there was no surgical confirmation of visualized dural defect or CSF leakage detected in MR cisternography because the patients refused surgery. However, the side of the defect corresponded to the side (left/right) of the clinical CSF leakage. Ten of all experienced spontaneous resolution of the CSF leakage with bed rest or medical treatment. The remaining one had continuity of the CSF leakage without further treatment, therefore, no follow-up record was available (Table 4).

Discussion

Over the years, different techniques have yielded varying rates of success in the attempts to accurately locate the CSF fistula. Precise localization of the CSF fistula helps in surgical planning and enhances the chance of successful dural repair, thus precluding the negative or recurrent exploration. Surgical plugging of a CSF fistula is important, as the fistula can be a source of recurrent pyogenic meningitis. The current investigators put the risk of recurrent pyogenic meningitis at 4%[4].

Plain CT studies alone have shown that detection of a CSF fistula is low. However Prashant G. et al revealed that high resolution CT correctly identified a CSF fistula or its absence with accuracy, sensitivity and specificity in 92%,92% and 100%. High resolution CT (upto 1 mm) sections through the region of interest with bone algorithm to enhance bone detail is extremely useful in detecting fractures/bone defect that are or could be the site(s) of CSF leakage. It would be also be difficult to rely only on high-resolution CT in the presence of multiple fractures or a hairline fracture of the skull base because only bony fracture without dural tear will not cause CSF leakage[6].

For more than a decade CT cisternography has been considered to be the standard of reference for diagnosis of CSF fistula. CT cisternography had a higher success rate than other techniques in locating the site of CSF leakage, reaching 92% in active leakage and 40% in inactive leakage. However, CT cisternography is invasive, time-consuming, a slight uncomfortable for the patient and carries slightly risk for complications such as headache and infection. It is relatively contraindicated in patients with active meningitis or raised intracranial pressure. Radionuclide cisternography using Tc-99m-DTPA via the lumbar puncture is also highly sensitive for detecting CSF leakage but it does not provide precise anatomic localization.

Table 4. Final outcomes of positive MR patients

	No. of patients (n=29)
Surgical treatment	18
Completely resolved	15
Persisted leaking	3
Conservative treatment	11
Completely resolved	10
Persisted leaking	1

The MR cisternography is a noninvasive technique that can detect a CSF fistula in multiple planes without the disadvantage of lumbar puncture and ionizing radiation. On the heavily T2-weighted fast spin-echo sequence, the inherent bright signal of CSF is well seen against the black background with fat suppression protocol. The bone defect may not always be well appreciated on MR images. Prashant et al revealed the MR cisternography alone could be accurately depict a CSF fistula or its absence with accuracy, sensitivity and specificity = 89%, 87%, 100% respectively. Complementary MR cisternogram and high resolution CT revealed accuracy, sensitivity and specificity = 96%, 95% and 100% respectively with 100% positive predictive value[7].

In the present series, eighteen of twenty-nine patients underwent surgery on the basis of demonstrable fistular tracts and/or dural defect with evidence of corresponding bony defect in six additional high resolution CT. For sixteen of the eighteen, site of CSF leakage correlated with positive findings in MR cisternogram with sensitivity = 89%. The CSF leakage stopped immediately after surgery in sixteen patients. In two patients, the sites of leakage were not found due to severe adhesion from previous surgery. The pathogenesis of CSF leakage related to trauma was found in 86% in contradiction to the previous study of Prasant et al[7] in 46% of the group study. The most frequent sites of documented dural/bony defect and location of connecting fistular tract from the subarachnoid space were cribriform plate and ethmoid sinus respectively following the previous study which could be due to the thinnest bony structure of the skull base.

Six patients had negative results. All patients in the present study underwent imaging only on the basis of clinically diagnosed CSF leakage. It would have been useful to evaluate the nasal or external ear fluid by laboratory analysis for the presence of CSF in doubtful cases of CSF leakage. B2-transferrin analysis has recently gained favor in identification of CSF. The

protein is highly specific for human CSF and only a small sample size is required without need for special handling or refrigeration. The test would confirm the presence or absence of CSF leakage. All six patients did not obtain the B-transferrin analysis due to lack of availability. Moreover, most CSF leakage are intermittent, the sensitivity of the MR cisternography is dependent on the time of examination which may increase the frequency of false negative diagnosis at MR cisternogram in inactive leakage. The term active CSF leakage indicates the presence of CSF leakage at the time of clinical presentation; likewise, inactive CSF leakage indicates lack of CSF leakage at the time of clinical presentation. Manelfe et al reported only 33% accuracy rate of fistula in patients with inactive CF leak[8]. Ten of eleven patients in the present series with positve MR cisternogram as well as patients with negative MR cisternogram who had no surgical intervention receiving conservative treatment by bed rest, elevation of the head, avoidance of coughing, sneezing or nose blowing and the administration of prophylactic antibiotic therapy resolved from CSF leakage.

Conclusion

MR cisternography is an efficacious, non-invasive, cost-effective imaging technique for evaluation of suspected CSF rhinorrhea and otorrhea with a sensitivity of 89% compared to the surgical results. The authors recommend the combination of plain high resolution CT scans followed by MR cisternography as optimal imaging approach for these patients.

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การประเมินผลการตรวจหารอยรั่วของน้ำไขสันหลังของสมองโดยใช้การตรวจคลื่นแม่เหล็กไฟฟ้า

โลจนา ตันติยาทร, จิรพร เหล่าธรรมทัศน์

วัตถุประสงค์ *: เพื่อประเมินประสิทธิภาพและประโยชน์ทางคลินิคในการใช้การตรวจคลื่นแม่เหล็กไฟฟ้าในการหารอยรั่วของน้ำไขสันหลังของสมอง*

วิธีการศึกษา *: เป็นการศึกษาย้อนหลังในผู้ป่วยจำนวน 35 รายที่ได้รับการวินิจฉัยว่ามีน้ำไขสันหลังของสมองรั่วทางจมูกหรือหู โดยผู้ป่วยได้รับการตรวจคลื่นแม่เหล็กไฟฟ้า (MR cisternography) โดยใช้เทคนิค heavily T2-weighted fast spin echo ในท่า axial, coronal และ sagittal ทุกรายร่วมกับ High–resolution CT ในบางราย ระหว่างเดือนมกราคม 2542 - ธันวาคม 2545 โดยใช้ข้อกำหนดว่ามีรอยรั่วคือ 1) เห็นทางของน้ำไขสันหลังที่เชื่อมต่อระหว่างน้ำไขสันหลังในสมองกับน้ำในโพรงจมูกหรือหูชั้นกลาง หรือ 2) รอยฉีกขาดของเยื่อหุ้มสมองชั้น dura หรือ 3) มีรอยแตกของกระดูกฐานกระโหลกร่วมมีลมเข้าไปอยู่ในสมอง หรือ 4) มีเนื้อสมองยื่นเข้าไปในโพรงอากาศ การประเมินความแม่นยำในการหาตำแหน่งของรอยรั่วโดยเปรียบเทียบกับผลการผ่าตัด*

ผลการศึกษา *: เมื่อเปรียบเทียบตำแหน่งของรอยรั่วที่พบในการผ่าตัดกับผลการตรวจจาก MR cisternography พบว่า MR cisternography ให้ความแม่นยำ (sensitivity) = 89% สาเหตุที่พบบ่อยที่สุดเกิดจากการบาดเจ็บ ตำแหน่งที่มีการฉีกขาดของ dura พบบริเวณ cribriform plate และมีน้ำไขสันหลังรั่วเข้าใน ethmoid sinus มากที่สุด*

สรุป *: จากการศึกษาพบว่าในผู้ป่วยที่สงสัยว่ามีรอยรั่วของน้ำไขสันหลังเข้าในโพรงอากาศหรือหูชั้นกลาง MR cisternography เป็นวิธีการตรวจที่ให้ความแม่นยำสูงในการบอกตำแหน่งของรอยรั่วใช้ทดแทนการตรวจ CT cisternography ซึ่ง invasive ได้*