Digital subtraction cisternography: a new approach to fistula localisation in cerebrospinal fluid rhinorrhoea

J V Byrne, C E Ingram, D MacVicar, F M Sullivan, D Uttley

Abstract

Positive contrast cisternography with digital subtraction of fluoroscopy images before computed tomography (CT) was employed in the investigation of eight patients with cerebrospinal fluid (CSF) rhinorrhoea. Fistulae were visualised by preliminary digital subtraction cisternography (DSC) in six patients and in five patients the sites of leakage were confirmed at surgery. Fluoroscopy facilitated interpretation of CT in all the positive studies and in two patients provided information which could not be deduced from CT cisternography (CTC) alone. The combined technique is recommended for the investigation of patients with recurrent and post operative CSF rhinorrhoea and when CTC alone fails to identify the site of leakage.

Successful surgical repair of cerebrospinal fluid (CSF) fistulae depends on accurate preoperative localisation.¹ Several diagnostic techniques have been advocated for such localisation which can be notoriously difficult.² These techniques rely on the intrathecal injection of a CSF marker to confirm the leak and demonstrate its situation. Substances that have been used include dyes such as indigo carmine or fluorescein, albumen labelled with technetium 99m, pantopaque and metrizamide.³⁻⁹ Leakage is confirmed by contamination with extrathecal contrast of cotton wool pledgets and its site is inferred from their placement in the nasal spaces.

Localisation by pledget staining or radionuclide scanning is an exacting technique which may give only limited anatomical detail.^{5 10 11} Computed tomography (CT) provides the best topographical information and for this reason is now widely used in conjunction with positive contrast cisternography.^{8 9 12 13} However, contrast may not be demonstrated within the fistula track and, as above, the leak site has to be inferred from the distribution of extrathecal contrast. Previous attempts to visualise contrast within the fistula by fluoroscopy were unsuccessful because of the relative unsuitability of the available agents due to excessive viscosity or toxicity.^{14 15} Recently introduced low osmolar contrast agents are

less viscous and toxic so that concentrations sufficient for fluoroscopy can be used intracranially. Fluoroscopy allows dynamic viewing of contrast leakage and digital subtraction of the video signal can be used to improve image quality.¹⁶ We have employed this approach, combined with CT cisternography, in the investigation of patients with CSF rhinorrhoea.

Method

Digital subtraction cisternography was performed when the patient was or had recently been leaking CSF. No specific premedication was prescribed, but regular anticonvulsant therapy was continued and patients with a strong history of iodine allergy or seizures refractory to treatment were not studied.

A standard lateral cervical puncture was performed with a 22G spinal needle. The position of the prone patient's head and the tilt of the table was adjusted until a small test injection of Iohexol 240 mgI/ml (Omnipaque, Nycomed Ltd) flowed freely over the clivus. The patient's head was then immobilised in a padded head clamp (Elema-Schonander) fitted to the fluoroscopy table. Contrast was injected until the entire subfrontal subarachnoid space was outlined. This was monitored by continuous lateral fluoroscopy and usually took between three and five minutes. The volumes of Iohexol required varied from 8 ml to 12 ml. Digital subtraction of the recorded video signal was performed on an IDIS (Quantel Ltd) mobile subtraction system.

Patients then transferred to the CT scanner, still in the prone position, with cotton wool plugs in both nostrils. Thin slice scans (1.5 mm) were performed in the coronal plane from the frontal sinuses to the dorsum sellae. The patient then turned supine and axial scans (5 mm slice thickness) of the skull base were performed. Following the procedure patients were confined to bed for 12 hours and remained in hospital under observation for a minimum period of 24 hours.

Results

Eight patients were examined by DSC for CSF rhinorrhoea. Four patients gave a history of head injury and in four patients rhinorrhoea occurred soon after cranial surgery. The average duration of symptoms was three

Atkinson Morley's
Hospital, Wimbledon,
London

Department of
Neuroradiology

J V Byrne
C E Ingram
D MacVicar
F M Sullivan

Department of
Neurosurgery
D Uttley

Correspondence to:
Dr Byrne, Department of
Neuroradiology, Atkinson
Morley's Hospital,
Wimbledon, London SW20
0NE, United Kingdom.

Received 3 May 1989
and in final revised form
28 February 1990.

Accepted 23 March 1990

Table Summary of patient details and radiological findings

Case	Age Sex	Previous surgery	Leak	DCS findings fistula visualised	Site	Leak	CTC findings Fistula visualised	Site	Findings Confirmed at surgery
Post traumatic rhinorrhoea									
1*	47 M	Anterior fossa repair	Yes	Yes (2 sites)	Cribriform, Sella	Yes	Yes (1 site)	Sella	Yes
2†	62 F	Anterior fossa repair	Yes	Yes	Frontal sinus	Yes	No	Frontal sinus	Yes
3	42 M	Anterior fossa repair	No	—	—	No	—	Petrous dural herniation	Yes
4	51 M	None	Yes	Yes	Petrous	Yes	Yes	Petrous	No
Post operative rhinorrhoea									
5	50 M	Transphenoidal Hypophysectomy	No	No	—	Yes	No	Staining of nasal pledgets only	No
6	64 M	Orbital clearance and cranioplasty	Yes	Yes	Cranioplasty	Yes	No	Orbit and frontal sinus	Yes
7	67 M	Orbital clearance and ethmoidectomy	Yes	Yes	Optic nerve sheath	Yes	No	Orbit	Yes
8	34 M	Resection of temporal fossa sarcoma	Yes	Yes	Middle fossa floor	Yes	No	Operative cavity and antrum	Yes

*Multiple fistulae.
†First attempt at DSC inconclusive due to inadequate immobilisation.

months, varying between 12 years and three weeks. Seven patients were actively leaking during the examination or had leaked during the preceding 24 hours. Three patients examined for leaks following head injury were referred for management of recurrent leaks

Figure 1 Case 1: CT cisternogram in the coronal plane showing contrast in an empty sella. The bony floor of the sella is deficient and contrast can be seen in the lateral part of the sphenoid sinus on the left.

Figure 2 Case 1: Lateral negative subtraction image of the skull base showing contrast filling the sella and posterior part of the anterior cranial fossa. Two fistulae are demonstrated by contrast leaking into the sphenoid and middle ethmoid sinuses (arrows).

after previous attempts at surgical repairs. Details of the patients and the radiological findings are summarised in the table.

Nine examinations were performed in the eight patients. One examination was inconclusive due to degradation of the subtracted images by misregistration artifact caused by head movement during fluoroscopy. Following introduction of the head clamp this patient was successfully re-examined.

The escape of cisternal contrast through dural fistula was visible on DSC studies in six patients. These fistulae were confirmed at operation in five patients; one patient with a middle ear fracture was managed expectantly and leakage ceased without treatment. Fistulae were not demonstrated in two patients. One patient (Case 3) with a history of intermittent rhinorrhoea and recurrent meningitis was not actively leaking when examined and no fistula or contrast leak was seen at DSC or CTC but the latter demonstrated a bony defect in the petrous mastoid through which a dural sac herniated into the middle ear cleft. This defect was repaired and the patient has experienced no further symptoms to date.

The other patient developed rhinorrhoea 12 months after transphenoidal hypophysectomy for Cushing’s disease. No leak was seen at DSC nor was a defect identified on CTC but contrast staining of nasal pledgets was demonstrated. Surgical exploration was deferred after he developed an abdominal abscess and CSF rhinorrhoea ceased spontaneously. Review CT scan nine months later demonstrated a recurrent intrasellar mass due to pituitary hyperplasia which presumably closed the fistula.

Computed tomographic cisternography confirmed CSF leakage in seven patients. These studies demonstrated contrast within dural fistulae in two patients. In a further four patients contrast was not visualised in the fistula but was identified in an operative cavity or adjacent sinus and in one patient staining of nasal pledgets was the only evidence of leakage.

Interpretation was facilitated by considering the two studies together since, in two patients CTC on its own could have been confusing. In case 1 the presence of two fistulous tracks could not be inferred from the

Figure 3 Case 4: Lateral positive subtraction image, contrast is flowing along the clivus from the cervical needle (bottom left) and filling the chiasmatic cistern. Contrast outlines the fistula (arrows) and is seen collecting in the nasopharynx.

CTC findings. This study demonstrated a defect in the floor of the sella and contrast pooled in the sphenoid and posterior ethmoid sinuses but not the fistulous tracts (fig 1). The DSC showed contrast leaking via the sella floor into the sphenoid sinus and demonstrated a second fistula through the cribriform plate into the ethmoid sinuses (fig 2). Similarly, in case 6 the CTC findings were ambiguous. This patient experienced rhinorrhoea soon after a frontal cranioplasty and resection of an orbital sarcoma. The frontal sinus was broached during the procedure and CTC demonstrated contrast pooling in the frontal sinus and orbit suggesting that the fistula originated in the sinus and the orbit was secondarily contaminated. However, DSC clearly demonstrated that the fistula originated at the lateral edge of the cranioplasty and that contrast flowed via the orbit to the frontal sinus and nasal cavity.

Patients tolerated the whole procedure well. The majority of patients experienced headache during intracisternal injection of contrast. This was transient, clearing within 15 minutes in all but two patients who were treated with oral analgesics. There were no other complications.

Discussion

Cerebrospinal fluid rhinorrhoea is most commonly caused by trauma and the anterior cranial fossa floor is the usual site of a fistula. Spontaneous rhinorrhoea may be due to a congenital bone defect with meningocele, or bone erosion by tumour or chronically raised intracranial pressure.^{6,17} Traumatic fistulae usually settle without surgical repair, 70%

closing within one week of injury and most within six months.² Non-traumatic fistulae and leaks developing after skull base surgery are less likely to close spontaneously,¹⁸ and require repair since persistent rhinorrhoea is associated with recurrent meningitis in 15–20% of patients.¹⁹

Computed tomography combined with positive contrast cisternography is widely employed for pre-operative assessment of patients with CSF fistulae. The technique can demonstrate fistulae outlined by contrast and/or contrast in adjacent paranasal sinuses and may show associated fractures. Failure to demonstrate contrast within the fistula track may be due to intermittent leakage, tortuosity of the track or a defect which is very large and does not retain contrast. Manelfe *et al*²⁰ proposed that fistulae be diagnosed only if contrast was visualised in a bone defect or when a defect was demonstrated in association with an extrathecal collection of contrast. In the latter instance localisation is indirect since the fistula's course must be inferred from the sites at which extrathecal contrast pools. Bone discontinuity identified by CT may not be the site of the fistula if the dura matter is intact.²¹

Fluoroscopy of the skull base during contrast filling of the basal cisterns gives the investigator a dynamic view and increases the likelihood of demonstrating contrast within a fistula. Furthermore recording the video signal for subsequent analysis of the sequence in which extrathecal contrast appears helps in the interpretation of the fistula's path and the demonstration of multiple tracks. Digital subtraction of the video signal¹⁶ improves the images but demands strict immobilisation of the patient. Since subtraction depends on images obtained before and after the arrival of contrast, only one view is possible unless biplane equipment is available.

Transient headache was the only complication experienced by our patients. We attribute this to the presence of intracranial radiographic contrast. Contrast volumes used for DSC were approximately twice those employed for CT cisternogram but the intracranial dose is difficult to quantify since some leaks into the fistula and some caudally into the spine. Drayer and Rosenbaum²² and Ahmadi *et al*²³ reported delayed headache and nausea with vomiting in about one third of patients having cisternography with metrizamide. Persistent headache occurred in a quarter of our patients but was not associated with vomiting or other symptoms. Currently available non-ionic contrast agents are associated with a lower incidence of post-myelogram headache and less neurotoxicity.²⁴ Injection by lateral cervical puncture should not, in experienced hands, add to the risk or complexity of the procedure.

Digital subtraction cisternography before CT involves additional radiation exposure. The exposure involved in fluoroscopy is small relative to CTC. The maximum output of our fluoroscopy unit is 3 milliamperes and the average duration of the examination was 4.5 minutes resulting in an exposure of 810 milliamperere seconds (mAS). This compares

with an exposure of 560 mAS for each CT slice and approximates to the radiation exposure involved in a barium meal. Care must be exercised in such comparisons since other factors influence the absorbed dose particularly the kilovoltage employed. CT and fluoroscopy operate at 140 and 90 kilovolts respectively; the higher energy beam results in a relatively lower absorbed dose. However, high resolution CT of the anterior cranial fossa requires a minimum of 10–15 slices.

To justify using DSC it must provide diagnostic information superior to that of CTC alone. Our results show that DSC achieved direct visualisation of fistulae in the majority (six of eight examinations) whereas contrast was demonstrated in fistulae by CTC in only two patients. Other reports, which distinguish between the demonstration of contrast within fistulae and indirect localisation suggest that CTC can achieve direct localisation in 30–37% of patients.^{20,25} Furthermore DSC provided unique information in two studies. It could be argued that DSC should only be used when CTC has failed. Since the morbidity is little more than that associated with lumbar puncture and the two techniques so complimentary we would argue that they are best combined.

In summary, the dynamic view provided by digital subtraction cisternography allows more confident demonstration of CSF fistula particularly in larger defects associated with post operative rhinorrhoea. It gives information additional to that available from CTC alone including the demonstration of multiple fistulae. These results were achieved without the introduction of a second invasive procedure and with minimal additional discomfort to the patient. The technique is recommended in combination with CTC or when CTC has failed to identify the site of leakage.

We thank Mrs H Outhwaite and Mrs G Thompson for typing the manuscript.

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