AJNR

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AJNR Am J Neuroradiol 1984, 5 (6) 797-800
http://www.ajnr.org/content/5/6/797

Nonefficacy of Routine Removal of CSF during Neurodiagnostic Procedures

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The charts of 750 patients were reviewed to determine the value of routinely removing cerebrospinal fluid at the time of myelography and cisternography for chemical and cytologic examination. In most patients cerebrospinal fluid findings were normal. In the few abnormal studies, the findings were often uninformative, superfluous, or insufficient for appropriate diagnosis. In no instance did routine analysis of cerebrospinal fluid uncover occult disease. Routine removal of cerebrospinal fluid for analysis in radiologic spinal taps seems to be inappropriate, and removal should be dictated by the clinical context in which the procedure is performed.

The removal of cerebrospinal fluid (CSF) at the time of a neuroradiologic study is a common practice. It is considered by many to be a routine part of the myelographic or cisternographic procedure. Indeed, acquisition of CSF is described as an important step in myelography in at least three textbooks currently used in radiology training programs [1–3].

Little consideration has been given to the efficacy of this practice. Is the routine removal of CSF warranted in all patients undergoing myelography or cisternography? How often are the CSF studies abnormal? Which CSF studies should be done routinely? Do the clinicians use the information obtained?

To help answer some of these basic questions and provide some guidelines for the acquisition of CSF, we reviewed the medical records (charts) of 750 patients who underwent pertinent neurodiagnostic studies. Each of the patients had CSF removed at the time of the study, the usual procedure at our institutions. Each chart was examined to determine the results of the CSF studies and if the results seemed to affect patient management.

Materials and Methods

Charts were reviewed from 656 consecutive myelograms, 54 metrizamide cisternograms, and 40 air cisternograms. Table 1 delineates the distribution of cases by preprocedure diagnosis. In most patients CSF had been drawn in two tubes, one for routine determinations of blood cell count, appearance, and color; the other for glucose and protein. In some cases additional CSF studies had been requested by the clinicians; these included culture and sensitivity, smear, cytology, or multiple sclerosis battery (e.g., myelin basic protein, immunoelectrophoresis).

The CSF was considered to be abnormal if the laboratory determinations did not fall within predetermined normal limits or did not coincide with generally accepted standards of normality [4–7]: (1) Appearance was abnormal if the CSF was other than clear and colorless, usually having been centrifuged; (2) Normal range of total protein was 15–45 mg/dl and glucose was 45–80 mg/dl. For bloody CSF samples an additional allowance was made for an increase in protein by 1 mg/dl for every 700 red blood cells (RBCs); (3) The normal number of white blood cells (WBCs) was less than five, with none of these cells being polymorphonuclear neutrophils. An appropriate adjustment was made for bloody CSF samples, in which one WBC was allowed for every 700 RBCs; (4) There was no strict criterion for absolute number

This article appears in the November/December 1984 issue of *AJNR* and the February 1984 issue of *AJR*.

Received January 30, 1984; accepted after revision May 4, 1984.

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***AJNR* 5:797–800, November/December 1984**
0195–6108/84/0506–0797

TABLE 1: **Preprocedure Diagnoses in Patients Undergoing Routine CSF Removal during Myelography and Cisternography**

Study: Indication	No. of Cases
Myelography:	
Radioculopathy	208
Pain, stenosis, spondylolisthesis	177
Myelopathy, multiple sclerosis, polyneuropathy	87
Mass, metastasis	80
Trauma, surgery	36
Tethered cord, meningomyelocele, diastematomyelia	22
Scoliosis	21
Infection	8
Syringomyelia	8
Arteriovenous malformations	3
Other	6
Subtotal	656
Cisternography:	
Cerebellopontine angle mass	48
Brainstem, cerebellar tumor	14
Sellar/suprasellar mass, empty sella	10
Cephalocele, arachnoid cyst	7
Arnold-Chiari malformation	6
CSF rhinorrhea	5
Other	4
Subtotal	94

of RBCs. Although most sources suggested that the normal number of RBCs should be very low, no specific numbers were given. RBC determinations were based on the acquisition of serial tubes of CSF to help distinguish a traumatic from an atraumatic puncture, and so were difficult to apply to our method of obtaining only the one tube for blood cell count. For our purposes RBCs were considered abnormal when paired with a report of abnormal appearance (e.g., xanthochromia). CSF cytology, culture and sensitivity, and smear were considered abnormal if positive.

All charts were reviewed to determine what, if any, effect the results of the CSF studies had on the patient's clinical course. Special attention was paid to the progress notes, discharge note, and laboratory summary sheets to attempt to document whether the information supplied by the CSF studies was noted and used by the clinical services.

Results

Of the 656 myelography patients, 61% were referred primarily from the neurosurgery service, 20% from orthopedics, 13% from neurology, 5% from internal medicine/pediatrics, and 1% from general surgery. Of the 94 cisternograms (air and metrizamide), 29% came from neurosurgery, 29% from otolaryngology, 28% from neurology, and 7% each from neuroophthalmology and medicine/pediatrics.

The cost of routine blood cell count, glucose, and protein determinations at our institutions was $40–$43.

Table 2 lists the number of normal and abnormal CSF studies, as well as the number of each type of abnormality. Specific abnormalities are discussed below:

Appearance

The laboratory noted abnormalities of appearance in 25 patients, with xanthochromia present in 17 of these 25. In most cases, xanthochromia was related to known tumor, previous surgery, or prior trauma. In only one case was it associated with a (previously) recognized spontaneous subarachnoid hemorrhage. In five cases no etiology was apparent; no efforts were made in any of these cases to investigate the xanthochromia further. In eight cases the appearance of the CSF was labeled as being "slightly cloudy" or "hazy." In five of these cases no abnormalities were present except for a relatively large number of RBCs (>1000 RBCs/mm^3). None of these patients had further investigation of the CSF. Of the other three, two had intradural tumors and one had osteomyelitis with a block; the abnormalities were obvious at myelography.

Protein

An elevation of protein was the most common cause of CSF abnormality, occurring in 110 patients. Elevations ranged from 47–1843 mg/dl, with the highest elevations caused by central nervous system (CNS) tumor. The most common causes of elevated protein were disk herniation, spinal stenosis, spondylolisthesis, and arachnoiditis. Tumor, multiple sclerosis, infection, and syringomyelia were less common. The diagnosis in these cases was established by the myelogram/cisternogram or by specific laboratory tests on CSF drawn at the time of the procedure, such as culture and sensitivity, cytology, multiple sclerosis battery, etc. Only three patients with elevated protein had repeat lumbar punctures initiated by routine CSF results. These patients had meningitic metastatic tumor (two patients) and multiple sclerosis (one patient), which were in the differential diagnosis before myelography, yet confirmed by subsequent CSF cytology or multiple sclerosis battery. Twelve patients had modest elevations of protein (51–163 mg/dl) without obvious etiology, but without subsequent investigation. Two patients had protein levels below normal without obvious cause. Neither of these patients had further workup directed at an explanation for the low values. No patients had occult CNS disease discovered as a result of their protein study.

Glucose

By far the most common cause in the 24 patients with a glucose abnormality was a mild elevation (87–123 mg/dl) from glucose intolerance (19 patients). In four patients a high CSF glucose level was unexplained and was not addressed clinically. Only one patient had low CSF glucose. This was not associated with CSF infection, meningitis, or tumor and was not investigated further.

Cellular Content: WBCs

Twenty-one patients had an increased number of WBCs (9–92 WBCs/mm^3) without concomitant RBC elevation. Most cases were associated with previously recognized disease, such as CSF rhinorrhea, CNS primary or metastatic tumor, or osteomyelitis. Two patients with multiple sclerosis and three patients with leptomeningeal carcinoma had pleocytosis; their diagnosis was established by immunoelectropho-

TABLE 2: **Findings in Routine Removal of CSF during Myelography and Cisternography**

Study	No. of Normal CSF Studies	No. of Normal Studies Annotated in Chart	No. of Studies Abnormal on the Basis of:				No. of Abnormal Studies Annotated in Chart
			Appearance	Blood Cell Count	Glucose	Protein	
Myelography:							
Lumbar	293	22	7	15	10	64	5
Thoracic	26	6	2	5	0	6	3
Cervical	110	16	7	6	7	10	9
Combined	97	16	5	5	2	11	7
Cisternography:							
Metrizamide	33	17	4	4	3	12	9
Air	31	1	0	2	2	7	3
Total	590	78	25	37	24	110	36

resis of CSF or by cytology drawn at the same time as routine studies. Five patients had pleocytosis from disease (epidural abscess, tumor) that was established by the myelogram. Four patients had unexplained elevation of the WBCs. Only one of these underwent subsequent lumbar puncture to confirm a suspected leptomeningeal recurrence of lymphoma.

Cellular Content: RBCs

Sixteen patients had elevated RBCs in association with abnormal appearance of the CSF. In almost all cases the etiology of the RBC elevation was apparent from the history (e.g., trauma) or from the results of the myelogram (e.g., spinal cord arteriovenous malformation or tumor). No unsuspected subarachnoid hemorrhages were found in our series.

Table 2 also enumerates the number of patients about whom CSF results were noted in writing in the medical records by the clinicians or were used in determining the subsequent course of management. Of interest, only a few of the results were annotated in the charts. CSF data obtained at the time of cervical, thoracic, or combined myelograms were most likely to be noted by the clinicians; the most common indications for myelography in these cases were myelopathy and polyradiculopathy. CSF results from metrizamide cisternograms were far more likely to be noted than air cisternograms. Brainstem pathology (suspected mass or Arnold-Chiari malformation) and CSF rhinorrhea were the indications for which CSF results appeared to be most helpful.

Review of our series showed that for both myelograms and cisternograms, the CSF results were about four times as likely to be noted in the chart if other CSF studies (multiple sclerosis battery, culture and sensitivity, cytology) were ordered at the time of myelography. In other words, when the clinical diagnosis was most uncertain, when infection was suspected, or when intraaxial tumor was probable, routine CSF results became important enough to document along with the special studies ordered because of clinical uncertainty.

The CSF results were commented upon in writing for 10% of neurosurgical patients, 1% of orthopedic patients, 52% of neurology patients, 30% of internal medicine/pediatric patients, 14% of neuroophthalmology patients, and 0% of general surgery patients. Stated differently, the nonsurgical services (neurology, internal medicine, pediatrics) were almost seven times as likely as the surgical services to remark in writing concerning the CSF studies.

Forty cases had routine CSF cytology or culture and sensitivity performed without high clinical suspicion at the time of myelography. None of these cases was positive, and none was noted by the clinicians in the chart. Twenty-seven cases had all or a part of the routine CSF results missing, but had no mention of the missing results in the chart or had notation of a repeat puncture to obtain the missing information.

Seven cases had routine CSF studies performed, despite normal CSF from lumbar puncture or failed myelogram within 3 days of the procedure. The new results were not significantly different and were not noted by the clinicians.

About 12% of patients had hospital admissions after the neurodiagnostic procedure. These patients provided a follow-up period of 3 months to 2 years. No patient developed disease that could have been detected retrospectively by the initial routine CSF studies.

Discussion

Our review of routine CSF studies showed that most were normal; 80% (526 of 656) from myelograms and 68% (78 of 94) from cisternograms were completely within normal limits. The most common abnormalities related to modest isolated elevations of protein and blood cell count. Protein elevation was attributable to an obvious cause (e.g., disk herniation) in most cases; cases without obvious cause usually had no further evaluation. Similarly, most cases of elevated WBCs had a recognized etiology either before or at the time of the neurodiagnostic study. In four cases, elevated WBC or protein led to more extensive evaluation of the CSF to confirm a suspected diagnosis. The CSF glucose elevations were generally related to glucose intolerance and never followed by more investigation. Abnormalities in appearance were often inconsistent with other CSF findings. Therefore, in most of the cases in which isolated CSF abnormalities were found, the information added little to the clinical differential diagnosis. In no instance did any abnormality lead to detection of an occult problem.

That many of the CSF studies were superfluous is suggested by the small number of cases for which the CSF

results were commented on in writing in the patients' charts. We recognize that chart review probably underestimates the frequency of clinical perusal of the CSF results, but believe that it gives some indication of the decision-making process. Although our study shows that a slightly higher percentage of abnormal studies was noted than of normal studies, very few cases were noted in writing at all. However, it was difficult to document accurately the use of CSF findings by the clinical staff in this retrospective type of study. The paucity of notation in the medical record could simply have reflected the charting behavior of the house officers. That is, abnormal CSF results in the face of an abnormal myelogram or normal CSF results in the presence of a normal myelogram could have confirmed the obvious, and not warranted mention in the medical record. On the other hand, we encountered several instances in which no CSF was removed or some of the results were missing, yet there was no written comment in the chart and little apparent effect on the clinical management of the patient.

Cases in which myelography was performed for recent trauma, low back pain, radiculopathy, or scoliosis and air cisternography for suspected acoustic neurinoma were the least likely to have the CSF studies checked, normal or abnormal. Thus, cases in which the clinical differential diagnosis was biased toward an operable lesion were the least likely to have their CSF results checked. This tendency was supported by the propensity of surgical services to note CSF results less often than did nonsurgical services.

Not all patients had clear-cut clinical syndromes or limited differential diagnoses. Patients with myelopathy, cranial nerve dysfunction, or possible infectious, neoplastic, or degenerative CNS disease were the most difficult diagnostically. In this group of patients, CSF findings seemed to be studied to the greatest degree. However, in many instances routine studies were insufficient and were supplemented by more specific CSF tests, such as multiple sclerosis battery, drawn at the same time. Thus, when the postmyelogram/postcisternogram diagnosis was in most doubt, routine studies alone did not suffice. On the other hand, when there was not a strong clinical suspicion of neoplastic or infectious disease, routine cytologic or bacteriologic studies were not helpful, being normal in all instances.

As health care providers become more concerned about the cost of hospitalization, more emphasis will be placed on the efficacy of various diagnostic tests. Particular emphasis will fall on streamlining diagnostic workups and eliminating low-yield tests [8]. In this retrospective study we found that routine removal of CSF during myelography and cisternography was not always productive or informative; the cost of these laboratory tests could have been eliminated in many instances. Thus, it would seem that (as in all other aspects of medicine) removal of CSF should not be done automatically, but rather tailored to the particular clinical situation. To this end we have proposed some initial guidelines for the removal of CSF, paramount to which is open communication between radiologist and referring physician:

1. The chart should be checked to avoid redundant removal of fluid in a patient with a recent puncture.
2. Removal of CSF in recent trauma is usually unwarranted.
3. Without a high clinical suspicion of infection or tumor, routine CSF glucose, culture and sensitivity, and cytology studies are unwarranted.
4. Unexpected xanthochromic, bloody, or cloudy CSF should be sent for routine tests, and additional fluid collected for other appropriate cytologic or bacteriologic study.
5. Uncomplicated clinical syndromes of lumbar or cervical radiculopathy, spinal stenosis, or scoliosis probably do not warrant routine removal of CSF samples. After all, many surgeons now are willing to operate on such patients solely on the basis of the CT scan [9]. In less clear-cut cases, the amount of CSF to be removed and the type of testing to be done should be based on the major clinical differential considerations. Rather than performing routine studies alone, specific attention should be paid to eliminating unnecessary CSF tests and obtaining specific tests to narrow the differential diagnosis.

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