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CSF Pulsations Within Nonneoplastic Spinal Cord Cysts

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Because of its sensitivity to fluid motion, MR imaging was used to investigate fluid dynamics in syringomyelia. Three major findings characterized syringomyelia: pulsatile fluid in cysts, nonpulsatile fluid in cysts, and damaged cord tissue. The fluid in preoperative syrinx cavities pulsated in a fashion similar to subarachnoid CSF. Pulsation was more prominent in large cysts but was also seen in small cysts. Nonpulsatile cysts were generally of smaller diameter, were shorter in length, and often were single; they could, however, coexist with pulsatile cysts. Nonpulsatile cysts had etiologies similar to those of pulsatile cysts: Chiari malformation, trauma, and unknown. Damaged cord, characterized by abnormal high signal on T2-weighted sequences, was seen in 15 of 16 patients and could be either focal or diffuse but was always adjacent to syrinx cavities. Postsurgical MR scans had a lower incidence of pulsatile cysts. In five patients with both pre- and postoperative MR scans, shunting of the cyst reduced the size of the pulsating cyst (two patients) or reduced the size of the cyst and eliminated pulsation altogether (three patients). Axial, T2-weighted images are recommended in the investigation of spinal cord cysts to determine the presence or absence of pulsatile fluid. The presence of pulsation indicates a nonneoplastic cyst. The absence or reduction of CSF pulsation may prove to be a valuable indicator of the success of a shunting procedure.

Nonneoplastic spinal cord cysts are associated with a variety of clinical entities, the Chiari I and II malformations and traumatic spinal cord injury being the most common [1–6]. In each entity, however, the etiology and pathogenesis of cyst development is poorly understood. Although there is still disagreement as to proper terminology we will use the term *syrinx* to refer to nonneoplastic cysts of the spinal cord.

MR imaging in comparison with CT has greatly simplified the diagnosis of syrinx and promises to expand our understanding of its pathogenesis and natural history [5–12]. Numerous MR pulse sequences are known to be sensitive to the oscillatory motion of CSF [13–16]. These sequences can be used to study the dynamics of fluid motion in the spinal canal and within the syrinx. A specific, prospective protocol with pulse sequences designed to take advantage of this sensitivity to flow was used to study pre- and postoperative syrinx patients.

Subjects and Methods

Sixteen syrinx patients were studied (Table 1). The etiology of syringomyelia was related to trauma in six patients, Chiari I (seven) or II (one) malformation in eight patients, and unrelated to a specific etiology in two. The syrinx was in the cervical cord in 10 pateints, in the thoracic cord in two, in the cervical and thoracic cords in three, and in the thoracolumbar region in one. Preoperative MR scans were available in 15 patients, five of whom were also scanned postoperatively. In one patient only a postoperative scan was available. Of the six patients with a shunting procedure, two were syringoperitoneal and four were syringosubarachnoid. Diagnoses were confirmed by surgery in all but six patients, three of whom had posttraumatic syringes and three of whom had Chiari malformations. For comparison, six

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TABLE 1: MR of Nonneoplastic Spinal Cord Cysts: Pre- and Postoperative MR Findings

Cause: Case No.	Age	Gender	Site	Preoperative MR		Postoperative MR	
				Pulsation: Width (mm)/Length (cm)	Myelomalacia	Pulsation: Width (mm)/Length (cm)	Myelomalacia
Chiari I							
1	27	M	C, T	Pulsatile: 4/14	Focal	Nonpulsatile: 2/10	Focal
2	40	F	C	Pulsatile: 7/>40[a]	Diffuse	Pulsatile: 2/>25[a] Nonpulsatile: portion	Diffuse
3	25	F	C	Pulsatile: 8/>16[a]	Focal	...	...
4	56	M	C, T	Pulsatile: 8/>30[a] Pulsatile: 8	Diffuse	...	...
5	11	M	C	Pulsatile: 10/17	Diffuse	...	...
6	33	M	C, T	Nonpulsatile: 3/4	Focal	...	...
7	9	F	T, L	Nonpulsatile: 20/15	Diffuse	...	...
Chiari II							
8	1½	M	T	Nonpulsatile: 4/3	Diffuse	...	...
Trauma							
9	44	M	C	Pulsatile: 8/9 Nonpulsatile: 5/2	Diffuse	Nonpulsatile: 5/7 Nonpulsatile: 5	Diffuse
10	33	M	C	Pulsatile: 9/>22[a]	Diffuse	Nonpulsatile: 2/5	Diffuse
11	29	M	T	Pulsatile: 8/>20[a] Nonpulsatile: 4/5	Focal	...	...
12	62	M	C	Nonpulsatile: 12/1.5	None	...	...
13	52	M	C	Nonpulsatile: 1/4.5	Focal	...	...
14	51	M	C	...	...	Nonpulsatile: 6/4	Focal
Unknown							
15	60	M	C	Pulsatile: 2/4 Nonpulsatile: 3/3	Focal	Pulsatile: 1/2	Focal
16	41	M	C	Nonpulsatile: 5/15	Diffuse	...	...

Note.—C = cervical; T = thoracic; L = lumbar.

[a] The exact length could not be measured because separate coils were used and the syrinx extended beyond the field of view.

patients with large cysts associated with intrinsic spinal cord tumors were studied with a similar protocol.

All scans were obtained on a 1.5-T MR scanner (GE Signa) with 5-in. (13-cm) circular and 7- by 12-in. (18- by 30-cm) rectangular surface coils by using the following protocol. Each patient had a sagittal T1-weighted scan with a repetition time (TR) of 600–800 msec and echo time (TE) of 20–25 msec; the number of excitations (NEX) was two, and a 256 × 256 matrix, 24-cm field of view (FOV), and 3-mm slice thickness were used to delineate cord morphology and the low-signal cystic component. In all but one patient, an axial T1-weighted scan (TR = 800–1000 msec, TE = 20 or 25 msec, NEX = 4 or 6, 256 × 128 matrix, 24-cm FOV, 3- or 5-mm slice thickness) was obtained to delineate cord size and the size of the low-signal areas presumed to represent cystic space(s). Each patient had an ungated scan (TR = 2000 msec, TE = 20 or 25 msec and 80 msec, NEX = 2, 256 × 256 matrix, 26-cm FOV, 3-mm slice thickness) in either the axial or sagittal view; in two patients, both views were obtained. Pulsatile flow could be identified by areas of signal loss on the TR = 2000-msec scan (sagittal or axial view). In addition, pulsations in subarachnoid CSF and cyst fluid were detected by two additional flow-sensitive sequences: (1) selective saturation recovery, gradient refocusing (SSRGR) [16], and (2) gradient recalled acquisition in the steady state (GRASS) with low flip angles [17]. Both of these sequences were single-slice scans that relied on the "time-of-flight" phenomenon of unsaturated protons entering the slice of interest so that flow was seen as an area of high signal, that is, flow-related enhancement. The parameters for SSRGR were TR = 500 msec, inversion time (TI) = 400 msec, TE = 12 msec, NEX = 2, 256 × 256 matrix, 24-cm FOV, and 3-mm slice thickness. For GRASS the parameters were TR = 22 msec, TE = 12 msec, NEX = 8, 256 × 256 matrix, 24-cm FOV, and 5-mm slice thickness. SSRGR and GRASS were performed in the axial projection, since in this view CSF pulsation caused inflow of unsaturated protons perpendicular to the slice and thus generated flow-related enhancement. The term ultralow is used to describe the flip angle because it was only 6°. These latter two pulse sequences were compared with the cord morphology depicted on axial T1-weighted sequences and with areas of signal loss on axial ungated long TR sequences (TR = 2000, TE = 80). CSF gating, performed in one patient, was accomplished by triggering the finger capillary blush with a photoplethysmograph. The trigger was set to about 400–500 sec after the pulse onset to achieve diastolic gating.

Results

The most important and most consistent finding on preoperative scans was pulsating fluid within the syrinx cavity. This was seen in five of eight Chiari malformation–associated syringes, in three of five posttraumatic syringes, and in one of two syringes of unknown etiology. Therefore, nine of 15 preoperative patients had this finding. Fluid pulsation was seen as an area of signal loss or signal void within the cord on long-TR, long-TE pulse sequences in either the axial or the sagittal projection (Figs. 1–3). When performed, the SSRGR (three patients) and GRASS (four patients) sequences confirmed the presence of motion in the cyst fluid, correlating closely with the area of low signal on T1-weighted images and with areas of signal loss or signal void on the axial

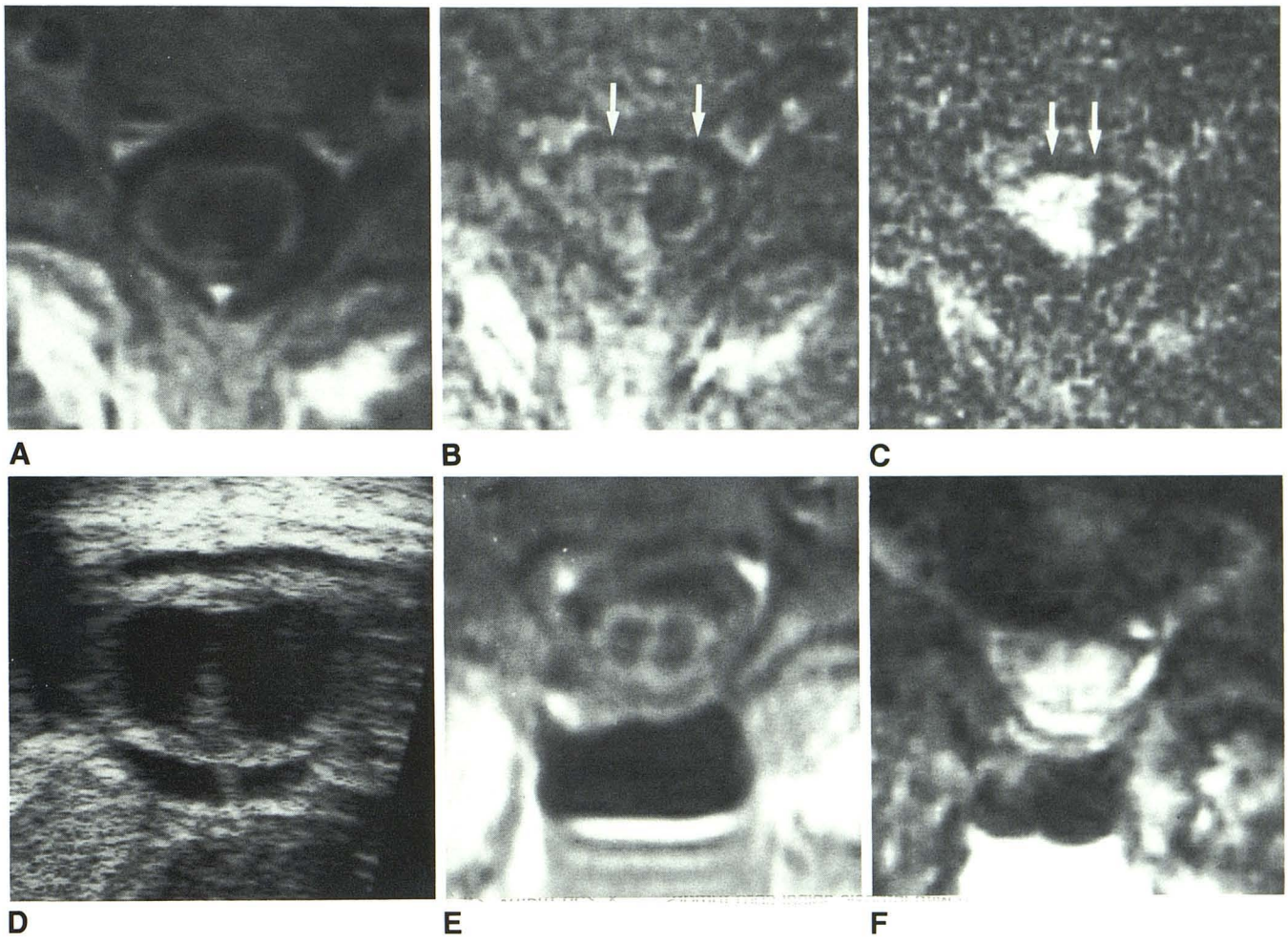

Fig. 1.—Case 9: Traumatic syrinx. Axial MR scans show three main components of syringomyelia: (1) cyst with pulsating fluid, (2) cyst with nonpulsating fluid, (3) myelomalacia.

***A*, Enlarged cord with two cysts was well seen with TR = 1000, TE = 20, slice thickness = 10 mm.**

***B* and *C*, 3-mm axial scans, TR = 2000, TE = 20 (*B*) and TE = 80 (*C*), show pulsatile and nonpulsatile nature of cysts. Cyst on left showed prominent signal loss on both echoes, whereas cyst on right showed the high signal intensity expected from static water (*C*). CSF anterior to cord also showed signal loss indicative of normal pulsation (*arrows*). The cord should have had a lower signal intensity than static CSF on this pulse sequence, but this cord had diffusely high signal indicative of some type of damage, which we termed myelomalacia.**

***D*, Intraoperative sonogram oriented to match MR images confirms two cysts.**

***E*, Postoperative proton density scan (TR = 1000, TE = 20) shows both cysts in cord to be decreased in size.**

***F*, T2-weighted scan (TR = 2000, TE = 80) at same level shows high signal intensity within both cysts. Left cyst no longer shows evidence of pulsation.**

ungated long-TR scans (Fig. 3). When compared with axial T1-weighted scans, the area of flow sometimes did not encompass the entire area of low signal intensity. The remainder of the low-signal-intensity area was assumed to be either static cyst fluid or possibly cord tissue damage. Intraoperative sonography in the two patients in whom it was performed confirmed that the cysts corresponded to the low-signal areas on T1-weighted images (Fig. 1).

In 11 preoperative patients, the axial view showed the syrinx to be a single cavity occupying varying proportions of the cord, whereas in four patients, two cystic spaces were observed (Table 1). Of interest were the differences in pulsation between these various cystic spaces. Of the 11 patients with a single cystic cavity (2- to 20-mm diameter), five had pulsatile fluid (four Chiari malformations, one posttrauma) and six had static fluid (three Chiari, two posttrauma, one unknown etiology). The axial TR-2000, TE-80 scans and the flow-sensitive sequences (SSRGR and GRASS) were consistent in discriminating between pulsating and nonpulsating cysts. Four patients had two distinct cysts: In one patient (Chiari I) both cysts were pulsatile, and in the other three (two posttrauma, one unknown etiology) one cyst had pulsatile fluid while the other had static fluid. Static cyst fluid could be identified as a separate cyst by identifying a septation on the T1-weighted scan. In only one patient with multiple complex but incomplete septations was there apparently static fluid in the same cavity as moving fluid.

The nonpulsatile cysts in general were of smaller diameter

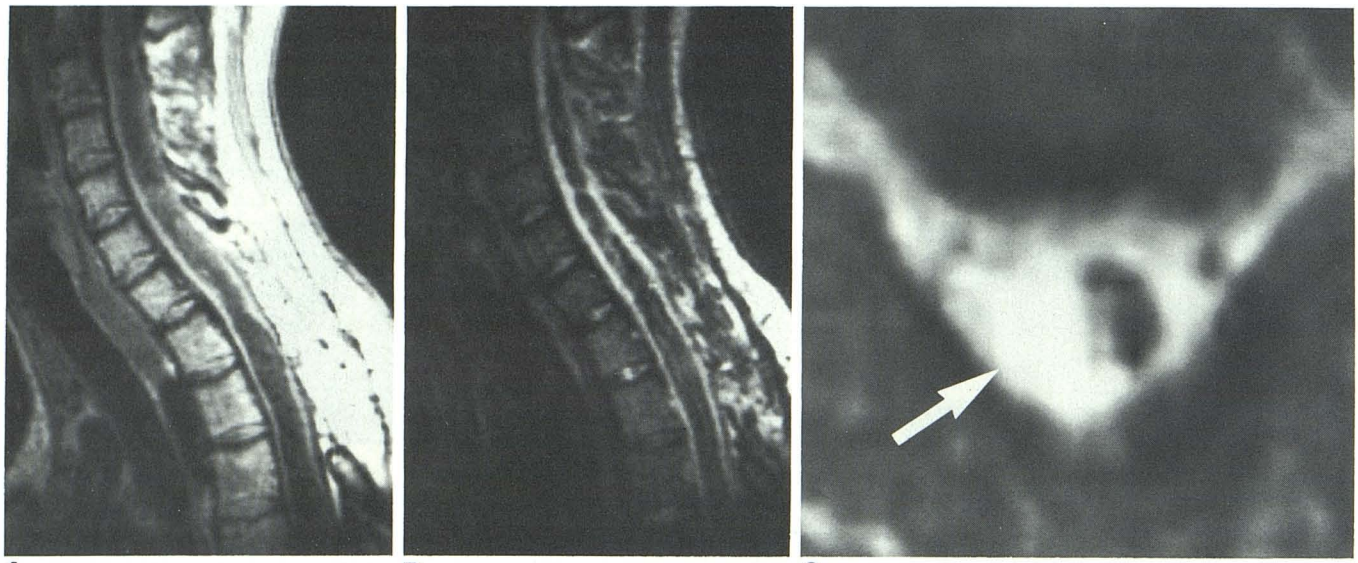

Fig. 2.—Case 10: Traumatic syrinx involving cervical and thoracic cords. *A*, T1-weighted scan. Areas of signal loss, indicative of pulsation, are evident on sagittal (*B*) and axial (*C*) T2-weighted scans. This is seen in this large traumatic syrinx on the sagittal scan (TR 2000, TE = 80) (*B*), in which signal loss correlates with low-signal area on T1-weighted scan (TR = 800, TE = 20) (*A*). *C*, Axial scan (TR = 2000, TE = 80) shows large signal void caused by pulsating fluid. Entire cord is of abnormal high signal, best appreciated on axial view (*arrow*), but also seen on sagittal view as high-signal parallel lines (*B*). Findings were consistent with myelomalacia.

and shorter length than pulsatile cysts. In two posttrauma patients, one such cyst was in a very atrophic cord (4 mm) and the other was a small, focal cyst (1.5 cm long). In the former patient, there was no surgical proof, and this thin (1-mm), low-signal area could have represented myelomalacia without true cyst formation, although it extended for 4.5 cm. Clinically this patient has been stable and has shown no evidence of progression. In Chiari patients (Fig. 4), two static cysts were only 3–4 cm long and 3–4 mm wide, but one was large, 20 mm in maximum diameter and 15 cm long. Two nonpulsatile cysts reached 15 cm in length.

On presurgical scans, if the cystic cord was large, CSF pulsations in the markedly narrowed subarachnoid space were not seen. In general when cord enlargement was present, the signal intensity of subarachnoid-space CSF was higher than expected because of reduced CSF pulsation. The subarachnoid flow voids were either absent or less prominent than normal. If the cord was not large enough to obliterate the subarachnoid space, CSF pulsations within it were normal. Gating to the peripheral pulse in one patient showed that the fluid motion within the cyst had the same periodicity as the normal oscillatory motion of CSF in the subarachnoid space (Fig. 5).

On the T2-weighted sequence (TR = 2000, TE = 80) the normal cord was usually of lower signal intensity than surrounding nonpulsating CSF. In 15 of the 16 syrinx patients it could be determined on either the pre- or postsurgical scan that the cord exhibited abnormal high signal (Figs. 1–3 and 5). High-signal areas could represent either abnormal cord tissue (myelomalacia and/or gliosis) or static cyst fluid. Comparison with the axial short-TR sequence, which yielded excellent cord morphology, helped differentiate static fluid (low signal intensity and discrete septations) from damaged cord tissue, which did not have as low a signal and showed no septations. These areas of noncystic abnormal signal intensity could involve the cord diffusely around the cystic cavity (eight patients) or they could be more localized, occupying only a portion of the cord (seven patients). In patients with both pre- and postoperative scans this abnormal cord signal intensity remained essentially unchanged after surgery, except in one patient in whom it decreased.

Postshunt scans differed from presurgical scans (Table 1). Of the six postsurgical scans, only two patients had pulsatile cyst fluid, and it was small, in the range of 1–2 mm. In the five patients in whom both pre- and postsurgical scans were available for comparison, the postsurgical scans showed a marked reduction in both the cord and cystic cavity (Figs. 1 and 6). Of these five patients, three cysts with prominent pulsations before surgery showed no pulsation after shunting (Fig. 1). Two cysts had residual pulsation, but it had diminished (Fig. 6). Overall, the average presurgical anteroposterior diameter of the cord was 12 mm; after shunting this decreased to an average of 5 mm. In all patients, the reduction of the cystic cavity accounted for this difference. Concomitant with a decrease in cord size was a return of normal flow voids in the subarachnoid space.

In the six spinal cord tumor patients with large associated cysts, each cyst showed high signal intensity on T2-weighted sequences (TR = 2000–2500, TE = 80). There was no evidence of cyst pulsation in any of the tumor patients, even when the subarachnoid space was completely obliterated by the large cyst (Fig. 7). No areas of signal loss were seen on

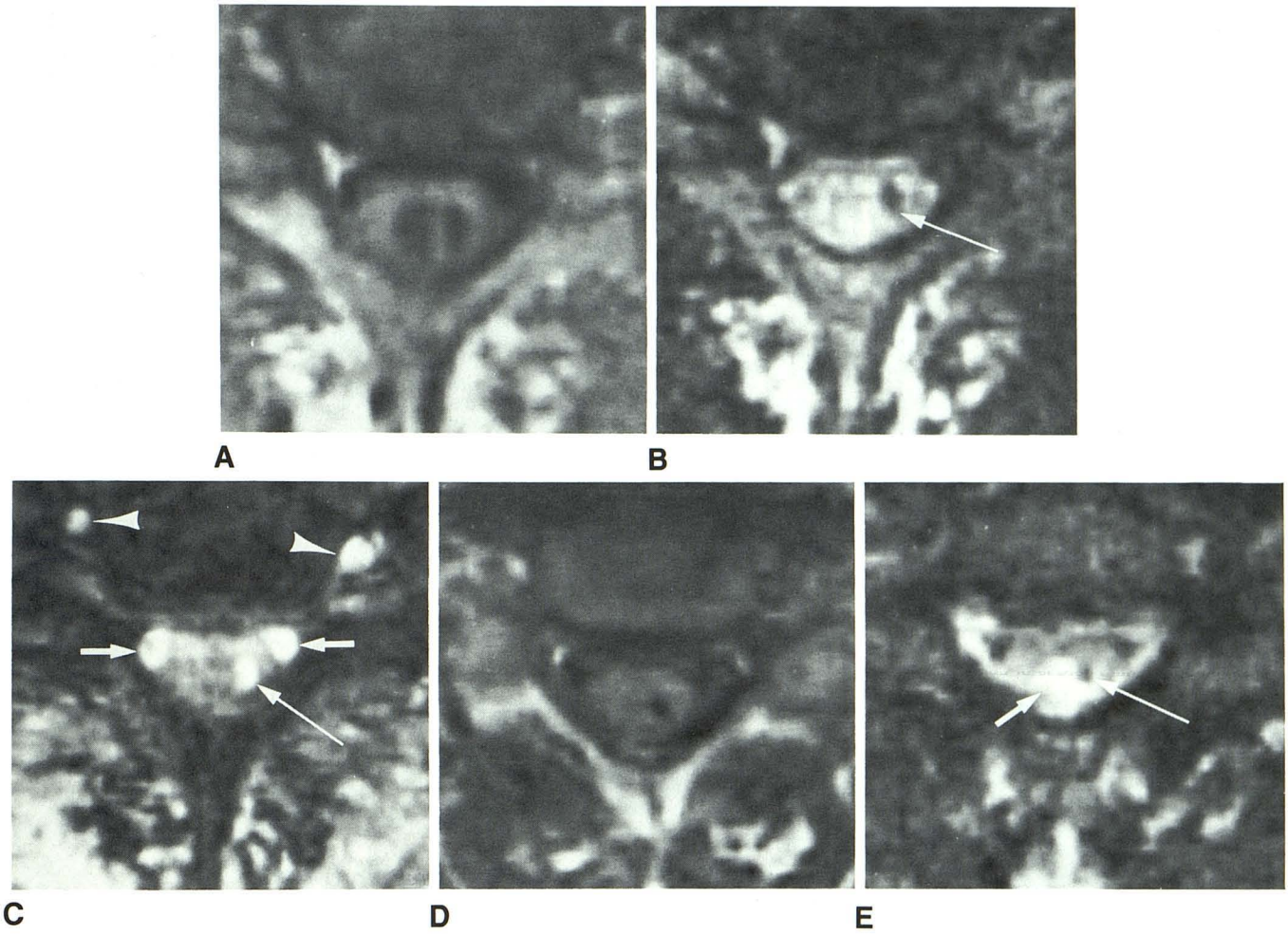

Fig. 3.—Case 15: Syrinx of unknown etiology.

***A*, T1-weighted axial scan (TR = 1000, TE = 20) shows two areas of low signal suggesting adjacent cysts.**

***B*, Axial scan (TR = 2000, TE = 80) within 2 mm of *A* shows area of signal void in left cyst indicating that fluid in cyst was pulsating (*arrow*). Fluid in right cyst is of high signal and, therefore, nonpulsatile.**

***C*, Selective saturation recovery, gradient refocusing pulse sequence, which is sensitive to flow and displays it as high signal, shows increased signal in same region as signal loss, confirming pulsatile fluid in cyst (*long arrow*). Right cyst does not show high signal (that is, no moving fluid). Areas of increased signal in vertebral arteries (*arrowheads*), in anterolateral recesses of subarachnoid space (*short arrows*), and to a lesser degree anterior to cord all indicate fluid moving perpendicular to slice. At a higher cervical level only pulsatile cyst was seen as well as abnormal cord.**

***D*, Axial T1-weighted scan (TR = 1000, TE = 20) shows homogeneous cord with a small cyst of low signal intensity.**

***E*, T2-weighted scan (TR = 2000, TE = 80) shows signal void in cyst indicating pulsation (*long arrow*) and segmental area of abnormal high signal within cord, myelomalacia (*short arrow*).**

ungated long-TR sequences, and no areas of high signal were observed on flow-sensitive sequences.

Discussion

Numerous theories have been proposed regarding the etiology of syringomyelia. None has been definitively proven or gained widespread acceptance. It is doubtful that hemorrhagic cysts play a significant role in posttrauma patients since none of the MR scans had evidence for old hemorrhage (that is, hemosiderin-laden macrophages) in the form of the magnetic susceptibility effect on T2-weighted images [18]. It is accepted that the pathogenesis of syrinx includes a role for altered CSF dynamics, but the nature of the alteration is not clear. Many of the disease states associated with syrinx, Chiari malformation, ankylosing spondylitis, and trauma have associated with them some changes in CSF motion. It is not surprising, therefore, that this investigation has found unusual CSF dynamics in syrinx cavities. Preoperative patients had a high incidence of fluid pulsation within the syrinx. Lack of pulsation was generally seen in the smaller cysts. The presence or absence of pulsation was not related to etiology of the syrinx but was more related to cyst size. Subarachnoid space and peritoneal shunting reduced the size of pulsating cysts in five of five patients; in three of the five, shunting not only reduced the cyst size but eliminated pulsations entirely.

The sensitivity of many MR pulse sequences to fluid motion can be used to advantage in the diagnosis and characteriza-

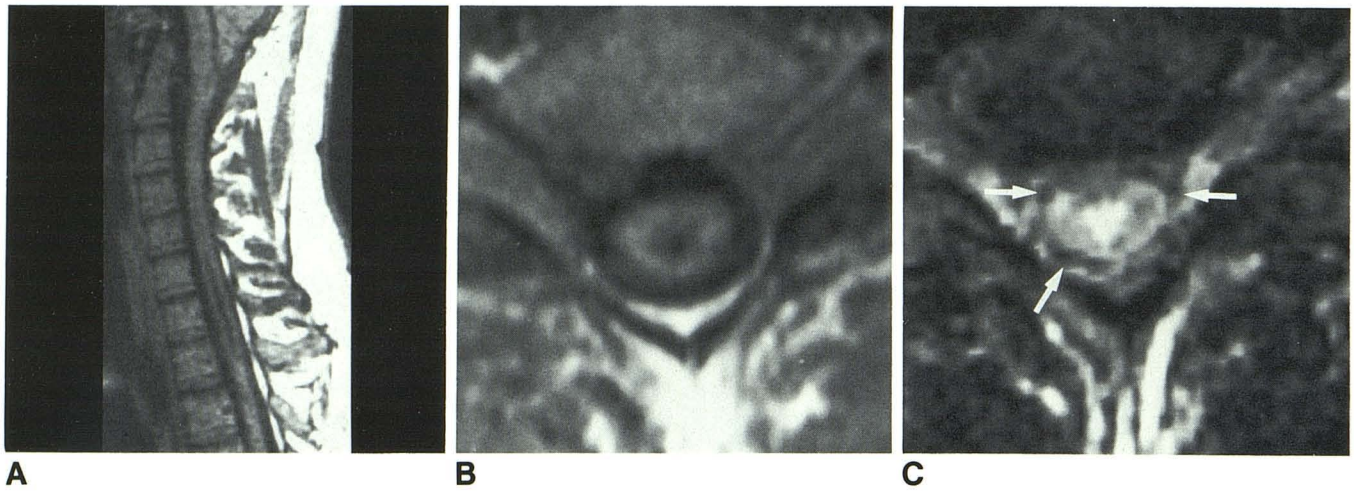

Fig. 4.—Case 6: Syrinx with Chiari I malformation.
A and *B*, Sagittal (TR = 600, TE = 20) (*A*) and axial (TR = 1000, TE = 20) (*B*) T1-weighted scans. Low cerebellar tonsils in *A*.
C, T2-weighted scan (TR = 2000, TE = 80). Cyst does not have pulsatile fluid, as shown by high signal from cyst fluid in central cord. Cord is of normal signal intensity, and areas of signal loss (*arrows*) are present in subarachnoid space, indicative of pulsatile CSF.

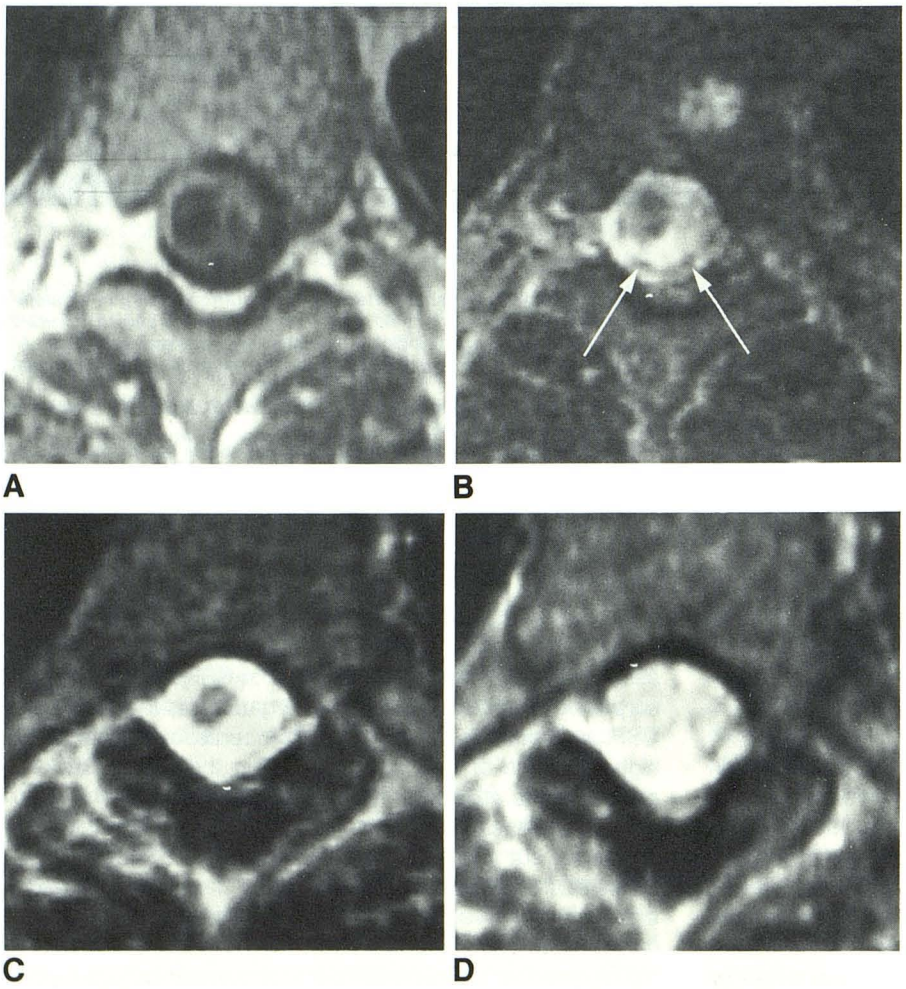

Fig. 5.—Case 11: Traumatic syrinx. Series of axial MR scans show pulsatile cyst, nonpulsatile cyst, myelomalacia, and synchronicity of pulsation with peripheral pulse.
A, T1-weighted sequence (TR = 1000, TE = 20) shows enlarged cord in thoracic region with two cysts of unequal size.
B, Thin-section (3-mm) axial scan (TR = 2000, TE = 80) shows large cyst to be pulsatile because of significant area of signal loss. Small cyst is nonpulsatile at this level. Posterior central region of cord just behind both cysts shows high signal indicative of myelomalacia. Thin black line posterior to cord represents pulsating CSF manifest as signal loss (*arrows*) and helps outline cord.
C and *D*, Thin-section (3-mm) axial scans compare ungated (TR = 2000, TE = 80) (*C*) and gated (*D*) scan at exact same level, but gated scan has an effective TR of about 1800 msec and a TE of 80 msec. Area of signal loss in *C* is not seen on gated image, where it is replaced by high signal intensity expected from static CSF. This showed that fluid within pulsatile cysts behaved in fashion similar to CSF in subarachnoid space in that pulsations were synchronous with peripheral pulse.

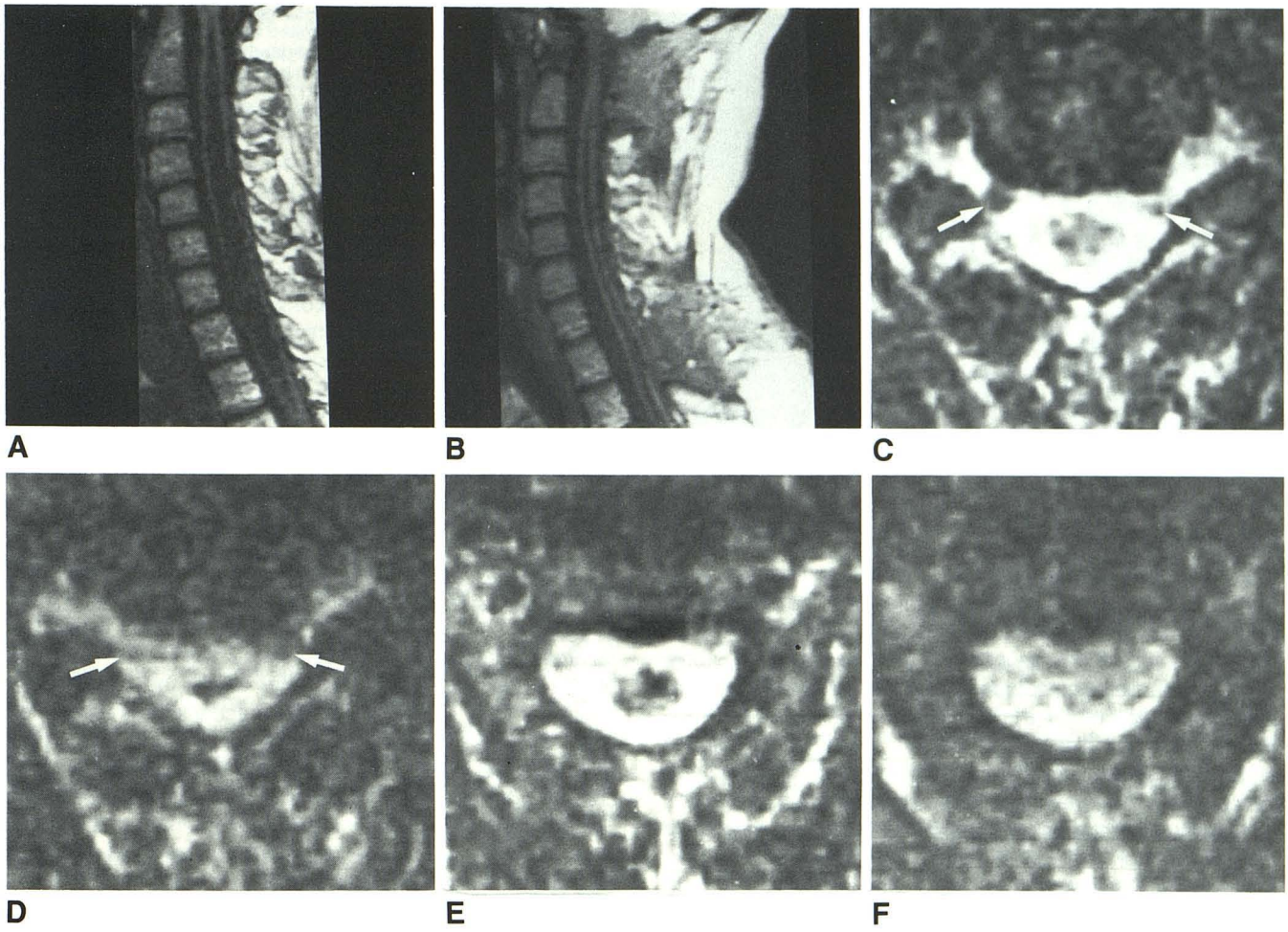

Fig. 6.—Case 2: Chiari I–related syrinx. Pre- and postshunt axial MR scans.

***A*, T1-weighted sagittal scan (TR = 400, TE = 25) before shunting shows large single cyst.**

***B*, After shunting, cyst has decreased as diameter (TR = 600, TE = 25).**

***C* and *E*, Before surgery. Single, large, pulsating cyst within cervical cord is seen well on scans with TR = 2000, TE = 80. Cord was of diffuse high signal making it difficult to discern from relatively static CSF in subarachnoid space. Anterolateral signal voids were seen but were less prominent than normal (*arrows*).**

***D* and *F*, After shunting, pulsating cyst has diminished on scans obtained at presurgery levels with the same scanning parameters. On *D*, cyst fluid still pulsates, but in a smaller cyst. Pulsations in anterolateral areas have become more prominent (*arrows*). At another level (*F*), pulsations within syrinx cavity have virtually disappeared with cord, becoming indistinguishable from surrounding CSF (*D*). The inability to differentiate cord tissue from surrounding CSF on both studies indicated diffuse abnormal signal within cord.**

tion of syringomyelia. Oscillating fluid such as CSF in the spinal canal causes a well-known phenomenon, that of signal loss or signal void on thin-slice long-TR, long-TE scans [13, 14]. This is caused by the combination of harmonic modulation of proton precessional phase induced by CSF pulsation and the two-dimensional Fourier transform method of image reconstruction [14]. The effect is greatest on axial thin slices because of the higher gradient strength used [14]. The increased gradient strength increases the phase shift caused by moving protons and thereby accentuating the signal loss [14]. Other flow-sensitive sequences confirmed fluid pulsation within the syrinx by exhibiting flow-related enhancement. The response to peripheral pulse gating showed the pulsation period to be determined by the heart rate in a fashion similar to normally pulsating CSF in the subarachnoid space.

This cardiac-related pulsation has implications for the pathogenesis of syringomyelia. Pulsation was most prominent in large cysts but was also observed in small cysts. The presence of pulsation in small cysts suggests this may be one mechanism of cyst enlargement. However, cysts do enlarge without the presence of pulsation. There may be two mechanisms for cyst enlargement: (1) cyst fluid production in nonpulsatile cysts and (2) a "water hammer" effect caused by pulsatile cyst fluid. How and where pulsations are transmitted to the cyst fluid is unknown, but presumably this is related to some type of communication with the subarachnoid space or

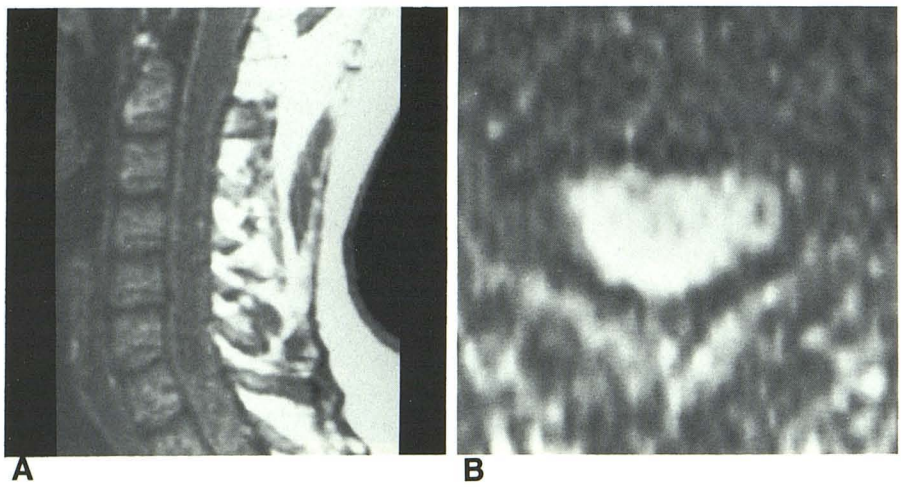

Fig. 7.—Large spinal cord cyst in cervical cord associated with ependymoma.

***A*, T1-weighted sequence shows large area of low signal in enlarged cord.**

***B*, Axial T2-weighted scan (TR = 2000, TE = 80, 3-mm slice thickness) shows high signal from cyst fluid with no evidence of pulsation.**

fourth ventricle. Clefts in the spinal cord have been reported between the cyst and subarachnoid space in the posttrauma type of syrinx but not in other types [19]. The possibility for such communications requires further elaboration. Simple transmission from the subarachnoid space through the cord is unlikely since tumor cysts that are much larger than syringes and that also compress the subarachnoid space showed no similar pulsation. Our investigation detected pulsation within the syrinx but did not characterize the direction or magnitude of the velocity components relative to systole and diastole or to location within the syrinx. Quantitative assessment of several segments of a syrinx is necessary to fully understand its fluid dynamics and the source and direction of pulsations.

Normally the cervical and thoracic subarachnoid spaces act as a conduit for CSF pulsations with the lumbar area, which serves as the area of compliance. In syringomyelia the cystic cavity seems to serve as a conduit for pulsations, especially when the cord is large enough to obliterate the subarachnoid space. If the cystic cavity has a distal blind pouch then the pulsations must be transmitted through the cord to the lumbar sac, which can still serve as the major area of compliance. This may be one mechanism of cord damage. After spine trauma, which causes high-grade or complete canal stenosis, the ability of the lumbar sac to provide compliance in the system may be compromised. In such instances the cord may be subjected to greater pulsatile stress. If the syrinx cavity has a distal opening then it would serve primarily as a conduit and the cord would be subjected to less stress compared with a syrinx cavity with a blind pouch. One benefit afforded by current surgical treatments, which create such openings to the subarachnoid space or the peritoneal cavity, may be relief of such pulsatile stress on the cord [20]. If shunting collapses the cyst, it may remain collapsed and show no pulsation.

Cord damage in syringomyelia is complex. Three structural changes seem relevant: cysts with pulsating fluid, cysts with static fluid, and intrinsic cord-tissue damage. When pulsating and nonpulsating cysts coexist, the nonpulsating cystic fluid collections are smaller and appear not to communicate with the main, usually larger pulsating cyst in the presurgical state. Significant cord damage was observed and was manifested as areas of high signal intensity on T2-weighted images. We have no histologic data to further define the cause of the abnormal high signal. Given the mechanical stress on the cord, gliosis is the most likely explanation. Local reabsorption of CSF could have a small role, but the lack of significant change after shunting suggests it was not a major factor. This abnormal signal could involve a thinned cord diffusely or could be more segmental in a more normal-sized cord. The degree of involvement was greater with pulsating cysts than with nonpulsating cysts. This cord abnormality could exhibit normal signal intensity on T1-weighted images but was easily identified as abnormal high signal of the spinal cord on T2-weighted scans. Cord damage, when more severe, could exhibit low signal intensity on T1-weighted images. When this occurs it cannot always be differentiated definitively from small static fluid cysts except by intraoperative sonography [3, 4, 21]. Metrizamide CT also cannot make this differentiation reliably [3, 4, 21, 22]. In our limited series, the cord damage was not reversed by surgery except for partial resolution in one patient.

Decompressing and shunting a syrinx seems to have a beneficial clinical effect in that it can reduce pain and sometimes improve, but usually only halt, the progression of motor and sensory deficits [4, 20, 21]. At present the best criterion for shunting seems to be the size of the cyst, the larger cysts seemingly responding better than the smaller ones [4]. If symptoms are related primarily to cord-tissue damage, surgical intervention does not seem indicated [4]. Given our findings, it would seem worthwhile for investigations to correlate the progression of symptoms and the response to treatment with two factors: (1) changes in cyst size and (2) changes in the presence and nature of fluid pulsation. This could be taken one more step, quantitation of pulsation throughout the syrinx. Since the large cysts are usually the pulsatile ones, their favorable response to surgery is not surprising [4]. Many posttrauma patients remain stable. This

may be because they have only small, localized, nonpulsatile cysts. The MR scan has opened up numerous avenues for investigating the natural history of all types of syrinx and the opportunity to better select patients for surgical intervention. We consider the presence of pulsation in the syrinx to be an important new variable in assessing its correlation with clinical findings, its progression, and its response to surgery.

Nonneoplastic cystic disease of the spinal cord appears to be somewhat more common than initially suspected. In many patients, especially those with the Chiari I malformation, syringomyelia is relatively easy to diagnose with MR. But as the spectrum of nonneoplastic cystic disease of the spinal cord broadens, differentiation from cyst associated with cord tumor may become more difficult [8, 23]. A syrinx with prominent, thick septations can mimic neoplasm, especially when the cord is enlarged. The diagnosis of neoplasm can be made confidently if cord enlargement can be identified at another level of the cord where no cyst has formed. Such a region may not be readily apparent. Axial long-TR, long-TE scans through a cystic region can be used to help make the neoplastic/nonneoplastic differentiation. In our experience, cysts associated with intrinsic spinal cord tumors, even when they are quite large, exhibit high signal and show no areas of signal loss that would indicate fluid pulsation. This differs from our syrinx patients with large cysts, all of whom had evidence for fluid pulsation. Techniques for detecting pulsation, therefore, can be helpful in differentiating neoplastic from nonneoplastic spinal cord cysts.

ACKNOWLEDGMENT

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