Bulging Lumbar Intervertebral Disk: Myelographic Differentiation from Herniated Disk with Nerve Root Compression

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Bulging Lumbar Intervertebral Disk:

Myelographic Differentiation from Herniated Disk with Nerve Root Compression

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Deformities of the lateral margins of the contrast material-filled lumbar thecal sac are common findings at myelography in patients with low back pain, but not all such deformities are due to herniated disks. Differentiation at Amipaque myelography between a diffusely bulging disk (unlikely to cause nerve root compression) and a herniated disk (which typically causes nerve root compression) is based on the curvature and extent of the extradural deformity of the anterolateral margin of the contrast-filled sac and on the presence of fusiform widening of the most distal part of the affected nerve root. The deformity caused by a bulging disk is rounded, usually symmetrical (although occasionally more prominent on one side), and does not extend above or below the disk space; the nerve root is uniform in caliber and normal in size. The deformity caused by a herniated disk is angular and extends cephalad and/or caudal to the level of the disk space; the affected nerve root is usually widened in its most distal visible part. A consecutive series of 33 patients with clinically suspected lumbar disk herniation and no previous history of back surgery underwent laminectomy. Using the criteria listed above for differentiation of bulging from herniated disk on Amipaque myelography, the myelographic diagnosis was correct in all six operatively confirmed bulging disks and in 26 (96%) of 27 operatively verified disk herniations.

In 1934, Mixter and Barr [1] first described the clinical picture and anatomic findings of herniation of a lumbar intervertebral disk causing nerve root compression with resultant low back pain, sciatica, and weakness of the affected lower extremity. Only 2 years later, in another classical paper, Hampton and Robinson [2] described the myelographic criteria for recognizing this lesion using an oily contrast medium.

Deformities of the lateral margins of the contrast-filled lumbar thecal sac are a common finding at myelography in patients with low back pain, but not all such deformities are due to herniated disks [3–5]. Perhaps the most difficult task for the myelographer is to differentiate the extradural deformity produced by a bulging disk (unlikely to cause nerve root compression) from that produced by a herniated disk (which typically causes nerve root compression).

Amipaque (metrizamide, Winthrop), a nonionic water-soluble contrast medium for myelography, reliably provides delineation of the lumbar nerve roots both within the thecal sac and in the root sheaths [6, 7]. Myelography with Amipaque can directly demonstrate distal widening of a nerve root compressed by a herniated disk, thus permitting more accurate differentiation of disk herniation from disk bulging.

Materials and Methods

A consecutive series of 33 patients with clinically suspected lumbar intervertebral disk herniation and no previous history of back surgery underwent laminectomy. Amipaque lumbar myelography had been performed on all 33 shortly before laminectomy. The concentration of contrast medium introduced into the lumbar subarachnoid space varied

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from 170 to 250 mg I/ml, but in most cases it was 190–200 mg I/ml. Volumes of contrast medium were 12–15 ml. In each case, the entire procedure was performed under fluoroscopic control with appropriate fluoroscopic "spot" films obtained in anteroposterior and oblique projections together with horizontal beam lateral radiographs.

Myelograms were analyzed jointly by three of the authors (S. A. K., R. G. S., and D. E. W.) who knew that the patients had undergone laminectomy but were unaware of the operative findings. Particular attention was directed at the level and side of interest to the presence or absence of: (1) an extradural deformity of the anterolateral margin of the contrast filled thecal sac, (2) nonopacification (cutoff) of the root sheath, and (3) widening of the nerve root immediately proximal to the site of sac deformity. (In two patients in whom no sac deformity was evident, nerve root size and configuration were assessed at the most distal point of nerve root visualization.) A lesion was classified as a *bulging disk* at myelography if the film study demonstrated an extradural sac deformity that was

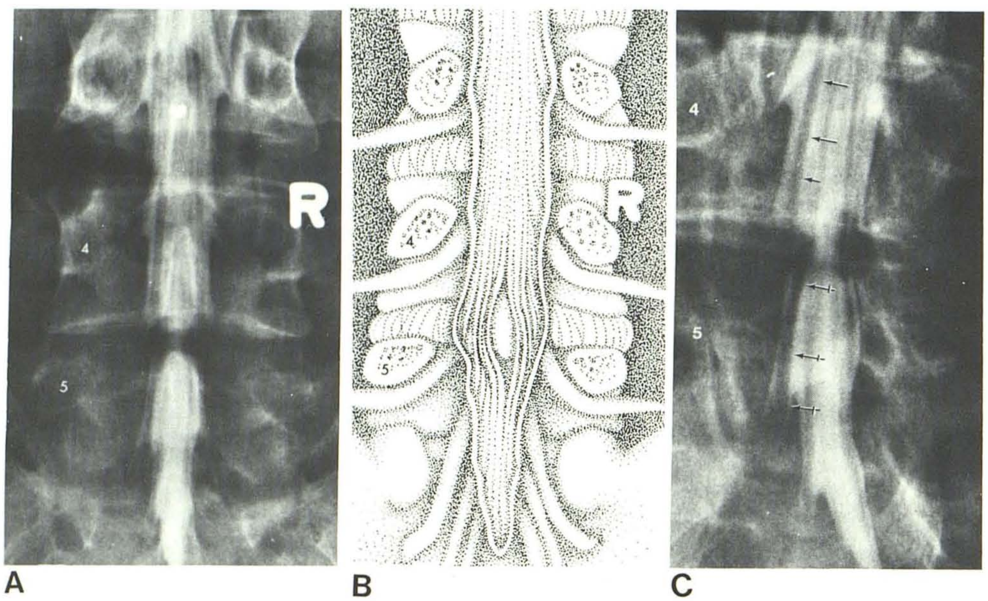


Fig. 1.—Diffusely bulging disk. **A**, anteroposterior view from Amipaque myelogram. Bilateral, symmetrical, rounded indentations into thecal sac at L4–L5 level of disk space give sac an "hourglass" configuration. L5 root sheaths are cut off bilaterally. **B**, Lateral displacement and crowding of nerve roots to both sides caused by centrally bulging disk; crowding of these nerve roots accounts for filling defect on each side of sac. **C**, Left posterior oblique view. Defect is not accentuated. Prominent left L5 root shadow is of uniform width over entire height of body of L4 (*uncrossed arrows*); it shows no distal widening. Left S1 root shadow is also prominent but uniform over a long distance extending caudally into root sheath (*crossed arrows*). Uniform caliber of these shadows indicates they are due to overlapping of dorsal and ventral roots. Operative exploration at L4–5 on left demonstrated L5 roots to be freely mobile and not compressed. Underlying disk exhibited moderate diffuse bulging with no focal protrusion.

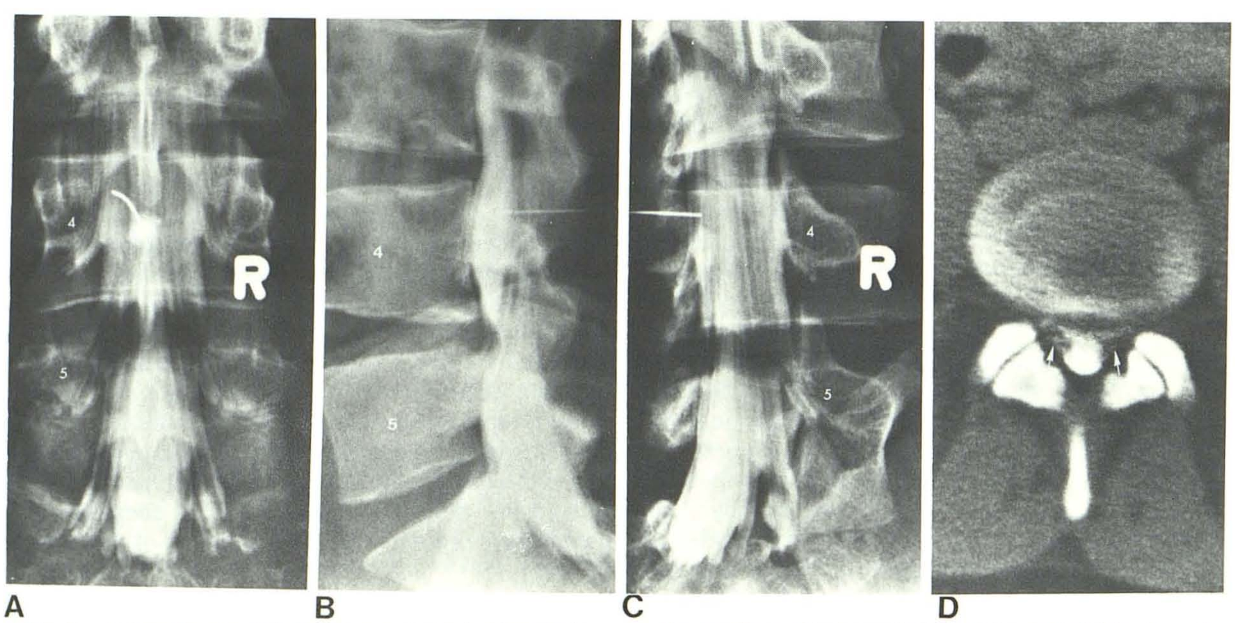
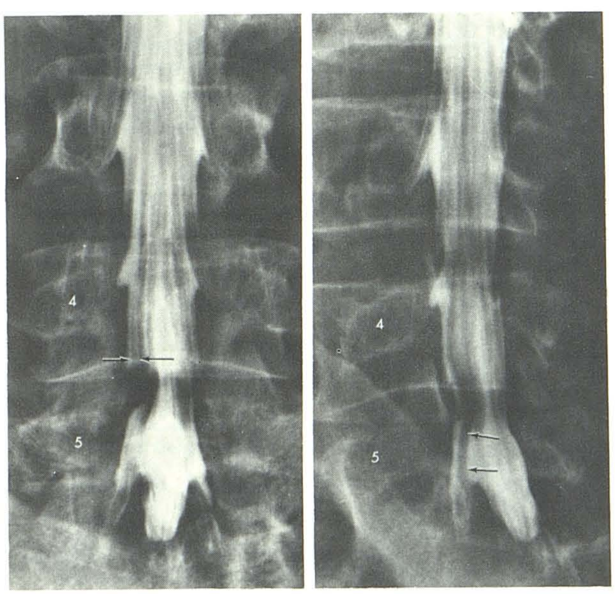


Fig. 2.—Diffusely bulging disk. **A**, Anteroposterior view from Amipaque myelogram. Symmetrical, rounded indentations of both lateral margins of thecal sac at level of L4–5 disk space. Despite these prominent indentations, L5 root sheaths are opacified. **B**, Horizontal beam prone lateral view. Bulging disk indents anterior margin of sac at L4–5, but contrast filling of L5 root sheaths partially obscures indentation. **C**, Right posterior oblique view. Defect is less impressive and located medial to right anterolateral sac margin. **D**, Axial CT image at level of lower margin of L4–5 intervertebral disk. Shallow concavity of anterior margin of contrast-filled thecal sac; indentation is most prominent centrally and nerve roots are displaced laterally to both sides (*arrows*). Crowding of nerve roots on each side prevents good opacification of anterolateral sac margins and accounts for bilateral filling defects in **A**.

rounded (symmetrical upper and lower margins) and did not extend cephalad or caudad to the level of the intervertebral disk space. Such deformities were most frequently bilateral and fairly symmetrical (figs. 1 and 2), although in two instances the deformity on one side was much more prominent (fig. 3). The deformity of the sac was usually not accentuated and was often actually less impressive on the oblique views. An essential criterion of bulging disk was also the demonstration of normal uniform (nonwidened) caliber of the most distal visible part of the nerve root.

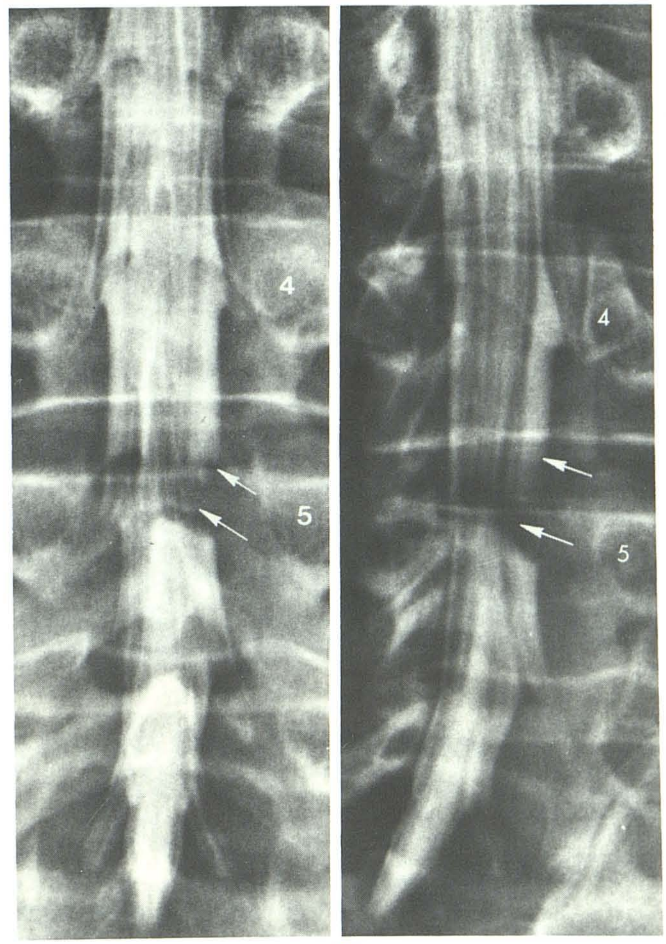
A lesion was classified as a *herniated disk* at myelography if the film demonstrated either: (1) an extradural deformity of the anterolateral margin of the sac that was angular and extended cephalad and/or caudad to the level of the disk space (fig. 4), (2) fusiform or scallionlike widening of the most distal visible part of the nerve root (fig. 5), or (3) both an angular sac deformity and distal nerve root widening (figs. 6–8). In most cases, these findings were best demonstrated on views obtained with the patient rotated 15°–30° into the posterior oblique projection on the side of the herniation; the oblique view displays the profile of the anterolateral margin of the sac and thus accentuates the deformity produced by a posterolateral disk herniation.

The operative records of all 33 patients were carefully reviewed to ascertain the condition of the affected nerve root and its relation to the adjacent posterolateral disk margin. A lesion was classified as herniated disk at surgery only if the surgeon had clearly recorded that the nerve root within its root sheath was displaced, stretched, compressed, and immobilized by a localized protrusion of disk material. In instances where the surgeon noted that the nerve root in its root sheath was freely mobile within the confines of the operative exposure and was not impinged upon by the adjacent disk, the case was classified surgically as a bulging disk.



A B

Fig. 3.—Unilateral bulging disk at L4–5. **A**, Anteroposterior view from Amipaque myelogram. Rounded indentation into sac on left is confined to height of L4–5 disk space. Left L5 root shadow (*arrows*) is not widened. L5 root sheaths are cut off on both sides due to diffuse bulging of L4–5 disk. **B**, Left posterior oblique view. Anterolateral margin of sac in profile; Deformity of sac margin less impressive than in **A**. Laminectomy revealed left L5 roots to be of normal caliber and freely mobile. Underlying disk was bulging but intact and did not impinge on roots. Prominent but uniform left S1 root shadow over a long distance due to overlapping of the dorsal and ventral roots (*arrows*).



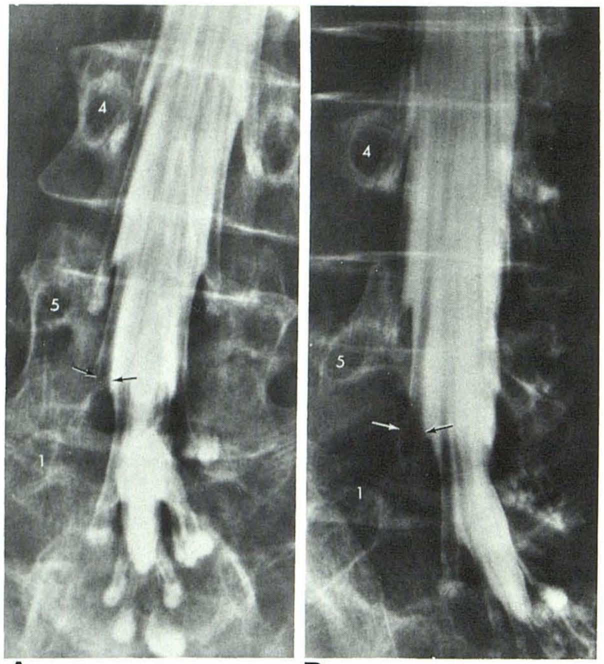
A B

Fig. 4.—Herniated disk at L4–5 on right; six lumbar vertebrae. **A**, Anteroposterior view from Amipaque myelogram. Angular indentation of lateral margin of contrast-filled thecal sac at level of L4–5 intervertebral disk space extends caudad to level of disk space (*arrows*). **B**, Right posterior oblique view. Angularity and depth of defect (*arrows*) accentuated. Right L5 root sheath is not opacified, and no widening of L5 root is identified. Laminectomy revealed a free fragment-herniated disk which had migrated caudad to the disk space and was compressing the L5 root.

Results

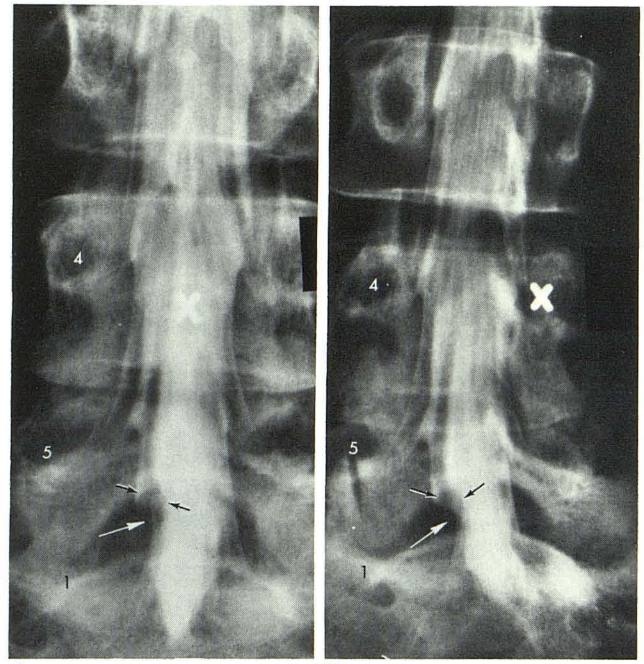
Of the 33 patients in this series, 27 were found at surgery to meet the criteria listed above for operative diagnosis of posterolateral herniated disk at one of the two lower lumbar levels. In six patients, no herniation was found, only a diffusely bulging disk with freely mobile nerve root of normal caliber at the explored level.

All of the six patients in this series with operatively proven bulging disk were correctly diagnosed on preoperative Amipaque myelography. None of these six myelograms demonstrated either angular sac deformity or distal nerve root widening (table 1). In all six cases, the deformity of the



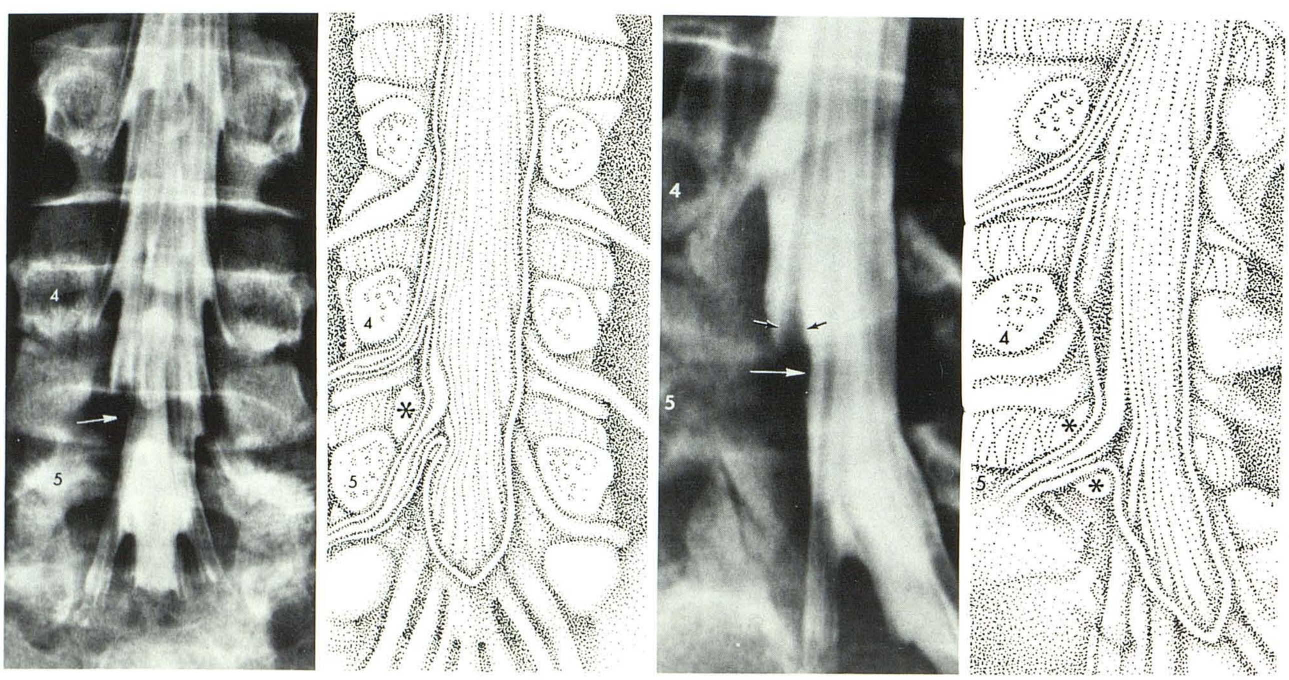
A B

Fig. 5.—Herniated disk at L5–S1 on left; scoliosis convex to left. Anteroposterior (**A**) and left posterior oblique (**B**) views from Amipaque myelogram. No deformity of opacified thecal sac. Left S1 root sheath is faintly opacified but elevated and cut off in proximal portion. Fusiform widening of most distal part of left S1 nerve root (*arrows*). At laminectomy, a large focal herniation of L5–S1 disk lay anterior to S1 root which was compressed and fixed in position.



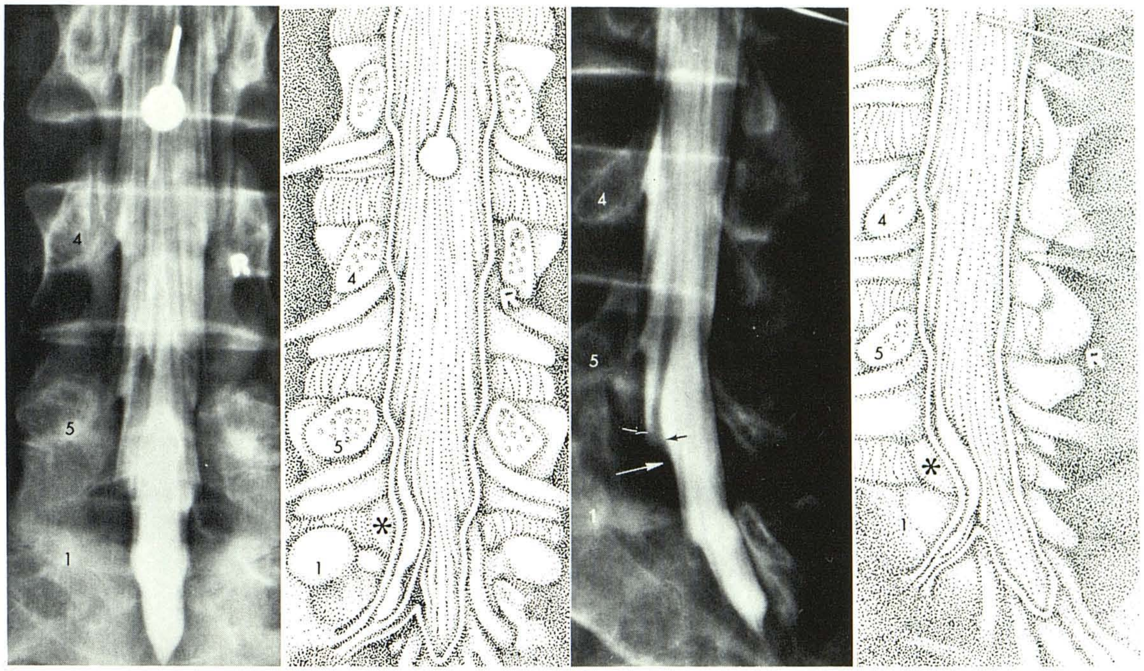
A B

Fig. 7.—Herniated disk at L5–S1 on left. Anteroposterior (**A**) and left posterior oblique (**B**) views from Amipaque myelogram. Angular deformity of anterolateral margin of sac cephalad to L5–S1 disk level (*white arrows*) with cutoff of S1 root sheath on left. Most distal visible part of left S1 root is widened in scallionlike fashion (*black arrows*). Opaque "X" is skin marker.



A B C D

Fig. 6.—Herniated disk at L4–5 on left. **A** and **B**, Anteroposterior view from Amipaque myelogram. Lateral margin of sac is flattened (*arrow*) and left L5 root sheath is cut off. **C** and **D**, Left posterior oblique view. Slight angular deformity of anterolateral margin of sac (*white arrow*) and most distal visible part of L5 root is widened (*black arrows*). Asterisks on artist's renderings indicate disk herniation.



A B C D

Fig. 8.—Herniated disk at L5–S1 left. **A** and **B**, AP view from Amipaque myelogram. No deformity of lateral margin of sac, but left S1 root sheath is cut off. **C** and **D**, Left posterior oblique view. Angular deformity of anterolateral sac margin (*white arrow*), and most distal part of left S1 root shows fusiform widening (*black arrows*). Asterisks on artist's renderings indicate disk herniation.

TABLE 1: **Amipaque Myelography: Correlation between Operative and Myelographic Findings**

Operative Findings		Myelographic Findings		
Type	Total No.	Nerve Root Widening	Root Sheath Cutoff	Angular Sac Deformity
Herniated disk:				
L4–5	12	9 (75)	11 (92)	11 (92)
L5–S1	15	15 (100)	15 (100)	13 (87)
Total	27	24 (89)	26 (96)	24 (89)
Bulging disk:				
L4–5	5	0	4 (80)	0
L5–S1	1	0	1 (100)	0
Total	6	0	5 (83)	0

Note.—Numbers in parentheses are percentages.

TABLE 2: **Amipaque Myelography: Correlation between Myelographic Diagnosis and Operative Findings**

Myelographic Diagnosis		Operative Findings	
Entity	Total No.	Herniated Disk	Bulging Disk
Herniated disk:			
L4–5	11	11	0
L5–S1	15	15	0
Total	26	26	0
Bulging disk:			
L4–5	6	1	5
L5–S1	1	0	1
Total	7	1	6

sac margins was gently rounded, was restricted to the level of the disk space, and was less prominent in the posterior oblique projection than on anteroposterior views. In four of the six patients, the rounded sac defects were bilateral and fairly symmetrical (figs. 1 and 2); in the other two cases, the rounded sac defect was predominantly unilateral (fig. 3). The *specificity* (likelihood of a negative myelographic diagnosis in patients without herniated disk) in this small series was 100% (six/six) (table 2).

Of the 27 patients with operatively confirmed disk herniation, 24 (89%) demonstrated an angular deformity of the anterolateral margin of the contrast-filled thecal sac extending cephalad and/or caudad to the intervertebral disk level on preoperative Amipaque myelography, including 11 (92%) of 12 cases at the L4–L5 level and 13 (87%) of 15 cases at L5–S1 (table 1).

Of the 27 patients with operatively verified disk herniation, 24 (89%) demonstrated distal widening of the affected nerve root at preoperative Amipaque myelography, including nine (75%) of 12 cases at the L4–L5 level and 15 (100%) of 15 at L5–S1 (table 1).

At the L4–L5 level, the myelographic diagnosis of disk herniation was based only on the presence of an appropriately situated angular sac deformity in two patients in whom the most distal visible part of the affected L5 root did not appear widened (fig. 4). At the L5–S1 level, the myelographic diagnosis of disk herniation was based only on the visualization of distal widening of the affected S1 nerve root in two patients in whom no angular sac deformity could be demonstrated (fig. 5).

In one patient with operatively proven L4–L5 disk herniation, neither an angular sac deformity nor distal root widening could be demonstrated at myelography; this myelogram was interpreted as bulging disk and represents the only false-negative myelographic diagnosis in this series. Thus, the *sensitivity* (likelihood of a positive myelographic diagnosis in patients with herniated disk) in this series was 26 (96%) of 27 (table 2).

Failure of opacification (cutoff) of the affected root sheath was noted at myelography in 26 (96%) of 27 operatively confirmed disk herniations and in five (93%) of six operatively confirmed bulging disks (table 1). Root sheath cutoff was therefore not of diagnostic aid in differentiating herniated disk from bulging disk.

Discussion

The accuracy of Pantopaque myelography for the diagnosis of herniated lumbar intervertebral disk is reported as 85%–90% at the L4–L5 level and 75%–80% at L5–S1 [8–11]. False-negative diagnoses are a particular problem at the L5–S1 level where the thecal sac is narrower and the canal is wider in transverse dimension than at L4–L5 or higher lumbar levels. There is more extradural soft tissue anterior and lateral to the sac at L5–S1 into which a disk can herniate and yet not impinge on the contrast-filled sac. This is particularly true if the herniation occurs far laterally near the intervertebral foramen [12, 13].

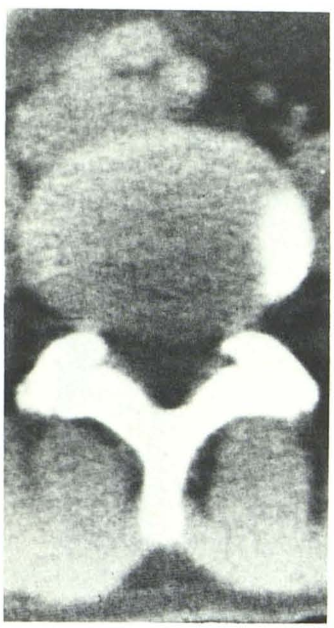


Fig. 9.—Diffusely bulging disk. Axial CT image at level of L4–5 intervertebral disk. Posterior margin of disk is convex, indicating minimal diffuse bulging, slightly greater on patient's left side than on right.

False-positive diagnoses can also be a problem. Many patients with sciatica do not have a herniated lumbar intervertebral disk [14], although their myelograms may demonstrate one or more extradural deformities of the lateral margins of the contrast-filled thecal sac at the lower lumbar disk levels. Diffuse bulging of the lower lumbar intervertebral disks is a common finding at myelography in individuals beyond the fourth decade of life [15]. The posterior margin of a diffusely bulging disk is convex [16] (fig. 9), and this convex bulge may indent the anterior margin of the thecal sac. If the degree of bulging is sufficiently great, the nerve roots within the sac will be displaced from the midline into the less capacious lateral recesses (fig. 2), resulting in bilateral rounded and fairly symmetrical deformities of the lateral margins of the contrast-filled sac [4, 15].

Occasionally, a disk will bulge more prominently on one side (fig. 9) and, if sufficiently prominent, will cause a deeper indentation into the contrast column on that side, raising the possibility that the defect is due to herniation rather than bulging (fig. 3). However, bulging disks rarely elevate the adjacent dura to such an extent as to place it under tension, and so the deformity is not angular and does not extend beyond the level of the disk space (findings typical of herniated disk).

Myelography with Amipaque permitted direct visualization of the compressed nerve root in all but three of 27 patients with operatively proven lumbar disk herniation (table 1). This finding was especially valuable in two patients in this series with L5–S1 disk herniations in whom there was no deformity of the contrast-filled sac; the diagnosis was based entirely on the demonstration of distal widening of the S1 nerve root on the affected side (fig. 5). Furthermore, there was no evident distal nerve root widening at myelography in the six operatively verified cases of bulging disk in this series. The lack of widening of the nerve root thus adds an additional criterion to the myelographic differentiation of bulging from herniation (table 3).

The relatively high radiographic density and viscosity of Pantopaque (iophendylate, Lafayette) usually precludes reliable and accurate visualization of the nerve roots in the

TABLE 3: **Herniated versus Bulging Lumbar Intervertebral Disk: Myelographic Criteria for Differentiation**

	Herniated Disk	Bulging Disk
Deformity of sac:		
Nature	Angular	Rounded
Localization	Extends cephalad and/or caudad to level of disk space	Confined to level of disk space
Deformity on oblique projection	Accentuated	Often less impressive
Laterality	Unilateral	Often bilateral ("hourglass")
Filling of root sheath	Cut off	Often cut off
Size of nerve root	Often widened distally	Normal (except in spinal stenosis)

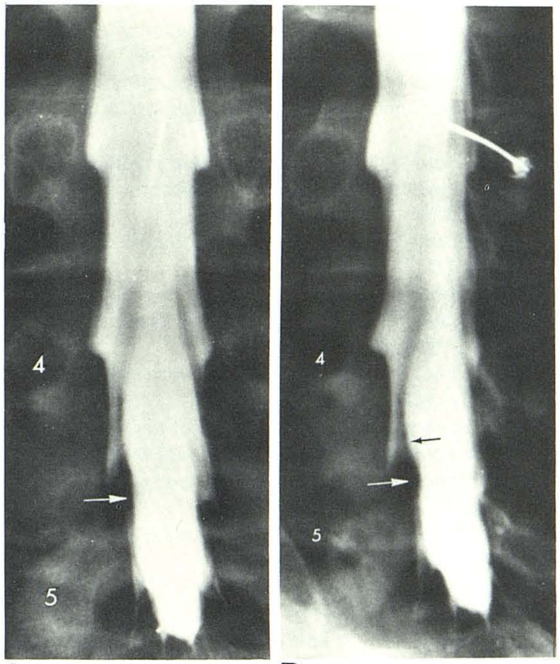


Fig. 10.—Herniated disk at L4-5 on left. Anteroposterior (**A**) and left posterior oblique (**B**) views from Pantopaque myelogram. Shallow angular deformity of left anterolateral sac margin extends rostrally from L4-5 disk space level (*white arrows*). Angular deformity accentuated on **B**. Prominent curvilinear lucency within sac widens distally (*black arrow*) and may represent compressed left L5 nerve roots.

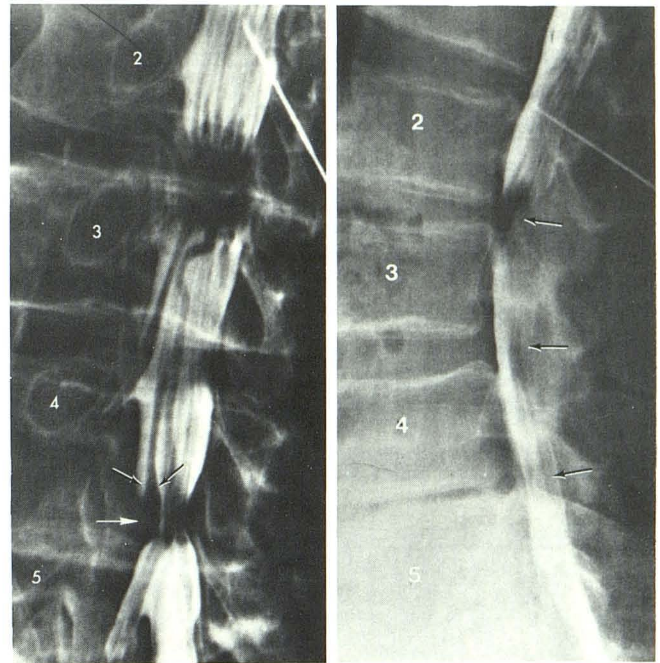


Fig. 11.—Narrowing of lumbar spinal canal ("spinal stenosis") with associated diffuse bulging of several lumbar intervertebral disks. **A**, Left posterior oblique view from Amipaque myelogram. Nearly complete block to flow of contrast medium at L2-3 and less severe "hourglass" constriction of sac at L4-5. Distally widened left L5 root (*black arrows*) with cutoff of left L5 root sheath. Anterolateral sac defect (*white arrow*) appears rounded, suggesting bulging disk (which usually does not cause nerve root compression). **B**, Horizontal beam lateral view explains this disparity: constrictions of sac are due mainly to posterior and lateral encroachment (*arrows*) by prominent and thickened laminae. L2-3 and L4-5 disks bulge only minimally into anterior margin of sac.

lumbar thecal sac and root sheaths. However, Shapiro [17] noted the presence on Pantopaque myelograms of "nerve root edema" caused by lumbar disk herniation. Although we have occasionally observed apparent widening of the affected nerve root on Pantopaque myelograms in patients with lumbar disk herniation, we have rarely been able to be certain that this finding actually represented the compressed nerve root (fig. 10). Reports in the Scandinavian literature of the accuracy of myelography with water-soluble contrast agents for the diagnosis of herniated lumbar intervertebral disk have made occasional mention of the finding of a widened nerve root in association with herniated disk but have neither emphasized this finding nor indicated the frequency of its occurrence [18-20].

One diagnostic pitfall of Amipaque lumbar myelography worthy of special note is the situation of overlapping nerve roots within the cauda equina that may simulate one uniformly wide root. This should not be mistaken for a compressed nerve root secondary to disk herniation; overlapping roots produce a relatively long segment of more or less uniformly increased width (figs. 1 and 3), while true nerve root widening secondary to disk herniation involves only a relatively short and extremely distal part of the root and is not uniform in caliber but rather appears either fusiform or scallionlike (figs. 5-8).

The overall diagnostic accuracy of Amipaque myelography in this series of 33 operatively confirmed cases was 32 (97%) of 33. Factors that contributed to this relatively high level of accuracy were: (1) the ability to demonstrate fusiform widening of the most distal visible part of the affected nerve root in cases of disk herniation, even when no angular sac deformity was evident, and (2) the insistence on accurate description of surgical findings with an operative diagnosis of disk herniation being established only when the surgeon described the nerve root as being fixed in position and compressed by protruding disk material.

Most diffusely bulging disks are not associated with nerve root widening (compression). In a small part of the population, however, myelography demonstrates severe hourglasslike constrictions of the sac at several lumbar disk levels with partial block to the flow of contrast medium at multiple levels and widening of one or more nerve roots (fig. 11). Careful inspection of oblique and lateral views in such cases reveals that the segmental constrictions of the sac are due not only to diffuse bulging of the intervertebral disks but also to narrowing of the spinal canal with impingement on the posterior and lateral aspects of the sac by prominent laminae, hypertrophied articular processes, and thickened ligamenta flava and capsular ligaments. Such cases are examples of "spinal stenosis," in which the nerve root compression is due more to the encroaching bony and ligamentous structures than to the bulging disks [21].

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