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Recognition of Lumbar Disk Disease: Comparison of Myelography and Computed Tomography

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A retrospective study was devised to determine the correlation between myelography and computed tomography (CT) in the recognition of abnormalities of the lumbar intervertebral disk. A group of 106 patients was studied who had had both myelography and CT within a 6 week period. Each examination was interpreted separately by a neuroradiologist who had no access to the patients' clinical findings or the results of any radiologic studies. On comparison of 290 interspace levels, there was agreement in definite abnormalities in 70%. Most discrepancies were due to suspicious findings and inconclusive studies of both kinds. In particular, there was poor correlation between the two examinations in the diagnosis of a slightly bulging disk. The major discrepancy rate was less than 5% overall and less than 1% among patients without prior surgery. On the basis of these findings, a diagnostic algorithm is suggested that would facilitate the workup of a similar group of patients.

Computed tomography (CT) is rapidly gaining acceptance in the diagnosis of disorders of the lumbar spine [1–5]. However, studies concerning its accuracy in large numbers of patients have not yet been published. As a first step in establishing its accuracy in intervertebral disk disease, comparison with myelography is necessary. A collaborative study involving two teaching institutions, Tulane Medical Center (TMC) and Charity Hospital at New Orleans (CHNO), a Louisiana State University teaching hospital, was devised to test the correlation between myelography and CT and to assess their relative accuracies in the evaluation of diseases of the lumbar intervertebral disk. A group of 106 patients in whom both examinations were performed within a 6 week period constituted the basis of this study.

Materials and Methods

Of about 500 spinal CT examinations performed at CHNO and TMC during a 1 year period, those patients were identified who had had concurrent myelography (examination within 6 weeks). Of 128 patients for whom both examinations were available, 17 were excluded because of an interval between examinations of greater than 6 weeks. Clinical diagnoses reflected a general hospital population; 20% of patients had had prior surgery. There was surgical follow-up in 39%.

All CT examinations were supervised by a neuroradiologist and performed on a high-resolution scanner (General Electric CT/T 8800 at CHNO and Picker Synerview 600 at TMC). Standard scanning techniques included narrow collimation and small field size. Examinations on the G.E. scanner were performed as an array of 5 mm contiguous sections, supplemented with angled gantry and reformatted images [6]. The section was usually parallel to the disk space at L4–L5, but it was parallel to the L5–S1 space in only about 40% of cases. Examinations on the Picker scanner were performed as 6 mm sections, overlapped by 1 mm, and angled through each interspace studied [3]. Most study patients (73 of 108) were examined at CHNO using the G.E. scanner. Nonstandard techniques that may have degraded CT image quality were present in 15 patients. Myelographic exami-

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nations were performed at the two collaborating institutions or at other local hospitals. Both metrizamide and Pantopaque examinations were included in this study.

Each myelographic and CT examination was coded and interpreted separately by a neuroradiologist from the neighboring institution who had no knowledge of the patient's clinical findings, radiologic findings, or subsequent course. In this manner, a truly "blind" reading was obtained.

Each myelographic level was evaluated with regard to defects: none, central (slight or prominent), root sleeve, or dural. Inconclusive examinations included those in which the interspace could not be adequately evaluated for any reason, whether related to the patient's anatomy or to the technique of the examination.

CT scans were interpreted from hard copy images. Attention was directed to the contour of each disk annulus and the presence of abnormal intraspinal soft-tissue structures. The annulus was described as normal or bulging (slight or prominent central bulge, slight or prominent lateral bulge). An examination was considered inconclusive when it did not optimally define the disk contour. Criteria for a positive CT study included: (1) an abnormal disk contour; (2) an abnormal soft-tissue structure inside the canal; and (3) the presence of mass effect on epidural fat, segmental nerves, or the dural sac. Findings that did not meet these criteria were considered suspicious. At the time of the initial reading, anatomic descriptors such as "slight bulge" were supplemented by clinical descriptors. Therefore, each interspace was rated as negative, inconclusive, suspicious, or positive by both types of examination.

Because numerical variables could not be used, a true statistical correlation could not be determined. An estimated correlation was determined, however, for perfect correlation (negative/negative, suspicious/suspicious, positive/positive, inconclusive/inconclusive). Discrepancies were characterized as major (negative/positive) or minor (negative/suspicious, positive/suspicious). Major discrepancies were considered such because they would have major impact on patient management. Minor discrepancies would have less impact, because, in clinical practice, suspicious findings are given less weight in determining therapy.

The patients were divided into groups: all 106 patients in the study, 21 postoperative patients only, and 85 patients without previous surgery. Patients who were studied by nonstandard techniques (10 mm sections, large field size and calibration, or examination with intrathecal contrast administration) were excluded in order to define a group of "standard" patients in whom CT accuracy would be at its theoretical maximum. Finally, cases with surgical correlation were analyzed separately to assess the relative accuracy of each method using surgery as the absolute standard.

Data were analyzed by interspace level and by patient examination. On the basis of the results of analysis, two diagnostic "flow charts" or algorithms (see Discussion) were devised and tested to determine which would better facilitate workup of a similar group of patients.

Results

Data correlation is found in table 1. Agreement was considered to be perfect when both examinations yielded identical results. Examination pairs containing major or minor discrepancies or one inconclusive examination were tabulated, and correlation and discrepancy information was given for the major patient groups.

TABLE 1: **CT-Myelographic Correlation: All Levels**

Patient Group Level	No. Examinations	Correlation (%)			
		Perfect	Major Discrepancy	Minor Discrepancy	Inconclusive
All:					
L3–L4	75	77	3	9	11
L4–L5	108	70	4	15	11
L5–S1	107	64	3	10	23
Combined	290	69	3	12	16
Prior surgery:					
L3–L4	8	38	12	25	25
L4–L5	16	44	25	25	6
L5–S1	18	55	17	11	17
Combined	42	48	19	19	14
No prior surgery:					
L3–L4	67	82	2	7	9
L4–L5	92	75	0	13	12
L5–S1	89	65	0	10	25
Combined	248	73	1	10	16
Standard*:					
L3–L4	59	88	2	5	5
L4–L5	79	80	0	11	9
L5–S1	73	71	0	10	19
Combined	211	80	0	0	11
Surgical†:					
L3–L4	3	34	33	0	33
L4–L5	23	68	9	9	14
L5–S1	26	64	4	8	24
Combined	52	64	8	8	20

* Cases without prior surgery examined with standard technique as defined in text.
† Surgical exploration at level studied.

As demonstrated in table 1, the correlations were significantly influenced by previous surgery. With the exception of postoperative patients, most of the discrepancies were minor or attributable to one inconclusive component of the examination pair (table 2). The major discrepancy rate among patients without prior surgery was less than 1%. In particular, there was only one case without prior surgery in which CT was normal and myelography was positive, and there were no cases without prior surgery in which CT was positive and myelography was normal. The clinically significant correlation between myelography and CT was very high in the previously unoperated patients.

Surgical confirmation was available in 41 of our patients who had not had previous surgery (table 3). In patients without prior surgery who had herniated disk fragments at surgery, 23 of 27 studies were perfectly correlated. There was only one minor discrepancy, although there were three inconclusive myelographic examinations. Discrepancies between surgery and both radiologic examinations were seen. In one case in which a herniated nucleus pulposus was found at surgery, both CT and myelography were considered negative for disk disease (fig. 1). Perhaps clinical correlation might have changed the myelographic interpretation or the CT technique of examination. However, overall, correlation between surgery and both methods was high. Few cases of minor discrepancy came to surgery, and no consistent correlation could be derived.

Discussion

The role of high-resolution CT scanning in the diagnosis of a variety of disorders is currently being defined. In each area of interest, CT is being compared with the current diagnostic procedure of choice in order to estimate its accuracy and to establish its place in current diagnostic protocols. In attempting to correlate CT with other procedures, however, it is important to design a study that will produce reliable results. In the first place, a large number of cases must be analyzed in order to justify confidence in the conclusions. Secondly, the same group of patients should undergo both types of examinations in order to maintain adequate controls. Furthermore, radiologic bias should be reduced by performing "blind" interpretations of each procedure. Finally, in comparing nonhomogeneous data, the clinical methods and contexts should be carefully defined, because the conclusions will be relevant only in similar contexts [7].

Myelography and CT produce grossly different images of the spine. CT is a cross-sectional method that provides direct visualization of the dural and epidural spaces, the segmental nerves, the intervertebral disks, and the bony canal. Myelography, on the other hand, provides views of the subarachnoid space and its contents only. Although the two differ greatly, some type of correlation between them is necessary, because these examinations will probably dominate the radiologic workup of intervertebral disk diseases for the foreseeable future.

Critical to our analysis was the manner in which anatomic abnormalities were correlated. Because myelography and CT demonstrate spinal anatomy differently, any strictly topographical correlation between them is unlikely to be perfect, although the clinical information contributed by each may be identical (fig. 2). For example, we found it difficult to correlate a laterally extruded fragment with a myelographic defect without taking into account the size of the spinal canal and epidural spaces. For this reason, we described each examination in both anatomic and clinical terms, the latter of which were used for correlation.

Some anatomic findings were considered "suspicious," in the sense that they did not fulfill our criteria for disk

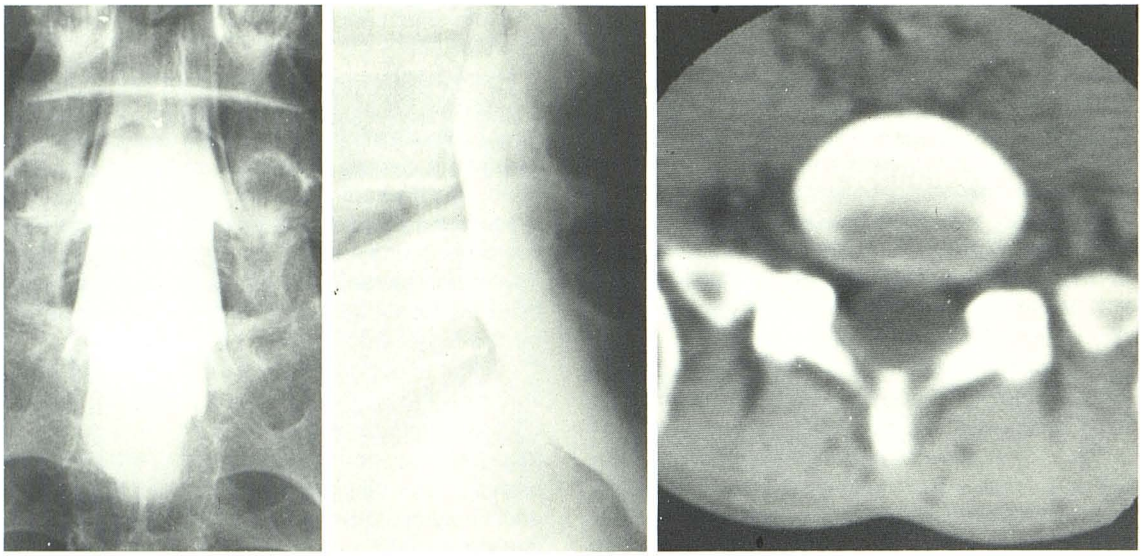
TABLE 2: **Reasons for Inconclusive Examinations**

	No. Examinations
Computed tomography:	
Limited contrast resolution (photon limited)	8
Spinal stenosis	4
Excessive Pantopaque	3
Postoperative fibrosis, fusion	3
Large field size	2
Patient motion	1
Total	21
Myelography:	
Large anterior epidural space	14
Obstruction above level considered	5
Arachnoiditis	2
Dry Tap	2
Dilute contrast medium	1
Total	24

TABLE 3: **Surgical Follow-up in Patients without Prior Surgery**

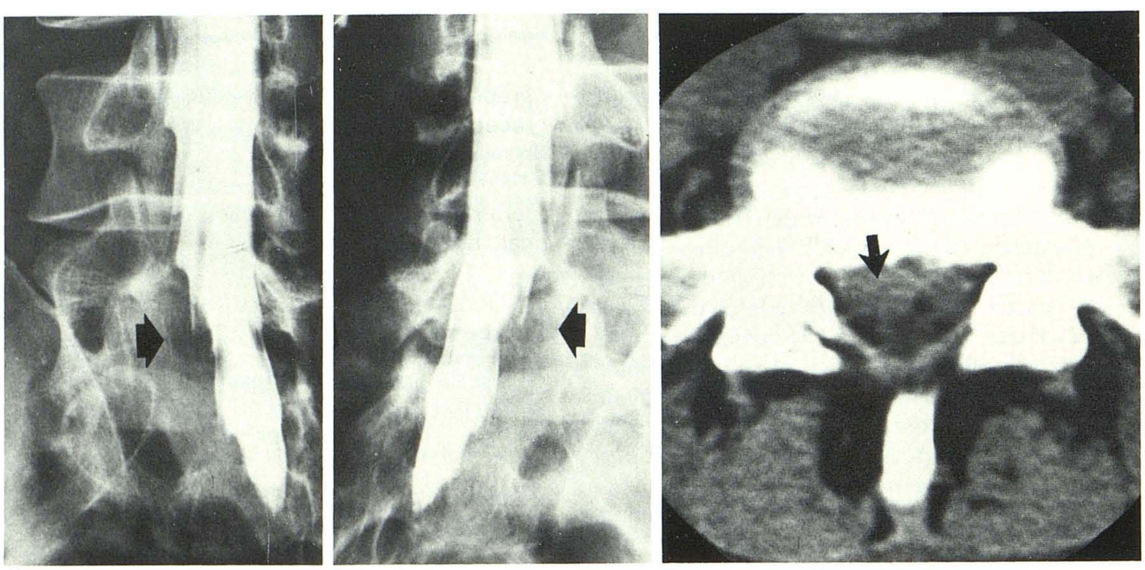
Surgical Findings	No. Interspaces*	No.			
		Perfect Correlation	Minor Discrepancy	Inconclusive (CT)	Inconclusive (Myelography)
Herniated disk	27	23	1	0	3
Spinal stenosis	9	2	1	2	4
Bulging annulus	3	2	1	0	0
Osteophyte	2	1	0	1	0
Lacerated annulus without bulge	1	0	1	0	0
Totals	42	28	4	3	7

Note.—In no instance was there a major discrepancy.
* There were 42 interspaces in 41 patients.



A B C

Fig. 1.—**A** and **B**, Metrizamide myelography. Root sleeves and dural sac considered negative for disk disease. **C**, Axial CT section, L5-S1 disk. Annulus is flat, epidural fat planes intact, and no distortion of dural sac. Because of right S1 radiculopathy, the patient had surgery, which revealed herniated disk fragment that migrated from L5-S1 interspace to level of right S1 foramen. On review of CT, angled gantry views did not extend down to this level. This case demonstrates the need for clinical correlation in interpreting any radiologic investigation of lumbar spine.



A B C

Fig. 2.—**A** and **B**, Metrizamide myelography. Nearly symmetrical extradural defects at L5-S1 level (*arrows*). **C**, Axial CT section at L5-S1 level. Abnormal high attenuation fragment in spinal canal (*arrow*) produces more mass effect on right. Topographic differences between two studies may be related to degree of obliquity during myelography, nerve root edema, or migration of fragment between two examinations.

protrusion and did not, in themselves, justify surgical exploration. Suspicious findings constitute an ambiguous group both clinically and in terms of this study. In clinical practice, these suspicious findings would require close clinical correlation or further workup. Occasionally, both myelography and CT would result in suspicious findings; these cases were included as perfectly correlated pairs according to the methodology of our study. Usually, however, these cases resulted in "minor discrepancies." The category of "major discrepancy" was reserved for negative/positive mis-

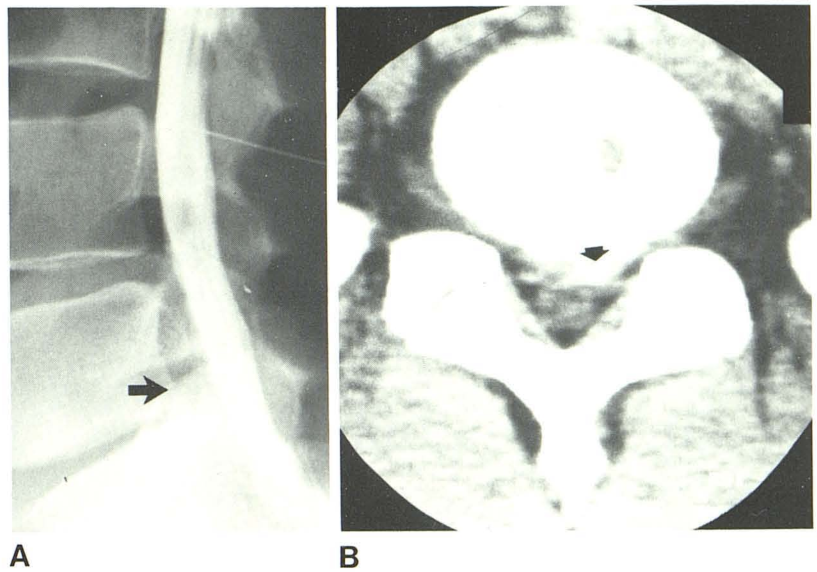


Fig. 3.—A, Metrizamide myelography. Anterior epidural space very wide at L5–S1 level (*arrow*). Although dural sac is flattened, herniated disk fragment cannot be diagnosed with certainty. B, Axial CT section at level of inferior end plate of L5. Partly calcified fragment in left anterolateral epidural space. Because of CT finding, space between L5 vertebral body and posterior longitudinal ligament was explored surgically more extensively than otherwise planned; a large disk fragment was extracted.

matches that would have had a major impact on the clinical management of a patient.

Our results demonstrate moderately frequent perfect correlation between myelography and CT, 70% of levels, 50% of patients. This correlation was offset by a number of minor discrepancies, 12% of levels, 17% of patients, and a high number of examination pairs in which one examination was inconclusive, 16% of levels, 28% of patients. Correlation was also lowered by the inclusion of postoperative patients and patients examined by nonstandard CT techniques, 31% of levels, 26% of patients, in whom correlation was particularly low.

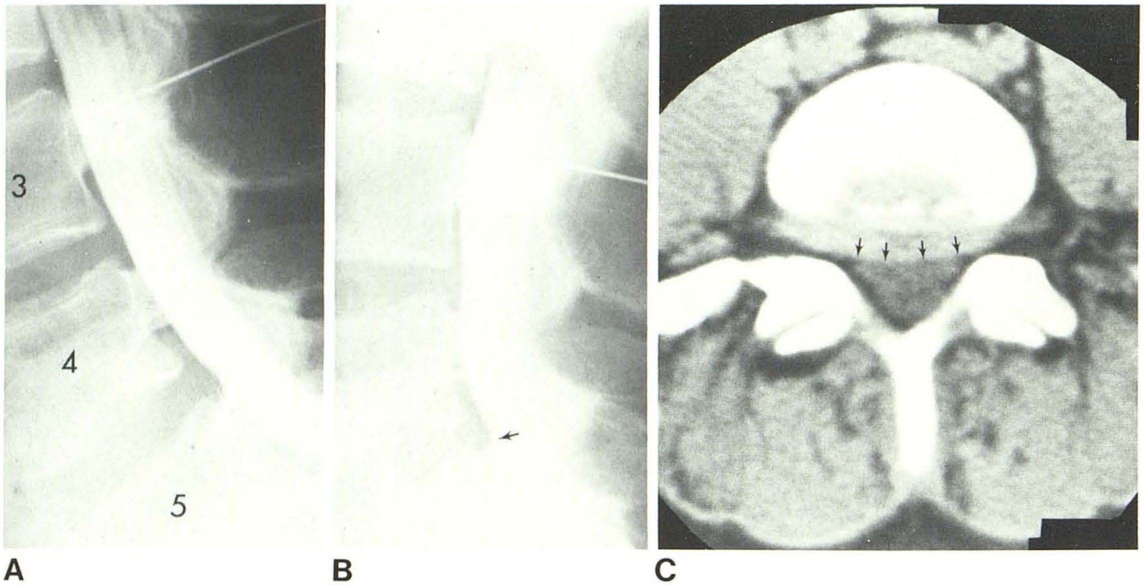
Most discrepancies were due to inconclusive examinations. More than half the inconclusive myelographies were due to anatomic factors (table 2), especially a large anterior epidural lumbosacral space (fig. 3). Another myelographic finding in 5% of patients was obstruction to the flow of contrast material at the L4–L5 level, precluding evaluation of the lumbosacral level. Arachnoiditis or a "dry tap" accounted for other inconclusive myelographic studies. One-half the inconclusive CT examinations were due to potentially correctable technical factors, such as limited contrast resolution or improper field size selection. Patient factors such as severe stenosis or excessive Pantopaque accounted for other inconclusive (for disk disease) CT studies.

Minor discrepancies in patients without prior surgery were usually related to a slight central bulge seen at either CT (19 of 26 levels) or myelography (17 of 21 levels) (fig. 4). This finding is likely to become an area of disagreement between these two methods because, although CT is capable of optimally visualizing the disk contour, myelography allows "stress views," such as standing flexion/extension views that may accentuate a slight bulge [8]. For clinicians who place emphasis on annular bulging, both studies may be necessary. For those who believe bulging to be a normal phenomenon, CT may suffice.

The crucial test of any diagnostic method is its ability to detect or exclude major disease. In our study, there were only two false-negative CT examinations if myelography is considered the standard for comparison. Both these occurred at the L3–L4 level; one occurred in a postoperative patient (fig. 5), the other in a patient without prior surgery. The former patient underwent exploration because of the myelographic defect. At surgery, the disk was normal, but there was epidural fibrosis. On review of the CT, the myelographic defect was considered to be due to subluxation of a facet. The other patient had no clinical findings to support the myelographic defect, and surgery was not performed.

False-positive CT examinations were confined to the postoperative group in whom epidural fibrosis may simulate a small, noncalcified disk fragment. There were no false-positive CT studies in patients without prior surgery, using myelography as the absolute standard. This striking finding may be due to our reliance on strict criteria for a disk abnormality. The number of false-positive and false-negative CT examinations may have been reduced also by considering some cases to be suspicious rather than negative or positive. These two methodologic features may have combined to raise the "cutoff" for disk disease (increasing the specificity and lowering the sensitivity) [9]. Despite the possibility that our methodology may have artifactually lowered the false-positive rate to zero, we suggest that the false-positive rate for CT is certainly low, especially when strict criteria for disk disease are used, and we recommend similar considerations in clinical practice.

Surgical follow-up was available at 52 levels. These patients constitute a highly selected group. Among them, there was a correlation rate of only 45%. This low correlation rate was due largely to the 20% of explorations at postoperative levels. Table 3 demonstrates that at levels without prior surgery, there was a 67% correlation rate, no major discrepancies, and twice as many inconclusive myelographies as CT examinations. Highlighting the difficulty with any purely radiologic correlation study was the presence of two



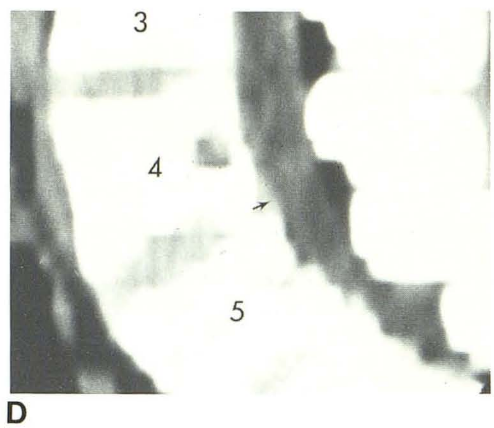


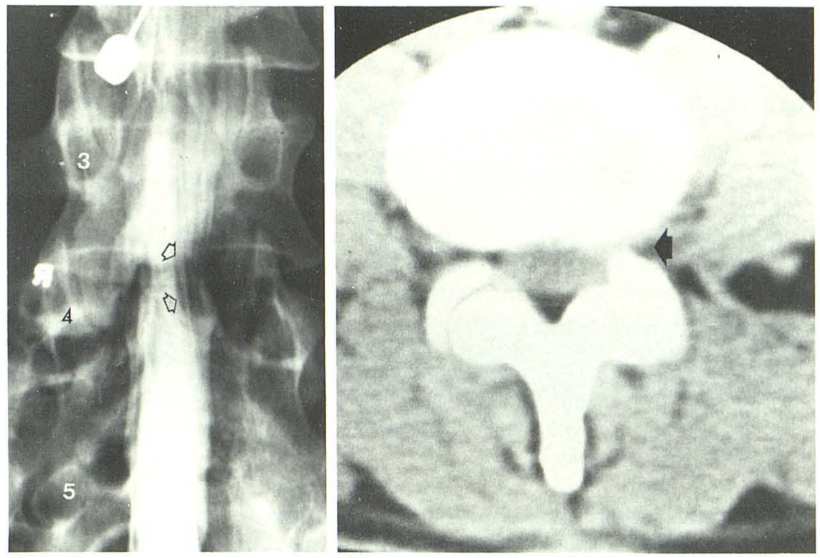
Fig. 4.—**A** and **B**, Flexion and extension standing lateral views at metrizamide myelography. Slight bulge of L4–L5 annulus more prominent on flexion than on extension (*arrow*). **C**, Axial CT section. Slight central bulge (*arrows*) without mass effect on segmental nerves. **D**, Midline sagittal reformatted image. Slight bulge (*arrow*). Bulging disk was found at surgery.

patients who had normal CT and normal myelography and at surgery were found to have disk abnormalities (fig. 1). Clinical correlation remains of paramount importance in guiding radiologic technique and interpretation.

In order to help define the relation of CT to myelography in the diagnostic workup of the patient with potential lumbar intervertebral disk disease, two competing diagnostic algorithms were devised [10]. The first assumed that myelography should be the first diagnostic test after plain films. A normal or abnormal myelogram would lead to either discharge from the study population or treatment. A suspicious or inconclusive myelogram would lead to subsequent CT, which would then guide the patient's clinical course. A similar flow chart was devised that began the patient's workup with CT.

The 85 patients without prior surgery in our study were individually followed through these diagnostic algorithms. This analysis showed that if myelography had been the initial diagnostic test, there would have been 85 myelographic examinations and 23 CT examinations. Had CT been the initial study, there would have been 85 CT and 16 myelographic studies. By beginning the workup with CT, therefore, the number of invasive procedures would have been reduced by a factor of 5. Furthermore, regardless of the sequence of examination, the final diagnosis would have been identical, with only one exception, a patient who had a negative CT examination and a positive myelogram. This patient did not undergo surgery because the myelographic defect, a lateral defect at L3–L4, did not correlate with her clinical findings.

From this study, we draw the following conclusions: (1) High-resolution CT scanning compares favorably with myelography in the recognition of lumbar disk disease. (2) Strict criteria for disk disease (abnormal annular contour, abnormal soft-tissue structures in the canal, mass effect on fat, nerves, or dura) should be used in CT interpretation. Negative or positive findings should be accepted as adequate for treatment planning; suspicious findings should suggest the need for myelography. (3) Clinical findings are of paramount importance in guiding both myelographic and CT techniques and interpretation. (4) If the referring physician suspects that annular bulging may account for the patient's



A B

Fig. 5.—**A**, Metrizamide myelography. Left lateral extradural defect at L3–L4 level (*arrows*). Part of lateral fusion mass apparent from L4 to S1 on left. **B**, Axial CT section. Left L3 foramen filled with high attenuation material; subluxation of L4 superior articular process into foramen (*arrow*). Disk was normal at surgery; there was epidural fibrosis in left L3 foramen. Superior articular process was not hypertrophied.

findings, then CT may not be sufficient and myelography or other procedures may be required for diagnosis. (5) Postoperative patients constitute a special group that may require both types of examination.

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