ORIGINAL ARTICLE

Lumbosacral Epiduroscopy Findings Predict Treatment Outcome

Hemmo A. Bosscher, MD, FIPP*; James E. Heavner, DVM, PhD, FIPP (Hon)*,†

*Departments of Anesthesiology, Texas Tech University Health Sciences, Lubbock, Texas ; †Cell Physiology and Molecular Biophysics, Texas Tech University Health Sciences Center, Lubbock, Texas, U.S.A.

■ **Abstract**

Objective: The aim of this study was to evaluate the significance of diagnostic markers obtained through epiduroscopy by evaluating the accuracy of outcome prediction after treatment of epidural pathology using epiduroscopy.

Design: A prospective observational study of 139 patients was performed. Patients with chronic low back and leg pain were included. Of the 150 patients who underwent epiduroscopy in the year 2008 at a US hospital, 139 were available for evaluation at 1 month.

Study: Outcome of treatment was predicted based on direct visual information (hyperemia, vascularity, and fibrosis) and mechanical information (pain to touch, contrast spread, and patency) obtained through epiduroscopy.

Main Outcome Measures: Outcome of treatment was measured at 1 month. Accuracy of prediction of outcome was calculated using contingency tables and odds ratios.

Results: A prediction of outcome was made in 114 of 139 patients (82%). This prediction was correct in 89 of these 114 patients (accuracy of 78%). The sensitivity and specificity of epiduroscopy with respect to the prediction of outcome were 75% and 82%, respectively. These results were statistically significant ($P < 0.01$).

In 25 of the 139 patients (18%), discrete epidural pathology was not observed. Nine of these 25 patients reported good relief after epiduroscopy. The sensitivity and specificity of epiduroscopy in the diagnosis of epidural pathology were 91% and 39%, respectively. These results were not statistically different ($P > 0.1$).

Conclusion: Our results show that lumbosacral epiduroscopy predicts outcome of treatment accurately in the majority of patients. This suggests that information obtained through epiduroscopy may carry significant diagnostic and prognostic value. ■

Key Words: lumbosacral epiduroscopy, low back pain, radiating pain, inflammation, vascularity, fibrosis, outcome prediction

INTRODUCTION

Endoscopy of the lumbosacral epidural cavity, epiduroscopy, is a novel technique used in the evaluation and treatment of low back pain.[1–9] The epidural space is not virtual and better thought of as a cavity filled with fat tissue, fibrous membranes, ligaments, lymphatic and blood vessels, and an extensive plexus of nerve tissue.[10–15] All of these structures and tissues play an important role in the proper function of the highly mobile spine and the central nervous system components it contains. The epidural cavity is small, which makes direct endoscopic visualization of epidural structures difficult. Current endoscopic technology is not well suited for such narrow spaces; hence, only a small part of the epidural cavity can be examined at a time. In addition, fat tissue hinders good views and pathology, or naturally narrow lateral recesses, may prevent the scope from passing into areas of interest. However, using a

Address correspondence and reprint requests to: Hemmo A. Bosscher, MD, FIPP, TTUHSC—Anesthesiology, 3601 4th st MS 8182 Lubbock, TX 79430, U.S.A. E-mail: Painmgmtdoc@hotmail.com.

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combination of saline infusion, fluoroscopy, and the magnifying and mechanical properties of the epiduroscope, certain aspects of the epidural cavity can be studied in great detail without the disruption caused by surgical exploration. Thus, important information on the anatomy and pathology of the epidural cavity in patients with low back and/or radicular pain can be obtained.

The visual function of epiduroscopy can be used to identify pathology of the epidural space such as hyperemia, changes in vascularity, fibrosis and adhesions, lateral recess stenosis, disk herniation, and ligamentum flavum hypertrophy. Fluoroscopy allows for exact location of the tip of the flexible scope with respect to the bony spinal canal, while direct visualization gives the relative orientation with respect to surrounding anatomical structures such as dura, root sleeves, dorsal root ganglion, posterior longitudinal ligament, or Hofmann/Trolard ligaments. Because the scope can be maneuvered, it is an excellent tool for evaluating absent or decreased patency of the spinal canal and neuroforamina at lumbar and sacral levels due to stenosis of the central spinal canal, lateral recesses, or neuroforamina. The working channel of the endoscope can be used for the injection of radiographic material. This gives highly selective epidurography that may delineate small defects or discontinuities of anatomical structures. Using a combination of the above-mentioned techniques, epidural pathology can be evaluated systematically and perhaps with greater accuracy with epiduroscopy than with more conventional diagnostic techniques such as MRI.[16]

In addition to its diagnostic function, epiduroscopy can be used to treat. For example, the mechanical action of the scope can be used to remove adhesions, while the working channel of the scope allows for targeted injection of medications or the introduction of surgical instruments.[17–19] Obviously, success of treatment depends on the underlying pathology. Therefore, success or failure of treatment can be used as a measure of the validity of diagnostic parameters obtained through epiduroscopy.

Observations made through epiduroscopy are suggestive of pathology of the spinal canal. However, an accurate diagnosis cannot be made as epidural pathology, as *observed through epiduroscopy*, has not been described in much detail, and references to the subject are limited in number and quality.[3,4,6,13,20,21] However, if one performs epiduroscopy with some regularity, the concept of what constitutes a *normal* epidural space becomes clearer. As a consequence, deviations from normal or pathology can be recognized. In addition to the identification of abnormalities of the epidural space, a correlation between treatment of presumed pathology using epiduroscopy and success of outcome becomes evident. Some observations of epidural pathology are recurring and could be considered as diagnostic markers such that a prognosis with respect to outcome of treatment can be made.

The aim of this study was to evaluate these diagnostic markers for consistency by evaluating the accuracy of prediction of outcome after diagnosis and treatment of epidural pathology using epiduroscopy.

METHODS

A prospective observational study of 139 patients was performed. IRB approval was obtained. Patients with back pain and radicular pain were included if symptoms were chronic (> 6 months), if surgery on the spine was not indicated, and if conservative treatment, including epidural corticosteroid injections, failed to provide adequate pain relief. Patients with prior surgery on the lumbar or sacral spine were included. Routine epiduroscopy, assisted by fluoroscopy, was performed under monitored anesthesia care.[6] The posterior lumbosacral epidural, lateral recesses, neuroforamina, and the anterior epidural cavity were studied between the vertebral levels of L2 and S2.

The following *visual* diagnostic parameters were obtained:

1. *Hyperemia*: Abnormal redness of a discrete area of dura root sleeve, peridural membrane, or other epidural structure, as compared to normal appearing areas of the epidural space (Figure 1).
2. *Changes in vascularity*: Increase or decrease in number, appearance, or size of blood vessels in a discrete area of the epidural space as compared to the blood vessels of the epidural cavity on the opposite side or at a different lumbar level. Veins that appeared bright or dark red, curved, balloon shaped, or tortuous were considered to be abnormal (Figure 2). Pulsating enlarged bright blood vessels were considered arterial.
3. *Fibrosis*: Tissue organized in strings and sheets of white fibers or the presence of impenetrable dense white tissue was considered fibrosis. In mild epidural fibrosis, the scope could easily be advanced. In severe fibrosis, it was difficult or

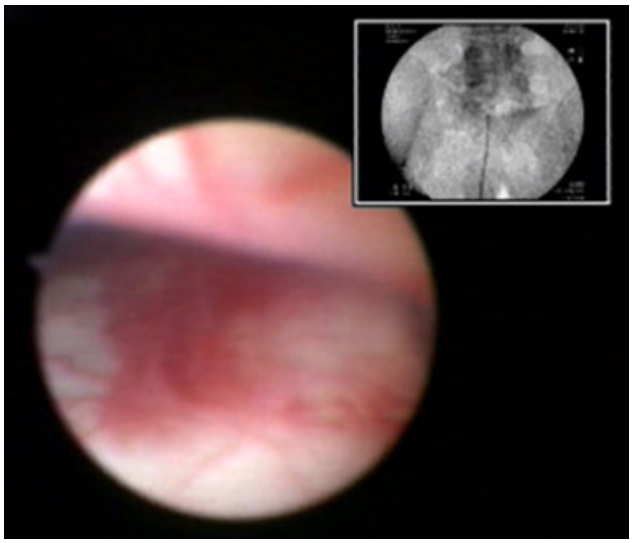

Figure 1. Increased small vessel vascularity or hyperemia on the dura. Center image is epiduroscopy view (posterior is up); upper right is fluoroscopic image showing location of epiduroscope tip.

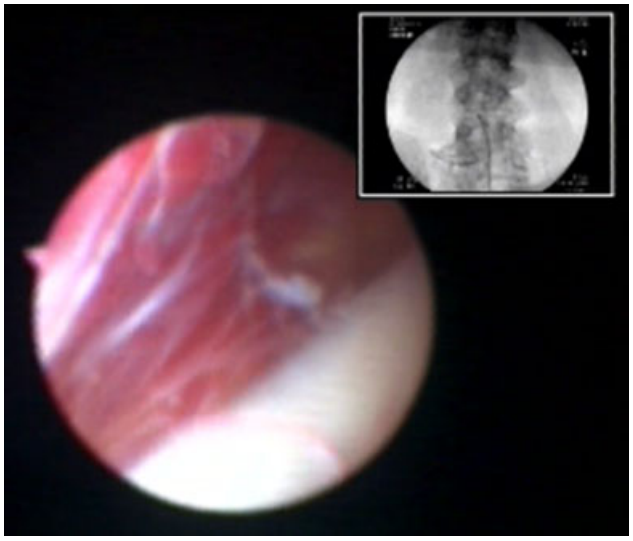

Figure 2. Increased vascularity. Dilated veins of the posterior epidural plexus. Center image is epiduroscopy view; upper right is fluoroscopic image showing location of epiduroscope tip.

impossible to advance the scope (Figure 3).[6] We previously described 4 degrees of fibrosis but chose in this study to use a grading of only 2 degrees (severe and moderate) considering this distinction appropriate markers for determining prognosis.[6]

The following *mechanical* diagnostic parameters were obtained:

1. *Concordant pain*: If mechanical manipulation of a discrete patch of tissue (not necessarily a nerve root) produced pain that, according to the patient, was similar in character and location to the pain for which the patient sought treatment. This response was compared to the response elicited on the contralateral noninvolved area of the cavity or at a different level on the ipsilateral side (usually not painful).
2. *Contrast spread*: The extent of spread of contrast material was evaluated (epidurography). Epidurography was considered normal if contrast, injected in the lateral recess just above the pedicle, followed the contours of the superior aspect of the pedicle laterally and the neural groove caudally (Figure 4). Any discontinuity in the spread of contrast along the inferior aspect of the neuroforamen on fluoroscopy was considered abnormal. Large interruptions were considered defects.
3. *Patency*: If the *inferior* aspect of the neuroforamina could be traversed with the tip of the epiduroscope while maintaining contact with the pedicle, the lateral recess was considered patent (Figure 5). If the scope could not be placed beyond the inferior aspect of the corresponding lamina (on fluoroscopy), the lateral recess was considered not patent. If the scope could be placed beyond this line, but not all the way toward the lateral aspect of the pedicle, patency was considered to be reduced.

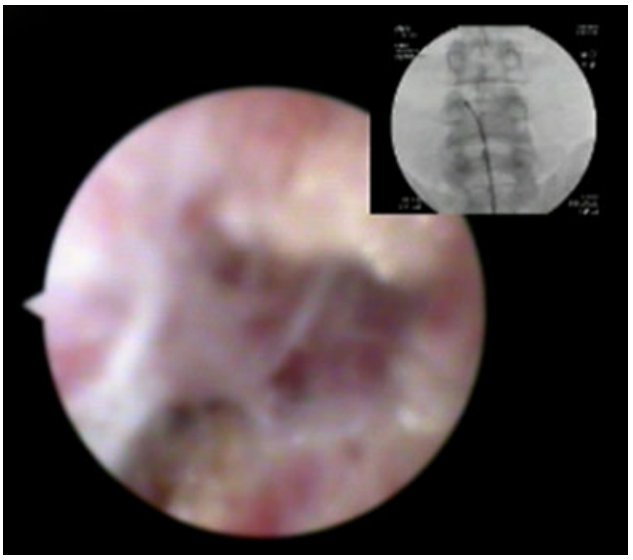

Figure 3. Area of increased vascularity, hyperemia and *fibrosis*. Center image is epiduroscopy view; upper right is fluoroscopic image showing location of epiduroscope tip.

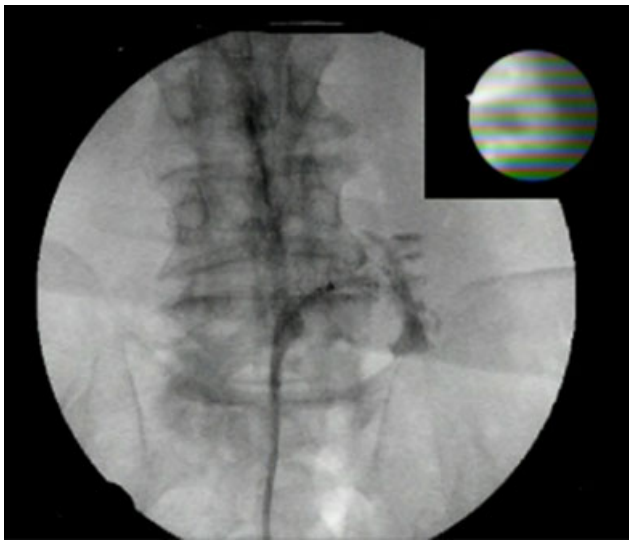

Figure 4. Epidurogram. Flow of contrast outside the spinal canal shows patency of the inferior neuroforamen. Center image is fluoroscopic image; upper right is epiduroscopy view.

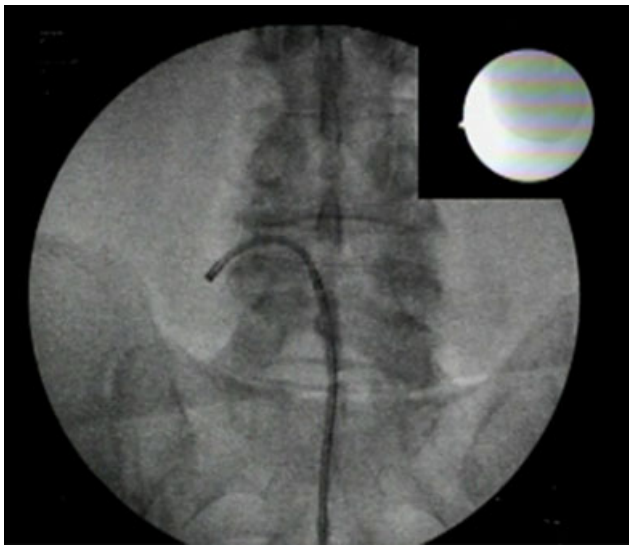

Figure 5. The epiduroscope is placed into the extra spinal space showing a widely patent inferior neuroforamen. Center image is fluoroscopic image; upper right is epiduroscopy view.

After diagnostic evaluation by epiduroscopy, all patients were treated. All patients were given prophylactic antibiotic intravenously just before the procedure started. Treatment included injection of hyaluronidase (Wydase 1500 U) to facilitate removal of barriers preventing injected fluids from reaching target areas. Next, any adhesions present in the inferior aspect of the neuroforamen and between the lamina and the posterior aspect of the nerve root were removed using forceful injection of saline through the working channel of the scope. Mechanical force was delivered by deflecting and advancing the tip of the scope. Fluid dissection was carried out by injecting approximately 3-mL increments of fluid up to 10 mL total with firm pressure applied with a thumb to the plunger of a 10-mL syringe containing the fluid. Mechanical dissection was carried out by moving the epiduroscope tip from side-to-side using firm pressure applied with an index finger to the deflection controller. Lastly, methylprednisolone (Depomedrol 80 mg) and ropivacaine (Naropin® 10 mL 0.2%) were injected at the site of pathology. Procedures were completed in 30 minutes or less. Total fluid volume injected was 60 ± 10 mL saline, 10 to 15 mL corticosteroid/local anesthetic mixture, 10 to 15 mL hyaluronidase in saline, plus 5 to 15 mL iohexol.

Based on the diagnostic parameters as described above, a prediction of outcome of treatment (excellent, good, fair, poor, indeterminate, see below) was made using the following algorithm:

If concordant pain present

and

Visual markers (hyperemia, increased vascularity, fibrosis) present

and

Normal epidurography and Patent neuroforamen → Prognosis excellent

or

Limited discontinuity on epidurography and mildly reduced patency → Prognosis good

or

Significant discontinuity on epidurography and markedly reduced patency → Prognosis fair

or

Neuroforamen not patent and absence of transforaminal spread → Prognosis poor

If concordant pain and/or visual markers absent → Prognosis indetermined

Patients were interviewed 1 month after epiduroscopy and asked to rate their satisfaction with the treatment. Outcome was considered "excellent" if the patient was highly satisfied with the result (ie, complete relief), "good" if patient was satisfied with the result (ie, good pain relief), "fair" if the patient was only partially satisfied with the result (mild-to-moderate pain relief), and "poor" if the patient denied any improvement.

A prediction was considered correct if pain relief was predicted to be good or excellent and outcome was good or excellent or if pain relief was predicted to be poor or

fair and outcome was poor or fair. No change in pain was considered an accurate prediction of outcome in patients in whom the diagnosis was undetermined.

Sensitivity, specificity, and accuracy of epiduroscopy in the prediction of outcome were determined. The frequency of the presence of a diagnostic marker in the different outcome groups was determined. Results were analyzed using contingency tables and calculation of odds ratios ($P < 0.05$ significant).

RESULTS

One hundred thirty-nine patients were included in the study. The median age of patients was 53 years with a range of 17 to 87 years. Fifty-five patients (40%) were male, and 12 patients had back surgery prior to the procedure. Symptoms of neck pain or headache indicating pressure increase associated with injection were not observed. Complications were rare, minor, and resolved within a day. Some patients had pain at the epidural space access site. Radiating pain was also observed if the dorsal root ganglion was touched by the epiduroscope tip.

A prediction of outcome, based on a diagnosis of epidural pathology through epiduroscopy, was made in 114 patients (82%). This prediction was correct in 89 of these 114 patients (accuracy of 78%). The sensitivity of epiduroscopy in the prediction of a good or excellent outcome (ie, the ability to identify treatable pathology using epiduroscopy) was 75%.

The specificity of epiduroscopy in the correct prediction of no change or only fair improvement with treatment (ie, the ability to identify untreatable pathology using epiduroscopy) was 82% (Table 1). Results were statistically significant ($P < 0.01$).

Discrete epidural pathology was not observed in 25 of 139 patients (18%). Sixteen of these 25 patients did not have pain relief, or only mild improvement, 1 month after epiduroscopy. Nine of these 25 patients reported good or excellent pain relief after epiduroscopy. The sensitivity of epiduroscopy in the diagnosis of epidural pathology was 91%. The specificity (ie, the ability to exclude the presence of discrete epidural pathology using epiduroscopy) was 39% (Table 2). Statistically, these results were not significantly different ($P > 0.1$).

Table 1. Predicted vs. Actual Outcome in Patients with a Diagnosis of Epidural Pathology

	Actual Outcome			
Predicted Outcome	Fair/Poor	Good/Excellent		
			Sensitivity	0.75
Fair/Poor 45	37	8	Specificity	0.82
Good/Excellent 69	17	52	Accuracy	0.78

Table 2. Prediction of outcome in patients with observed epidural pathology vs. patients without observed epidural pathology

	Correct Prediction	Incorrect Prediction		
			Sensitivity	0.91
Pathology observed 114	89	25	Specificity	0.39
No pathology observed 25	16	9	Accuracy	0.76

Prognosis of outcome was made in all patients with concordant pain and findings of discrete epidural pathology on epiduroscopy. However, in 1 patient, the diagnosis was based on epiduroscopic observations only, as the procedure was performed under general anesthesia. In these patients, frequency of observation of diagnostic markers for the different actual outcome groups is presented in Figure 6.

Frequency of observation of diagnostic markers is presented for patients in whom a prognosis of outcome could not be made (ie, no change with treatment using epiduroscopy) (Figure 7).

DISCUSSION

Our results show that epiduroscopy predicts outcome of treatment accurately in the majority of patients. This suggests that information obtained through epiduroscopy may carry significant diagnostic and prognostic value. In addition, diagnostic markers obtained through epiduroscopy may reflect epidural pathology not diagnosed using conventional imaging techniques such as MRI.

Recent studies have evaluated the value of epiduroscopy in the diagnosis and treatment of patients with back pain and/or leg pain.[3–5,7,9,18,22] Technical limitations with respect to visualization and lack of a systematic approach, to the evaluation of the epidural space through epiduroscopy, make the results of these studies difficult to interpret. Most investigators have evaluated epiduroscopy with respect to outcome after treatment, not in terms of observations. Pathological conditions such as fibrosis, granulation, increased vascularization, or canal stenosis have been observed. However, the *epiduroscopic* criteria by which such pathology is defined and proposed mechanisms by which treatment exerts its effect remain arbitrary because references to a standard are not available.

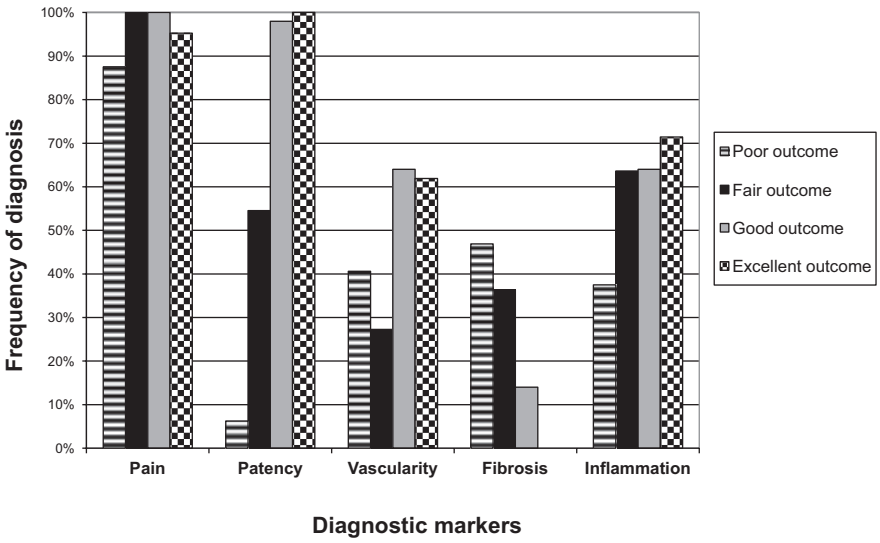

Figure 6. Diagnostic markers in outcome categories.

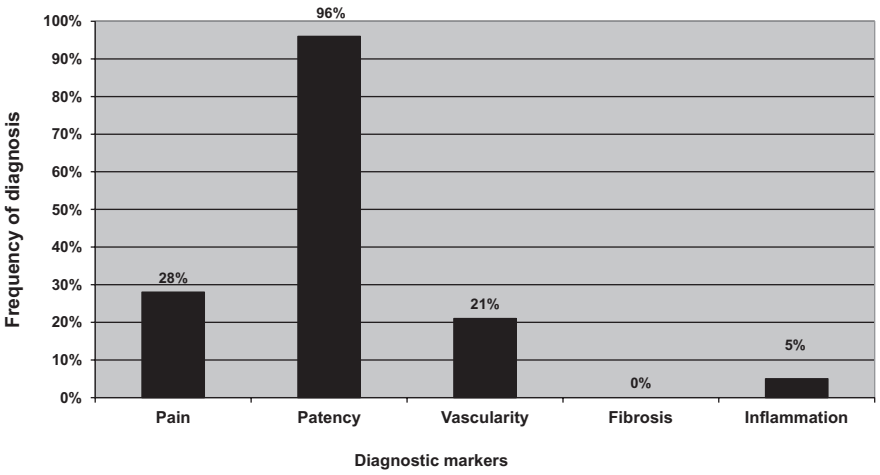

Figure 7. Diagnostic markers in patients with an undetermined prognosis.

In our study, an attempt was made to identify epiduroscopic criteria for the identification of otherwise unspecified epidural pathology. The outcome component was meant as an indicator of the discriminative value of these criteria, and neither as a confirmation of presumed epidural pathology observed through epiduroscopy, nor as a measure of efficacy of treatment.

Concordant Pain

The contents of the normal epidural space are not painful when touched with the epiduroscope. Presence of concordant pain to touch, at a *discrete* epidural patch, was a critical factor in the prediction of outcome. Whether the outcome was favorable or unfavorable, reproducible pain was a necessary condition for the diagnosis of significant epidural pathology. This suggests that a painful epidural patch may contain the pain generator but alternatively and may merely be a conduit for pain transmitted from a pain generator at a distant site. However, the accuracy of the prediction of outcome was good if additional diagnostic markers suggested local pathology in the area of concordant pain. Treatment of more extensive pathology, such as severe epidural fibrosis or lateral recess stenosis, was less predictable. This suggests that pathology involved in the pathogenesis of low back or leg pain may be closely associated with these painful epidural patches.

The notion of concordance under heavy sedation may be subject to criticism. Although most patients were able

to describe pain to touch as similar to their usual pain, the exact characterization of the pain response did not seem to be of major significance as absence of any pain response led to low accuracy of prediction, while presence of any type of pain response led to high accuracy.

Selective Epidurography

Another important diagnostic marker was the result of selective epidurography. Normal flow of contrast (ie, following the contours of the spinal canal and epidural structures) in combination with concordant pain was indicative of a favorable outcome. Presence of a defect, even if small, made the prognosis less favorable. This also suggests the existence of a relatively small area of epidural space, responsible for the generation of back and leg pain in patients. A large defect on epidurography was correlated with a poor outcome and suggests severe epidural pathology, which interestingly, may not always be diagnosed with conventional imaging techniques such as MRI or CT scan.[5,6]

Epidural Patency

Closely related to the free flow of contrast material using selective epidurography is the ability to pass the scope into specific areas of the spinal canal. Lateral recess stenosis (acquired or congenital), disk herniation with significant neuroforaminal narrowing, or severe epidural scarring may cause hindrance to scope advancement. In general, inability to pass the scope into the lateral recesses, independent of the cause, carried an unfavorable prognosis. This may be explained by the extent of epidural pathology in these areas or the inability of the scope to reach the site of pathology (ie, site of concordant pain). As good spread of contrast material on local epidurography in the presence of hindrance to scope advancement carried a relatively favorable prognosis, the latter explanation is supported in some patients. Ability to advance the epiduroscope outside the neuroforamen, keeping the scope in close proximity to the superior aspect of the pedicle on fluoroscopy, was an accurate predictor of a good outcome, and this maneuver may play an important role in the treatment of low back and leg pain.[23,24]

Epidural Vascularity

Presence of increased or decreased vascularity is an indicator of epidural pathology. Pathology represented by increased vascularity is heterogeneous and includes venous congestion through outflow obstruction (intraspinal or extraspinal), arteriovenous anastomoses or inflammation accompanied by vasodilatation.[25–29] In patients with increased vascularity on epiduroscopy, pain relief with treatment may be the result of improved venous outflow after adhesiolysis through mechanical removal of tissue containing inflammatory substances or through the chemical reduction in vasoactive mediators in the inflammatory response. Increased vascularity was often observed in patients with lateral recess stenosis, which can lead to marked vasodilatation through outflow obstruction or possibly through the activation of arteriovenous shunts.[27] Long-term pain relief with treatment using epiduroscopy is unlikely in these patients. Increased vascularity in the absence of lateral recess stenosis or severe epidural fibrosis may be a diagnostic marker for a treatable condition such as inflammation and has a more favorable outcome.

Epidural Fibrosis

Dense fibrosis may obliterate the entire epidural space and is characterized by a *decrease* in vascularity.[6] This condition is mostly associated with prior surgical intervention and has a poor prognosis. Epidurography will be abnormal, and scope advancement is impossible in these patients.[5,6,30] Mild-to-moderate fibrosis, in conjunction with local pain reproduction, was an indicator of a more favorable outcome, possibly because pathology was accessible and more amendable to treatment.

Inflammation

The importance of inflammation as a diagnostic parameter was moderate. This is expected because inflammation is a generic term and the characteristics of inflammation of the epidural space are not well known. This can be explained by the absence of loose connective tissue and therefore absence of interstitial space in the epidural cavity. Epiduroscopic findings such as a pain response, increased vascularity, and mild fibrosis were observed frequently, suggesting an inflammatory response. Abnormal redness of the dura or surrounding tissue, suggesting hyperemia or exudate, was less often seen.

It is also possible that inflammation in the epidural space appears different because the reaction to tissue damage in the epidural space is different than, for example, the reaction to tissue damage in the peritoneal

or pleural cavity.[17,28] In addition, inflammation may be confined to a very small area of the epidural space and can be missed by epiduroscopy. This may explain some favorable outcomes of epiduroscopy in the presence of concordant pain but without diagnostic markers suggestive of inflammation. Interestingly, if markers of inflammation were identified, they were often found in the lateral recesses, *not* continuous with dura, nerve root sleeve, or dorsal root ganglion. In most instances, where the scope was placed directly over the posterior longitudinal ligament covering the disk, we were not able to identify markers suggestive of inflammation.

Diagnosis and Prognosis of Epidural Pathology

No single finding on epiduroscopy predicted outcome accurately for all patients. However, based on empirical relations between outcome and certain combinations of diagnostic markers, an algorithm could be developed that predicted outcome accurately in most patients. In this algorithm, a large defect on epidurography and concordant pain at discrete epidural patches were the most important variables, which separated the different outcome groups. In each outcome group, observation of a visual abnormality was a necessary condition to make a diagnosis. If no abnormality was observed, the prognosis was considered indeterminate. In the presence of observable pathology, accessibility of the spine and patency of the inferior aspect of the neuroforamina were the final determinants of a prognosis. It is of note that observations such as bulging, herniated, or inflamed appearing disk and compressed or inflamed appearing nerve root were seldom made and did not play a role in the algorithm.

Limitations of this study include the lack of well-defined criteria for the study parameters. This is partly due to a limited number of studies in this field, technical limitations of epiduroscopy, and an incomplete understanding of the pathophysiology of low back pain. Another limitation is the accuracy of measuring the degree of pain relief. Variability in the experience of pain and the presence of additional unrelated pain generators make a comparable quantitative measurement of pain relief difficult. However, the definition of few broad outcome classes using *satisfaction* with the degree of pain relief as a measure of outcome, rather than pain relief itself, made the classes sufficiently distinct for the purpose of this study.

In conclusion, information obtained through lumbosacral epiduroscopy has significant diagnostic and prognostic value and may be helpful in the management of patients with low back pain and/or leg pain. More detailed knowledge of the anatomy, histology, and pathology of the *intact* lumbar epidural space will improve our ability to study and understand the pathophysiology of low back and leg pain.

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