Anterior Thoracic Surgical Approaches in the Treatment of Spinal Infections and Neoplasms

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Background. Thoracic surgeons are commonly consulted to provide anterior thoracic exposure for infection and malignant neoplasms involving the thoracolumbar spine. These cases can present significant technical and management challenges secondary to the underlying pathology, associated anatomic inflammation, and impaired functional status. In this study, we review the perioperative outcomes in patients undergoing anterior spinal exposure for infection and neoplasm.

Methods. 130 consecutive patients (61 women, 69 men) undergoing corpectomy, debridement, or debulking for osteomyelitis (n = 50) or neoplasms (n = 80) with decompression/stabilization at a single institution were analyzed. Primary endpoints included morbidity, mortality, and perioperative neurologic outcomes.

Results. The mean age was 61.1 years. A cervical/sternotomy (n = 8) approach was used for levels C7 to T2, thoracotomy (n = 79) for levels T3 to T10, and thoracoabdominal (n = 43) for T11 to L2 involvement. Primary spinal neoplasms (n = 22, 16.9%) and metastases (n = 58, 44.6%) were treated with corpectomy and prosthetic stabilization and were associated with increased operative time (310 vs 243 minutes, \( p = 0.02 \)) and blood loss (825 vs 500 mL, \( p = 0.002 \)). Osteomyelitis was associated with longer hospital stays (12 vs 7 days, \( p < 0.001 \)). The 30-day and 90-day mortality was 9.2% and 20.8%, respectively. The major complication rate was 27.7%. The median length of stay was 9 days. Surgical intervention resulted in significant improvement in pain, numbness, weakness, and bowel and bladder dysfunction.

Conclusions. Anterior spinal exposure represents an important modality in facilitating the treatment of patients with osteomyelitis, pathologic fractures, and spinal cord compression syndromes. These procedures are associated with a significant risk of morbidity and mortality, but they are effective in achieving spinal stabilization and alleviating neurologic symptoms.


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A detailed neurologic examination is performed preoperatively to document the patient’s neurologic status before intervention. Preoperative imaging typically involves computed tomography, magnetic resonance imaging, or both at the discretion of the neurosurgeon to delineate the details of the spinal pathology. General endotracheal anesthesia is typically accomplished with a double-lumen tube to permit lung isolation during thoracotomy and thoracoabdominal incisions. A single-lumen tube is adequate for the cervicothoracic approach. Monitoring of somatosensory evoked potentials (SSEP) is routinely performed in all cases, and baseline waveforms are documented before the patient is positioned. Positioning should be performed in conjunction with the attending spine and thoracic surgeons to minimize the risk of injury to the spinal cord and nerve roots.

The specific approach chosen in a given case depends primarily on the level of spine involvement. A cervicothoracic approach with manubrial split is typically used for spinal pathology involving C7 to T2. Thoracotomy is preferred for T3 to T10 lesions. A thoracoabdominal incision is used for spinal involvement between T11 and L2.

For the cervicothoracic approach, patients are positioned supine with a transverse shoulder roll to permit slight neck extension as tolerated. The head is turned away from the operative side. An oblique incision is made anterior to the sternocleidomastoid muscle. The sternocleidomastoid muscle and carotid sheath are retracted laterally, and the laryngeal mechanism, thyroid, and esophagus are reflected medially. A manubrial split with placement of a Finochietto retractor is also performed to permit enhanced access to the uppermost thoracic vertebrae (Fig 2) [3]. A nasogastric tube can be inserted to facilitate identification of the cervical esophagus. The prevertebral space is then entered, and the lower cervical and upper thoracic spine is exposed immediately posterior to the esophagus. A blunt self-retaining Weitlaner retractor is typically used to enhance exposure during the case (Fig 2). This approach was most commonly used for benign etiologies, with chemotherapy and radiation therapy most frequently used for the treatment of malignant cervical neoplasms. For lower tumors (T2 to T4), median sternotomy or a hemiclamshell incision can be used, especially in the setting of larger tumors [4]. Great care is taken to avoid aggressive retraction on the thyroid and laryngeal mechanism to avoid injury to the recurrent laryngeal nerve. A left-sided cervical approach is generally preferred, given that the course of the recurrent laryngeal nerve is more consistent on the left as it courses proximally within the tracheoesophageal groove.

The most common procedure performed in this series was a thoraecotomy for spinal pathology localized to T3 to T10. For high thoracic (T3 and T4) levels, a posterior auscultatory triangle thoraecotomy with paraspinal extension of the incision up to the base of the neck was preferred [5]. A standard muscle-sparing lateral or posterolateral thoracotomy was used for mid-thoracic
and lower thoracic exposure. Single-lung ventilation with use of a double-lumen tube or bronchial blocker was performed. A key guide in planning the optimal incision was to enter the chest two interspaces above the targeted vertebra. Given the oblique course of the ribs, this incisional approach centered the targeted spinal level optimally within the operative field. The rib below the incision was resected and could be used for preparation of an autograft, as desired. The adjacent inferior rib was notched to promote even broader exposure. The Bookwalter retraction system was most commonly used and provided excellent retraction of the chest wall, lung, and diaphragm. Two shallow bladder blades maintained adequate rib separation, and the deep, straight blades maintained downward traction on the lung and ipsilateral diaphragm (Fig 3). The authors preferred a right-sided approach for most thoracic spine exposures in patients with neoplasm and osteomyelitis, especially when approaching levels T4 to T8. A left thoracotomy incision was particularly useful for levels T8 to T10. The primary determinants of laterality included the relative position of the pathologic process within the spine, a history of prior surgical procedures (which might have prompted the use of a contralateral approach), and anatomic factors such as the presence of the liver on the right side.

A thoracoabdominal approach was used for patients with pathologic conditions between T11 and L2 [6]. The approach usually required resection of the tenth rib and circumferential division of the ipsilateral hemidiaphragm. Special care was taken to preserve a diaphragmatic margin of at least one-centimeter along the chest wall to allow for re-attachment during closure. The Bookwalter retraction system was particularly useful in reflecting the peritoneal contents and liver. The psoas musculature was mobilized to allow access to the targeted vertebra(e). Generally speaking, a left-sided approach was preferred so that the liver did not crowd the operative field. An extrapleural, retroperitoneal approach at the level of the eleventh rib may also be used, and avoids direct entry into the pleural space [7]. When possible, the pleural edges were loosely reaproximated over the repair site. Jackson-Pratt drains were placed adjacent to the involved vertebrae. In cases of diaphragm division, the muscle edges were reaproximated with a running 0-0 Prolene suture. Chest closure was performed in the standard fashion after adequate hemostasis was assured. A single chest tube was inserted into the pleural cavity at the conclusion of the operation.

Segmental Artery Isolation and Division
A critical component of spinal exposure is the isolation and division of the segmental arteries that arise from the adjacent aorta and run along the vertebral body to ultimately become the intercostal arteries. The segmental arteries also give off important collateral branches that pass into the vertebral foramina to Anastomose with the anterior and posterior spinal arteries [8]. Smaller nutrient arterial branches that feed the vertebral body also arise.

Fig 2. Cervicothoracic spine exposure. An oblique incision is performed along the sternocleidomastoid muscle. The manubrium is split inferiorly. The sternocleidomastoid and carotid sheath are reflected laterally, and gentle medial retraction is applied to the trachea and esophagus.

Fig 3. The Bookwalter retraction system provides excellent exposure during thoracotomy and thoracoabdominal approaches.
from the segmental arteries. Given these relationships, the segmental arteries are ideally isolated and divided close to the aorta so as not to interrupt the collateral blood flow to the spinal arteries, thus potentially diminishing the risk of spinal cord ischemia. The parietal pleural envelope is opened at least one interspace above and below the target lesion to maximize exposure. The use of the Bovie should be avoided during this portion of the procedure to minimize the risk of infarction of the spinal artery. We prefer the use of bipolar electrocautery to minimize the risk of damage to the spinal roots and cord. Particular awareness of the artery of Adamkiewicz is emphasized. This artery constitutes a significant contribution of the blood flow to the anterior spinal artery, providing important inflow to the lower half of the spinal cord. The artery is most commonly found on the left side in approximately 80% of cases. It can occur anywhere between T7 and L2 but is typically seen between levels T8 and T10 [9]. Test occlusion with an atraumatic clamp and examination of the resulting SSEP can be used to guide the ligation of segmental vessels. Some authors advocate the use of computed tomographic angiography or magnetic resonance imaging to identify the artery of Adamkiewicz preoperatively, especially if multiple spinal levels are involved [10]. Occasionally, the artery of Adamkiewicz may be evident on preoperative imaging, which can assist in preoperative planning. The artery, however, is not always evident in the available preoperative radiographic imaging, and we do not specifically order additional testing in an effort to identify this arterial contribution to the anterior spinal artery. We do routinely look for this artery intraoperatively when working between levels T7 and L2, especially on the left side. A test occlusion is always performed before the division of larger segmental vessels, and the impact on SSEP monitoring is noted. If there is any concern regarding the test clamp and SSEP signals, the corresponding artery is preserved. This is necessary in fewer than 5% of cases. Once the segmental arteries are controlled, a spinal needle can be placed into the target disc space and an intraoperative plain x-ray film is taken to confirm the proper level.

Follow-Up
Perioperative data were collected from the hospital chart, from anesthesia and operating room records, and from the electronic medical record, office charts, or both for each patient. Complications were documented for each patient within the Lung Cancer Database based on standard definitions established for the Society of Thoracic Surgeons General Thoracic Database [11]. Perioperative mortality was defined as occurring when any patient died within the first 30 days after operation. The 90-day mortality data were also calculated. The mean follow-up time was 31.7 months for the entire cohort.

Statistical Analysis
Student’s t test was used to compare the distributions of continuous data, and Fisher’s exact test was used to compare the frequencies of categoric measures between groups. Overall survival was estimated with the Kaplan-Meier method. Significance was assessed with the log-rank test.

Results
Patient Characteristics
The patient demographics are summarized in Table 1. The mean patient age for the entire cohort was 61.1 ± 12.9 years (range, 22 to 86 years). Among the patients in the neoplasm group (n = 80), 22 (16.9%) had primary neoplasms of the spine. These included plasmacytoma (n = 10), schwannoma (n = 4), hemangioma (n = 3), chordoma (n = 2), hemangioendothelioma (n = 2), and giant cell tumor (n = 1). The remaining 58 patients were documented to have spinal metastases from lung (n = 13), kidney (n = 12), breast (n = 7), melanoma (n = 4), thyroid (n = 4), colon (n = 2), head and neck (n = 2), chondrosarcoma (n = 2), leiomyosarcoma (n = 2), liposarcoma (n = 1), bladder (n = 1), esophagus (n = 1), and unspecified source (n = 7). Adjuvant therapy was administered in 70% of cases. The presumed mechanism of osteomyelitis in the majority of these cases was likely hematogenous seeding or involvement by local contiguous infection (eg, epidural abscess). The most common organism cultured from among these patients was *Staphylococcus aureus*. Other rare organisms encountered in this series included *Streptococcus pneumoniae* and *Pseudomonas aeruginosa*.

A cervicothoracic approach was performed in 8 (6.2%) cases, thoracotomy in 79 (60.8%), and thoracoabdominal in 43 (33.1%). There was no significant difference in age or sex distribution when the neoplasm and infection cohorts were compared. Thoracotomy was more commonly performed for spinal neoplasms (70.0% vs 46.0%, p = 0.01), and a thoracoabdominal incision was used more frequently in the setting of osteomyelitis (52.0% vs 21.2%, p = 0.0005). Patients with spinal neoplasm had higher age-adjusted Charlson comorbidity scores than did those with osteomyelitis. The Eastern Cooperative Oncology Group scores were higher in the infection group (Table 1).

Perioperative Outcomes
The operations performed for neoplasm were associated with increased operative times (310 vs 243 minutes, p = 0.02) and blood loss (825 vs 500 mL, p = 0.002) compared with those for osteomyelitis. Length of stay was significantly longer in patients with spinal infection (12 vs 7 days, p < 0.001) (Table 2). The overall morbidity was 52.3%, with a major morbidity rate of 27.7%. The most common major complications were respiratory failure (n = 17, 13.1%), sepsis (n = 8, 6.2%), and pneumonia (n = 7, 5.3%). Infectious complications (sepsis, pneumonia, empyema) were significantly more common in patients with osteomyelitis than in patients with neoplasm (28.0% vs 7.5%, p = 0.002). Empyema occurred in 3 of 50 (6%) of patients with osteomyelitis. In this situation, the organisms affecting the spine correlated with those involving the pleural space (*S. aureus*). Empyema occurred in 2 of
80 patients (2.5%) with spinal neoplasm. The most common minor complication was atrial fibrillation or supraventricular tachycardia (10.0%). Reoperation was required in 5.3% of patients for bleeding, hardware removal, or inadequate spinal stabilization. The overall mortality rate was 9.2% at 30 days and 20.8% at 90 days. The cervicothoracic approach was associated with decreased operative time and blood loss in comparison with the thoracotomy and thoracoabdominal approaches (Table 3).

Neurologic Outcomes
The perioperative neurologic outcomes are depicted in Figure 4. The most common clinical presentation was pain (94.6%), followed by numbness (33.1%) and paraparesis (31.5%). Anterior spinal surgical procedures led to significant improvements in pain, numbness, unilateral weakness, paraparesis, and bowel and bladder dysfunction in 91.2% of patients (Fig 4). A lower rate of paraplegia was observed after operation (5.4% vs 8.5%), although this difference did not achieve statistical significance. No significant differences were noted when neurologic outcomes were compared between the neoplasm and infection groups. Patients with neoplasm were significantly more likely to go home at the time of discharge (46.3 vs 16.0%, \(p = 0.0006\)). Correspondingly, patients with osteomyelitis had a significantly higher rate of discharge to a nursing facility (22.0% vs 3.8%, \(p = 0.002\)).

Survival
Patients undergoing spinal operations for neoplasm had significantly reduced survival in comparison with those undergoing operations for infection (Fig 5) (\(p = .028\)). The overall survival at 5 years was 48% versus 26%, respectively.

Comment
Anterior surgical approaches to the thoracic spine were initially performed for the surgical management of Pott’s disease [12]. This general strategy has been associated with decreased operative times and blood loss, and with earlier patient mobilization in comparison with posterior approaches. Tumors involving the spine are most commonly localized within the vertebral body, and spinal cord compression typically results from posterior extension of tumor into the spinal canal. Anterior approaches therefore represent an optimal approach in this setting, permitting excision of the tumor and preservation of the stability of the posterior spinal elements [13, 14]. With the development and expansion of spine instrumentation and stabilization techniques, anterior approaches are now used for a variety of indications beyond infectious causes, including degenerative disc disease, fractures, scoliosis, and neoplastic involvement. Anterior approaches are now routinely performed in the neck [15], chest [16], and abdomen [17], and thoracic surgeons are commonly

<table>
<thead>
<tr>
<th>Variable</th>
<th>Neoplasm (n = 80)</th>
<th>Infection (n = 50)</th>
<th>(p) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time (min)</td>
<td>310 (103–713)</td>
<td>243 (143–613)</td>
<td>0.02</td>
</tr>
<tr>
<td>Blood loss (mL)</td>
<td>825 (100–1100)</td>
<td>500 (200–1800)</td>
<td>0.002</td>
</tr>
<tr>
<td>ICU stay (d)</td>
<td>3 (1–19)</td>
<td>4 (1–32)</td>
<td>0.58</td>
</tr>
<tr>
<td>Chest tube duration (d)</td>
<td>4 (2–26)</td>
<td>5 (2–13)</td>
<td>0.78</td>
</tr>
<tr>
<td>Length of stay (d)</td>
<td>7 (2–27)</td>
<td>12 (3–39)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Complications (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>41 (51.3%)</td>
<td>27 (54%)</td>
<td>0.86</td>
</tr>
<tr>
<td>Major</td>
<td>18 (22.5%)</td>
<td>18 (36%)</td>
<td>0.11</td>
</tr>
<tr>
<td>Mortality (30-day %)</td>
<td>5 (6.3%)</td>
<td>7 (14.0%)</td>
<td>0.21</td>
</tr>
<tr>
<td>(90-day %)</td>
<td>18 (22.5%)</td>
<td>9 (18.0%)</td>
<td>0.66</td>
</tr>
</tbody>
</table>

ICU = intensive care unit.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cervicothoracic (n = 8)</th>
<th>Thoracotomy (n = 79)</th>
<th>Thoracoabdominal (n = 43)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time (min)</td>
<td>257 (222–269)</td>
<td>288 (103–713)</td>
<td>284 (143–613)</td>
</tr>
<tr>
<td>Blood loss (mL)</td>
<td>550 (200–750)</td>
<td>750 (100–4100)</td>
<td>700 (100–1600)</td>
</tr>
<tr>
<td>Length of stay (d)</td>
<td>7 (2–21)</td>
<td>9 (4–39)</td>
<td>9 (3–39)</td>
</tr>
<tr>
<td>Complications (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>4 (50.0%)</td>
<td>42 (53.2%)</td>
<td>22 (51.2%)</td>
</tr>
<tr>
<td>Major</td>
<td>2 (25.0%)</td>
<td>20 (25.3%)</td>
<td>14 (32.6%)</td>
</tr>
<tr>
<td>Mortality (30-day %)</td>
<td>0 (0%)</td>
<td>7 (8.9%)</td>
<td>5 (11.6%)</td>
</tr>
<tr>
<td>(90-day %)</td>
<td>1 (12.5%)</td>
<td>18 (22.8%)</td>
<td>8 (18.6%)</td>
</tr>
</tbody>
</table>
consulted to assist in providing exposure and supervising the perioperative treatment of these patients.

Excellent results have been reported in the setting of degenerative disc disease, trauma, and scoliosis. Morbidity rates of 11% to 15% and mortality rates of less than 3% can be reliably achieved in this setting [18–21]. In contradistinction, surgical intervention for spinal neoplasms and osteomyelitis have been associated with a significant increase in perioperative morbidity and mortality (8.2% to 25%) [13, 22]. Naunheim and associates [22] reported a low overall mortality rate of 3.2% among all patients undergoing anterior spinal approaches, with this rate increasing to 25% in patients with osteomyelitis. An increased rate of complications has also been observed in up to 50% of patients [23]. In the current study we similarly found significantly elevated rates of perioperative morbidity (51% to 54%) and mortality (6.3% to 14%) in these high-risk groups. Patients with these conditions are frequently debilitated and malnourished, with significant comorbid conditions and diminished functional status. Indeed, patients in both cohorts demonstrated elevated Charlson comorbidity scores and impairments in Eastern Cooperative Oncology Group status (Table 1). Operations in this setting are further complicated by intense desmoplastic reaction and obliteration of the normal tissue planes, contributing to the observed increased operative times and blood loss (especially in the setting of neoplasm) (Table 2). Significant blood loss encountered during these cases mandates liberal transfusion of packed red blood cells, inasmuch as the cell saver is not an option in the setting of infection and cancer. Furthermore, the nonelective nature of these cases denies the possibility of preoperative autologous blood donation.

Clinical presentations frequently involved acute neurologic symptoms requiring prompt intervention in the background of advanced cancer or generalized sepsis. The anterior approach is highly successful in palliating and alleviating acute neurologic symptoms. In this study, acute numbness, weakness, and bowel and bladder dysfunction were improved in 91.2% of cases. Patients presenting with complete paraplegia were less apt to recover. Back pain was also significantly improved; however, the majority of patients were found to have residual pain on follow-up after operation. Pain assessments are complicated in these patients, given the added insult of generous incisions with associated rib spreading, which can create a new pain syndrome related to the operation itself. Our current practice is to use paravertebral blocks with postoperative patient-controlled analgesia when clinically appropriate. We have also used infusional nerve block catheters placed at the time of operation, with effective results (On-Q, IFlow Corp., Lake Forest, CA). Despite aggressive efforts at pain control, increased rates of respiratory failure (13.1%) and pneumonia (5.3%) were observed. The reasons for this are multifactorial and include the effects of incisional pain, patient immobilization, malnutrition, and compromised functional status.

Despite the heightened morbidity and mortality profiles, the significant majority of patients were effectively palliated by surgical intervention and were able to be discharged to home or rehabilitation facilities. These data suggest that although the prognosis in these patient groups is guarded, effective neurologic and functional palliation can be accomplished with surgical intervention in appropriately selected patients.

There are several limitations with the current analysis. The retrospective design introduced the possibility of bias in patient selection when surgical approaches were compared. We tried to limit this effect by analyzing all patients undergoing spine exposure for neoplasm or infection over a 16-year period. Another limitation is the lack of objective symptom questionnaires and quality-of-life instruments in the assessment of neurologic and functional outcomes.

In conclusion, anterior spinal exposure represents an important modality in facilitating the treatment of...
patients with osteomyelitis, pathologic fractures, and spinal cord compression syndromes. These procedures are associated with a significant risk of morbidity and mortality. However, these approaches can be very effective in achieving spinal stabilization and alleviating neurologic symptoms. A close partnership between thoracic surgeons and spine surgeons in the perioperative treatment of these patients is necessary to optimize outcomes.

The authors wish to acknowledge the important contribution of Peg Reamer and Judy Forster in clinical trial enrollment. We would also like to recognize Althea Schneider of the Thoracic Surgery Tumor Registry for her assistance in database management and analysis.

References

DISCUSSION

DR DANIEL MILLER (Atlanta, GA): Nice job, Dr Schuchert. I think an important issue in these cases is how you handle the pleural space. Because when you do the exposure for disc disease, you usually leave one chest tube in for 3 or 4 days, and that is it. But in these cases as you presented today, because of the tremendous amount of blood loss and gross infection, I drain the chest cavity extensively with multiple chest tubes and leave them in for a longer period of time. I saw your chest tubes were in for a shorter time. Could you comment please on how you handle the pleural space in these patients?

DR SCHUCHERT: We definitely drain these spaces well, usually with one or two chest tubes, and we also will routinely place Jackson-Pratt drains in the immediate vicinity of the targeted level, and those do stay in. Extended drainage of the pleural space was a significant contributor to the longer length of stay, especially in the infectious cases.

DR ERIC L. GROGAN (Nashville, TN): You discussed the high pneumonia rate, and I have struggled with the appropriate pain control options, because a lot of these patients can’t get epidurals. So the first question is, what do you typically do for their pain control? And then the second question is, have you looked at the extrapleural approach when you do exposures for T10 to L1? I started doing the extrapleural approach and staying out of the chest space. So I would be interested in your experience with that approach, too.

DR SCHUCHERT: We have done that approach as well, and it is really surgeon dependent. But I think that is an excellent approach to help stay out of the pleural space.

DR GROGAN: What about the pain issue?

DR SCHUCHERT: A variety of techniques. We rely pretty heavily more recently on paravertebral blocks in these folks; you avoid epidural-associated complications, and they can be very effective. Rod will occasionally place the pain infusional catheters; we have several of those in this series. But I would say the majority of folks we are now currently managing with paravertebral blocks and patient-controlled analgesia.
DR JOHN A. HOWINGTON (Evanston, IL): What is your incidence of postthoracotomy pain syndrome with this resected rib with a big wide retractor? The second thing is, are you using fluoroscopy before your prepping and draping to more narrow down to where you need to come in to hopefully avoid such a large disruption?

DR SCHUCHERT: In terms of localization, we usually will determine based on our preoperative imaging and then we will localize the target. Usually it’s evident grossly, but if there is any question, we will get intraoperative film to determine that we are working at the appropriate level.

I’m sorry, the first question?

DR HOWINGTON: Postthoracotomy pain.

DR SCHUCHERT: These definitely are big incisions, and pain is an issue. Pneumonia was one of the more frequent complications, approximately 5%; respiratory failure was closer to 13%. Those are some of the major complications, and they are a direct result, I believe, of pain.

Interestingly, we don’t have specific pain data to give us objective numbers, but the pain that you alleviate sometimes is more prominent than the pain that we give them, and so these folks tend to feel a general sense of relief. They may be sore from their incision, but they’re so happy that their back pain is better, it’s less of a complaint.

DR HOWINGTON: So a thing to consider when they are on the table before you prep and drape is actually using fluoroscopy and seeing where on the chest wall the level is. We have done that because we were having issues of denervation that Eric talked about, the idea that you can come down right on the space, right over it, and shingle rib, not have to take out a rib and cut another rib.

And we have been using something that may be interesting, which is the new drug, the liposomal marcaine, that may be a wonderful drug in this setting where we can’t use an epidural catheter that will last for about 4 days and hopefully reduce some of our respiratory complications.

DR SCHUCHERT: I think those are excellent points.

DR VARUN PURI (St. Louis, MO): It sounds like you were managing these patients on your service. Is that correct?

DR SCHUCHERT: Yes.

DR PURI: I don’t know if that’s the case at your university, but at our institution we have very little access to these individuals afterwards, and they are managed by the neurosurgical and orthopedic services. So that automatically means that the risk of perioperative complications and respiratory complications is way different than what it would be on our ward. So I would like your comment on that.

DR SCHUCHERT: I agree. And that depends on the hospital where you work. The culture will be very different at each location. In our hospital, the neurosurgeons really rely on us to help take care of these patients, to assist with the level of acuity and monitoring many of these issues that you allude to. But these are complex patients that require very aggressive management, and you have to expect and look for the complications, because they happen quite often.