Effect of Sarcopenia on Postoperative Morbidity and Mortality After Thoracolumbar Spine Surgery

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abstract

Sarcopenia is the loss of muscle mass associated with aging and advanced disease. This study retrospectively examined patients older than 55 years (N=46) who underwent thoracolumbar spine surgery between 2003 and 2015. Each patient's comorbidity burden was determined using the Charlson Comorbidity Index, and the Mirza Surgical Invasiveness Index was used to measure procedural complexity. Sarcopenia was diagnosed by measuring the total cross-sectional area of the psoas muscle at the L4 vertebrae using perioperative computed tomography scans. Of the 46 patients assessed, 16 were in the lowest third for L4 total psoas area (sarcopenic). Average follow-up time was 5.2 years (range, 6 days to 12.7 years). The cohort of patients with sarcopenia was significantly older than the cohort without sarcopenia (mean age, 76.4 vs 69.9 years; \( P = .01 \)) but did not have a significantly different mean Charlson Comorbidity Index (3.3 vs 2.0; \( P = .32 \)) or mean Mirza Surgical Invasiveness Index (7.1 vs 7.0; \( P = .49 \)). Patients with sarcopenia had a hospital length of stay 1.7-fold longer than those without sarcopenia (8.1 vs 4.7 days; \( P = .02 \)) and a 3-fold increase in postoperative in-hospital complications (1.2 vs 0.4; \( P = .02 \)), and they were more likely to require discharge to a rehabilitation or nursing facility (81.2% vs 43.3%; \( P = .006 \)). Patients with sarcopenia had a significantly lower cumulative survival (log rank=0.007). All 4 deaths occurred among patients with sarcopenia. Patients with sarcopenia have a significantly increased risk of in-hospital complications, longer length of stay, increased rates of discharge to rehabilitation facilities, and increased mortality following thoracolumbar spinal surgery, making sarcopenia a useful perioperative risk stratification tool. [Orthopedics. 2016; 39(6):e1159-e1164.]

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Although sarcopenia has been identified as an independent predictor of mortality in patients undergoing organ transplants and those undergoing surgery for pancreatic and colorectal cancer, there is a dearth of evidence regarding the effect of sarcopenia on orthopedic surgical outcomes. In addition, sarcopenia is associated with osteoporosis and an increased risk of osteoporotic fractures, which are factors that may also compromise clinical outcomes following thoracolumbar spine surgery.

In this investigation, the authors examined the correlation of sarcopenia with morbidity and mortality following thoracolumbar spinal surgery. They hypothesized that sarcopenia would be associated with an increase in postoperative complications, length of hospital stay, and overall mortality in thoracolumbar spine surgery patients.

**Materials and Methods**

**Study Design**

After obtaining institutional review board approval, hospital records of 46 patients undergoing thoracolumbar decompression or decompression with fusion from 2003 to September 2015 were analyzed. The sample size was determined by the number of available patients with complete data. Patients were included if they were older than 55 years, if there was a perioperative computed tomography (CT) scan available for measuring psoas muscle cross-sectional area (performed an average of 4.3 months from date of surgery; range, 0–21.4 months), and if both inpatient and outpatient clinic follow-up data were available. No minimum follow-up time was required in an effort to include all instances of mortality, including those who died shortly following surgery. In addition, clinical follow-up data were cross-referenced with public death records to confirm all incidences of death up to December 2015. Patients were excluded if a CT scan had been performed greater than 2 years from the patient’s surgery date or if the patient’s postoperative clinical follow-up was unavailable, insufficient, or poorly documented. All thoracolumbar spine diagnoses and surgical indications were included.

Preoperative Charlson Comorbidity Index (CCI) was calculated for each patient and used to assess baseline comorbidity burden and health status. The CCI accounts for medical comorbidities including end organ disease (eg, end-stage renal disease) and presence of malignancy (localized and metastatic).

The Mirza Surgical Invasiveness Index (CCI) was calculated for each procedure to account for surgical procedure variability on the patient. The Mirza Surgical Invasiveness Index was developed to rate spine surgical procedures based on the type and complexity of intervention involved in the procedure. This invasiveness index has been validated for spine procedures by its association with estimated blood loss (EBL) and operative time.

**Measurement of Sarcopenia**

To assess sarcopenia, the cross-sectional areas of the left and right psoas muscles at the level of the transverse process of L4 were measured on axial CT scan (Figure 1) using OsiriX imaging software (Pixmeo, Geneva, Switzerland). This software is readily available online at no cost and has been shown to have high interrater reliability with reliability coefficients between 0.77 and 0.99. The cross-sectional areas were then summed to find the L4 total psoas area, a commonly used metric of sarcopenia in the surgical population. Patients falling into the lowest third for their sex-specific L4 total psoas area were deemed sarcopenic.

**Outcome Variables**

The outcome variables assessed for each patient included the number of total postoperative complications classified according to the Clavien-Dindo system (Table 1), the length of hospital stay, and mortality. Additional outcome measures included the number of severe postoperative complications (defined as Clavien-Dindo grade IV or V) and the patient’s disposition destination (skilled nursing facility, inpatient rehabilitation, or home).

**Statistical Analysis**

Student’s t test was used to compare mean differences in length of hospital stay and number of complications for patients with sarcopenia vs those without. Differences in disposition were compared with chi-square testing. Analysis of variance (ANOVA) was used to measure differences across thirds. A Kaplan-Meier analysis along with log rank testing was used to measure differences in mortality over time. A P value of .05 was considered significant for all tests (SPSS version 21 statistical software package; IBM, Armonk, New York).

**Results**

A total of 46 patients met the study inclusion criteria. Indications for surgery included spinal stenosis in 32 patients, degenerative scoliosis in 4, epidural abscess or diskitis in 5, acute fracture requiring operative fixation in 3, and radiculopathy in 2. Average follow-up time was 5.2 years (range, 6 days [died in hospital] to 12.7 years). Sixteen patients of 46 (8 men and 8 women) fell into the lowest third for L4 total psoas area (TSA) and were deemed sarcopenic (Table 2).
Patients with sarcopenia were significantly older than those without sarcopenia, with a mean age of 76.4 vs 69.9 years, respectively ($P=.01$). There was no statistically significant difference in mean CCI (3.3 vs 2.0; $P=.32$) or mean Mirza Surgical Invasiveness Index (7.1 vs 7.0; $P=.49$) between patients with sarcopenia and those without (Table 3).

As shown in Table 4, mean length of stay for patients with sarcopenia was 1.7-fold longer than that for patients without sarcopenia (8.1 vs 4.7 days; $P=.02$). In addition, patients with sarcopenia had a 3-fold increase in the mean number of total complications (1.2 vs 0.4; $P=.02$) and a 10-fold increase in major complications (0.3 vs 0.03; $P=.04$) vs patients without sarcopenia. Five of the 6 major complications in this cohort occurred in patients with sarcopenia. Patients with sarcopenia were also more likely to be discharged to a skilled nursing facility or inpatient rehabilitation facility (81.2% vs 43.3%; $P=.006$).

Patients with sarcopenia had a significantly lower cumulative survival over time when compared with patients without sarcopenia (log rank=0.007) (Figure 2). All 4 patients in this cohort who died following surgery had sarcopenia.

**DISCUSSION**

Sarcopenia has previously been shown to be a predictor of complications and mortality in patients undergoing emergency general surgery, surgical oncology, and organ transplant. To the current authors’ knowledge, this study is the first to demonstrate a correlation between sarcopenia and postoperative morbidity and mortality following spinal surgery. Despite having nonstatistically different comorbidity and surgical invasiveness scores, patients with sarcopenia patients had 1.7-fold longer hospital stays and a 3-fold higher complication rate compared with patients without sarcopenia.

These findings are particularly salient given the pervasiveness of sarcopenia among orthopedic patients. A cross-sectional study by Ji et al examining patients undergoing hip fracture surgery and joint arthroplasty reported a 44.1% rate of sarcopenia in the orthopedic patient population compared with a 33.2% rate in control patients in an outpatient department. In a study by Hida et al comparing skeletal muscle mass in patients with osteoporotic vertebral fracture vs those without, sarcopenia was an independent risk factor for osteoporotic vertebral fracture. Although both of these studies suggest that sarcopenia may be an important

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**Table 1**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Any deviation from standard postoperative care without the need for pharmacologic, surgical, endoscopic, or radiological intervention; surgical wound debridement at the bedside</td>
</tr>
<tr>
<td>2</td>
<td>Complication requiring nonstandard pharmacological intervention, blood products, or total parenteral nutrition</td>
</tr>
<tr>
<td>3</td>
<td>Complication requiring surgical, endoscopic, or radiologic intervention</td>
</tr>
<tr>
<td>4</td>
<td>Multi-organ dysfunction; requirement of intensive care unit level of care; dialysis</td>
</tr>
<tr>
<td>5</td>
<td>Death</td>
</tr>
</tbody>
</table>

*Data from Clavien et al.*

**Table 2**

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Lowest Third (Sarcopenic)</th>
<th>Middle Third</th>
<th>Highest Third</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8</td>
<td>7</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Age, mean±SEM, y</td>
<td>76.4±2.2</td>
<td>69.8±2.5</td>
<td>70.1±1.4</td>
<td>.04</td>
</tr>
<tr>
<td>L4 total psoas area, mean±SEM, mm$^2$</td>
<td>1477.1±147.7</td>
<td>1936.5±152.0</td>
<td>2635.1±202.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Preoperative diagnosis, No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinal stenosis</td>
<td>11</td>
<td>11</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Degenerative scoliosis</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Epidural abscess/diskitis</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Acute fracture</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Radiculopathy</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Charlson Comorbidity Index, mean±SEM</td>
<td>3.3±0.8</td>
<td>2.8±0.5</td>
<td>2.9±0.4</td>
<td>.85</td>
</tr>
<tr>
<td>Surgical Invasiveness Index, mean±SEM</td>
<td>7.1±1.6</td>
<td>5.9±1.4</td>
<td>8.1±1.3</td>
<td>.59</td>
</tr>
</tbody>
</table>

Abbreviation: SEM, standard error of the mean.
consideration in patients undergoing orthopedic surgery, neither study assessed patient outcomes.

In the current study, the authors found that sarcopenia had a poorer cumulative survival over time, with all 4 deaths in the study occurring among patients with sarcopenia. Furthermore, in the small study population, 5 of the 6 major complications occurred in patients with sarcopenia. These findings are similar to those previously reported for patients undergoing surgery in general fields.7-12

This study had several potential limitations. The relatively small sample size of the study population is a potential limitation, and larger prospective investigations will be needed to further assess the usefulness of sarcopenia in predicting outcomes following thoracolumbar spine surgery. In addition, this study includes several preoperative indications for undergoing thoracolumbar decompression and possible fusion. Although it is possible that this introduced additional variability to the study, this list of indications was collected as a representative sample of cases performed at a large tertiary center and is therefore reflective of a spine practice in an academic setting.

An additional potential limitation is that only L4 psoas area was used to define sarcopenia, although there are numerous other methods currently used to assess sarcopenia in clinical research. Researchers have used Hounsfield units to assess psoas density, quadriceps area, dual energy X-ray absorptiometry (DEXA), and bioelectrical impedance analysis to assess muscle amount and quality. However, DEXA and bioelectrical impedance analysis are less specific for sarcopenia than measurements of cross-sectional area.21-23 In addition, measures of muscle strength (eg, handgrip, knee flexion/extension, and peak expiratory flow) and physical performance (eg, Short Physical Performance Battery, gait speed, timed get-up-and-go test, and the stair-climb power test) have also been evaluated but are not possible

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**Table 3**

Demographics of Patients With Sarcopenia Versus Patients Without Sarcopenia

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Sarcopenia</th>
<th>No Sarcopenia</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, No.</td>
<td>8</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Age, mean±SEM, y</td>
<td>76.4±2.2</td>
<td>69.9±2.0</td>
<td>.01</td>
</tr>
<tr>
<td>L4 total psoas area, mean±SEM, mm²</td>
<td>1477.1±147.7</td>
<td>2285.8±198.2</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Charlson Comorbidity Index, mean±SEM</td>
<td>3.3±0.8</td>
<td>2.0±0.4</td>
<td>.32</td>
</tr>
<tr>
<td>Surgical Invasiveness Index, mean±SEM</td>
<td>7.1±1.6</td>
<td>7.0±1.4</td>
<td>.49</td>
</tr>
</tbody>
</table>

*Abbreviation: SEM, standard error of the mean.*

**Table 4**

Postoperative Morbidity in Patients With Sarcopenia

<table>
<thead>
<tr>
<th>Patient Outcome</th>
<th>Sarcopenia</th>
<th>No Sarcopenia</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay, mean±SEM, d</td>
<td>8.1±1.5</td>
<td>4.7±0.9</td>
<td>.02</td>
</tr>
<tr>
<td>Total postoperative complications, mean±SEM, No.</td>
<td>1.2±0.3</td>
<td>0.4±0.2</td>
<td>.02</td>
</tr>
<tr>
<td>Major postoperative complications, mean±SEM, No.</td>
<td>0.3±0.2</td>
<td>0.03±0.1</td>
<td>.04</td>
</tr>
<tr>
<td>Discharged to skilled nursing or rehabilitation facility</td>
<td>81.2%</td>
<td>43.3%</td>
<td>.006</td>
</tr>
</tbody>
</table>

*Abbreviation: SEM, standard error of the mean.*

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**Figure 2:** Kaplan-Meier curve showing a significantly lower postoperative survival (log rank=0.007) for patients with sarcopenia (red) vs patients without sarcopenia (blue).
to assess retrospectively, and furthermore may be inaccurate measures in patients undergoing spinal surgery due to neurological compression and spinal malalignment.23–26 Currently, no single definition of sarcopenia has been shown to be most clinically useful, and additional studies to compare these methods are required. The current authors chose total psoas area in an effort to assess a clinically relevant and potentially clinically useful measure. Spine surgeons with access to preoperative CT and magnetic resonance imaging scans can measure psoas area, which may help in preoperative assessment of risk.

The results of this study indicate that sarcopenia may be an important consideration in patient selection for thoracolumbar spine surgery. Identifying patients at higher risk for poor outcomes could aid both physicians and patients in decision making. Screening for sarcopenia may be a useful tool in determining which patients are at high risk of morbidity and mortality following spinal surgery. This form of preoperative assessment could potentially conserve valuable health care system resources by reducing complications and readmissions. Further prospective investigation is needed to assess sarcopenia as a novel method of predicting morbidity and mortality in patients undergoing spinal surgery.

REFERENCES
24. Callahan D, Phillips E, Carabello R, Frontera WR, Fielding RA. Assessment of lower ex-


