Complications and outcomes after spinal deformity surgery in the elderly: review of the existing literature and future directions

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Object. The elderly population (age > 60 years) is the fastest-growing age group in the US. Spinal deformity is a major problem affecting the elderly and, therefore, the demand for surgery for spinal deformity is becoming increasingly prevalent in elderly patients. Much of the literature on surgery for adult deformity focuses on patients who are younger than 60 years, and therefore there is limited information about the complications and outcomes of surgery in the elderly population.

In this study, the authors undertook a review of the literature on spinal deformity surgery in patients older than 60 years. The authors discuss their analysis with a focus on outcomes, complications, discrepancies between individual studies, and strategies for complication avoidance.

Methods. A systematic review of the MEDLINE and PubMed databases was performed to identify articles published from 1950 to the present using the following key words: “adult scoliosis surgery” and “adult spine deformity surgery.” Exclusion criteria included patient age younger than 60 years. Data on major Oswestry Disability Index (ODI) scores, visual analog scale (VAS) scores, patient-reported outcomes, and complications were recorded.

Results. Twenty-two articles were obtained and are included in this review. The mean age was 74.2 years, and the mean follow-up period was 3 years. The mean preoperative ODI was 48.6, and the mean postoperative reduction in ODI was 24.1. The mean preoperative VAS score was 7.7 with a mean postoperative decrease of 5.2. There were 311 reported complications for 815 patients (38%) and 5 deaths for 659 patients (< 1%).

Conclusions. Elderly patient outcomes were inconsistent in the published studies. Overall, most elderly patients obtained favorable outcomes with low operative mortality following surgery for adult spinal deformity.

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Key Words • spinal deformity • elderly • complication • outcome • minimally invasive • future direction

Adult spinal deformity is a significant problem for many patients, in particular, the elderly. The elderly (defined here as those aged 60 years and older) is the fastest-growing demographic in the US. Currently estimated to be 12.4% of the population, the number of elderly patients has been projected to increase to 19.6% by the year 2030. Spinal deformity is a major morbidity in this population, with pain and balance problems associated with spinal deformity often representing a significant obstacle to mobility in this age group. In a recent study, Schwab et al. reported a prevalence of spinal deformity as high as 68% in those older than 60 years. Of all patients hospitalized with a diagnosis of spinal deformity, 50% were 65 years and older.

Nonsurgical management for spinal deformity in the elderly is likely underreported. While it is hypothesized that a majority of spinal deformity patients are treated nonoperatively by their primary physicians, an increasing number of patients are opting for surgery. The goals of surgery are to halt the progression of the deformity, restore the sagittal and coronal balance, optimize cosmesis, and improve neurological function. Unlike most spine disease processes, spinal deformity is a complex entity comprising more than one problem. Thus, complete deformity correction is often not possible and should not be considered the goal. Rather, surgery seeks to alleviate the symptoms of the existing deformity while preventing further deformation.

Surgical morbidity and mortality have been shown to be higher in the elderly. Therefore, preoperative evaluation of these patients is particularly important. Specifically, the presence of coexistent disease and reduced physi-
ological reserve have been shown to adversely affect outcomes in elderly patients.6,28,39 Studies have demonstrated that preoperative tests of pulmonary, renal, and cardiac functioning are at least partially predictive of postoperative complications associated with these organ systems in elderly patients.6,31,37,46,57 Furthermore, malnutrition has also been indicated as a risk factor for postoperative nosocomial infections in elderly patients; nutritional status should therefore be evaluated and managed appropriately prior to operating.26,32,34,40,49,58

Considering the increased demand for scoliosis surgery by the elderly, it is important to conduct clinical studies with long-term follow-up to assess the best way to manage surgical complications and strategies to avoid these complications. To provide insight into what has already been researched, we reviewed and analyzed the published studies involving patients > 60 years of age who underwent surgery for scoliosis. The specific aims were to assess whether the deformity treatment is beneficial to the elderly based on patient-reported and standard clinical outcomes and to understand the frequency and type of complications that are encountered.

Methods

Literature Review

A query of the PubMed and MEDLINE databases was performed to identify articles pertinent to spinal deformity surgery in the elderly published between 1950 and 2011. An initial search using the key words “adult scoliosis surgery” and “adult spine deformity surgery” returned 3106 articles. The query was further limited to the English-language literature (2595 articles) and a patient age of 60 years or older (733 articles). Abstracts from these articles were reviewed by 2 separate authors (D.D. and M.S.). This yielded 129 articles for detailed review.

Of these 129 articles, 107 were excluded from analysis because of failure to meet the patient age criteria or report postoperative outcomes. The remaining 22 articles were included in the analysis. Articles were reviewed for data on methodology (retrospective vs prospective), number of patients, mean patient age, and mean follow-up. Clinical outcomes data based on postoperative ODI scores, change in ODI scores from preoperative, postoperative VAS instrument scores, and change in VAS scores from preoperative was also recorded when available. Because studies often used differing definitions of major and minor complications, all complications were grouped and the total rate of complications calculated.

Statistical Analysis

All descriptive statistics were calculated using JMP 7.02 (SAS Institute). Averages for age, length of follow-up, and changes in ODI and VAS scores were calculated. Additionally, studies that reported patient-reported outcomes were summarized. Complications were calculated by adding up the total number of reported complications and dividing this number by the total number of patients experiencing complications. The incidence of mortality was similarly calculated by totaling the number of deaths and dividing this number by the number of patients who died.

Results

The review included 22 articles with data reported for 1417 patients. Four studies were conducted prospectively, and 18 studies were conducted retrospectively. The mean patient age was 74.2 years, and the average follow-up period was 3 years. Two studies did not report the average patient age, and 5 studies did not report the average follow-up period.

Seven studies comprising 262 patients reported a mean preoperative ODI of 48.6 (Table 1). Seven studies comprising 252 patients reported a mean postoperative ODI of 25.4. The average same-study decrease was 24.1. Eight studies consisting of 363 patients reported a mean preoperative VAS score of 7.7. Seven studies consisting of 335 patients reported a mean postoperative VAS score of 2.5. The average same-study decrease was 5.2.

Eight studies that included patient-reported outcomes were also examined (Table 2). These studies included a total of 808 patients. On average, 73.1% of patients reported outcome following surgery as “excellent/good,” 15.2% as “fair/unchanged,” and 13.4% as “poor/worse.” Because studies often used differing definitions of major and minor complications, all complications were grouped and the total rate of complications calculated. A total of 311 complications were reported by 14 studies including 815 patients to give an overall complication rate of 38% (Table 3). Mortality was reported by 13 studies and averaged 0.85%.

All studies of corrective procedures reported improvement of deformity from radiographs obtained immediately postoperatively to the final follow-up. There were only 2 studies that reported preoperative and postoperative degrees of correction. Specifically, Li et al.35 reported a 44% Cobb angle improvement from a mean 35.1° of preoperative deformity to 23.2° at final follow-up. In 2010, Di Silvestre et al.18 reported a 37.5% scoliosis improvement from a mean of 16.9° to 11.1° at final follow-up.

Progressive junctional kyphosis was reported in 2 studies reviewed for this paper. DeWald and Stanley17 reported progressive junctional kyphosis in 26% of patients (10 of 38) with construct lengths ranging from 6 to 8 levels and terminal cephalad levels ranging from T-10 to L-1. Daubs et al.13 reported progressive junctional kyphosis in 2% of patients (1 of 46) adjacent to their most cephalad level of fusion.

Four studies reported reoperation rates. Daubs et al.15 reported 15 patients (32%) who required additional procedures (for example, misplaced pedicle screw, prominent implants, pseudarthrosis, and progression of scoliosis). Daubes et al.13 reported an 11% reoperation rate for patients who developed pseudarthroses with rod breakage, acute disc herniation at the disc space directly above the construct, and painful instrumentation requiring removal of a multilevel segment. Rosen et al.46 reported that 2% of patients required reoperation for additional decompression and fusion, while Li et al.35 reported a 3% revision rate at 1 year.
Spinal deformity in the elderly

**TABLE 1: Literature review of clinical outcomes and complications for elderly patients undergoing surgery for scoliosis**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Study Design</th>
<th>No. of Pts</th>
<th>Mean Age (yrs)</th>
<th>Mean FU (yrs)</th>
<th>ODI Preop</th>
<th>ODI Postop</th>
<th>VAS Score Preop</th>
<th>VAS Score Postop</th>
<th>No. of Complications</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benz et al., 2001</td>
<td>retrospective</td>
<td>68</td>
<td>76.5</td>
<td>3.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>32</td>
<td>1.5</td>
</tr>
<tr>
<td>Bess et al., 2009</td>
<td>retrospective</td>
<td>28</td>
<td>73.2</td>
<td>NA</td>
<td>49</td>
<td>NA</td>
<td>7.8</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Best &amp; Sasso, 2007</td>
<td>retrospective</td>
<td>127</td>
<td>73.2</td>
<td>4.6</td>
<td>NA</td>
<td>NA</td>
<td>8.8</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Cassinelli et al., 2007</td>
<td>retrospective</td>
<td>166</td>
<td>73.3</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>61</td>
<td>0</td>
</tr>
<tr>
<td>Daubs et al., 2007</td>
<td>retrospective</td>
<td>46</td>
<td>67</td>
<td>4.2</td>
<td>49</td>
<td>25</td>
<td>NA</td>
<td>NA</td>
<td>37</td>
<td>2.2</td>
</tr>
<tr>
<td>DeWald &amp; Stanley, 2006</td>
<td>retrospective</td>
<td>38</td>
<td>72.4</td>
<td>2.5</td>
<td>NA</td>
<td>NA</td>
<td>24</td>
<td>NA</td>
<td>0</td>
<td>NA</td>
</tr>
<tr>
<td>Galiano et al., 2005</td>
<td>retrospective cohort</td>
<td>19</td>
<td>82.2</td>
<td>2.7</td>
<td>NA</td>
<td>36.4</td>
<td>8.5</td>
<td>3.9</td>
<td>NA</td>
<td>17</td>
</tr>
<tr>
<td>Jo et al., 2010</td>
<td>retrospective</td>
<td>48</td>
<td>71.2</td>
<td>2</td>
<td>NA</td>
<td>NA</td>
<td>7.1</td>
<td>2.8</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Kiliçer et al., 2005</td>
<td>retrospective</td>
<td>40</td>
<td>73</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Li et al., 2009</td>
<td>retrospective</td>
<td>34</td>
<td>75.1</td>
<td>2.8</td>
<td>45</td>
<td>18</td>
<td>NA</td>
<td>NA</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Raffo &amp; Lauerman, 2006</td>
<td>retrospective</td>
<td>20</td>
<td>NA</td>
<td>2.6</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Ragab et al., 2003</td>
<td>retrospective</td>
<td>118</td>
<td>74</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>24</td>
<td>4</td>
</tr>
<tr>
<td>Rosen et al., 2007</td>
<td>prospective</td>
<td>57</td>
<td>81</td>
<td>0.8</td>
<td>48</td>
<td>27</td>
<td>22</td>
<td>5.7</td>
<td>2.2</td>
<td>22</td>
</tr>
<tr>
<td>Scheufler et al., 2010</td>
<td>retrospective</td>
<td>30</td>
<td>73.2</td>
<td>1.6</td>
<td>57.2</td>
<td>24.8</td>
<td>2.6</td>
<td>7.5</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Shabat et al., 2008</td>
<td>prospective</td>
<td>25</td>
<td>83.95</td>
<td>3.1</td>
<td>NA</td>
<td>NA</td>
<td>23</td>
<td>8.8</td>
<td>3.6</td>
<td>0</td>
</tr>
<tr>
<td>Di Silvestre et al., 2010</td>
<td>retrospective</td>
<td>29</td>
<td>68.5</td>
<td>4.5</td>
<td>51.8</td>
<td>27</td>
<td>8</td>
<td>6.7</td>
<td>3.3</td>
<td>0</td>
</tr>
<tr>
<td>Smith et al., 2011</td>
<td>retrospective</td>
<td>38</td>
<td>70</td>
<td>2</td>
<td>43</td>
<td>24</td>
<td>NA</td>
<td>NA</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>Wang et al., 2003</td>
<td>retrospective</td>
<td>88</td>
<td>78.5</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>18</td>
<td>0</td>
</tr>
</tbody>
</table>

* FU = follow-up; NA = not available; Pts = patients.

**TABLE 2: Literature review of postoperative patient-reported outcomes for elderly patients undergoing surgery for scoliosis**

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Study Design</th>
<th>No. of Pts</th>
<th>Mean Age (yrs)</th>
<th>Mean FU (yrs)</th>
<th>Excellent/Good</th>
<th>Fair/Unchanged</th>
<th>Poor/Worse</th>
<th>Outcome (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arinzon et al., 2004</td>
<td>retrospective</td>
<td>152</td>
<td>72</td>
<td>3.5</td>
<td>65</td>
<td>20</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Benz et al., 2001</td>
<td>retrospective</td>
<td>83</td>
<td>81.4</td>
<td>3.6</td>
<td>71</td>
<td>19</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Best &amp; Sasso, 2007</td>
<td>retrospective</td>
<td>68</td>
<td>76.5</td>
<td>3.5</td>
<td>60</td>
<td>19</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Greenfield et al., 1998</td>
<td>retrospective</td>
<td>136</td>
<td>73.2</td>
<td>4.6</td>
<td>69.1</td>
<td>14.7</td>
<td>16.2</td>
<td>16.2</td>
</tr>
<tr>
<td>Jonsson &amp; Strömquist, 1994</td>
<td>prospective consecutive</td>
<td>30</td>
<td>73.8</td>
<td>NA</td>
<td>56.7</td>
<td>26.7</td>
<td>16.7</td>
<td>16.7</td>
</tr>
<tr>
<td>Jönsson et al., 2001</td>
<td>retrospective</td>
<td>118</td>
<td>74</td>
<td>NA</td>
<td>92</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Wang et al., 2003</td>
<td>retrospective</td>
<td>88</td>
<td>78.5</td>
<td>NA</td>
<td>leg 43/42; back 43/33</td>
<td>NA</td>
<td>leg 15; back 24</td>
<td>10</td>
</tr>
</tbody>
</table>

**Discussion**

Adult deformity is a significant problem for many patients. The majority of patients seek nonsurgical treatment.23 Many surgical treatment strategies exist, and the type of reconstruction that is necessary is patient specific. However, surgical options for elderly patients are limited by medical comorbidities, the ability to tolerate a long operation, and life expectancy. Interestingly, the elderly have been shown to significantly benefit from surgery in terms of improvements in symptoms.35

The aim of the current study was to provide analytical data regarding scoliosis surgery in the elderly population. The current review focused on the ODI, VAS scores, and patient-reported outcomes, the most consistently used measures. Complications and strategies for complication avoidance were included in this review.

**Clinical Outcome**

Among the elderly, patients most likely to receive significant alleviation of symptoms tended to have higher levels of deformity and increased disability.18,35,41,47,51,54 High ODI, high VAS scores, and low 12-Item Short Form Health Survey (SF-12) scores were associated with an improvement in symptoms. A baseline SF-12 score of 35...
or less, for example, was 6 times more likely to improve compared with an initial score higher than 35.21 A similar trend was observed among the Scoliosis Research Society scale scores; however, there were only a few studies that used this outcome measure. Overall, patients with less initial morbidity, that is, lower ODI and VAS scores, had a decreased chance of improving clinically compared with those with more severe symptoms.

A study by Jönsson and Strömqvist50 found that in a cohort of surgical patients 70 years of age and older, 74.3% had good or excellent outcomes for lower-back pain and 80.4% had similar results for leg pain. Among patients 80 years and older undergoing laminectomy for spinal stenosis, Galiano et al.21 noted that at 2.7 years of follow-up, there was a 54.1% improvement in ODI and a statistically significant decrease in analgesic usage.

Elderly patients pose a unique challenge to the spine surgeon. Because their mobility and activities of daily living tend to be affected, the fear of losing their independence is greater than that in younger individuals.22 This stresses the importance of setting realistic expectations for the patients. Interestingly, a study by Gepstein et al.24 found that in patients older than 64 years, there was such a correlation between high expectations and satisfaction in those treated for lumbar spinal stenosis that preoperative expectations could be used to predict patient satisfaction.

There is a growing body of literature supporting the use of spinal surgery in the elderly. Arinzon et al.3 analyzed the surgical management of spinal stenosis in elderly patients in 2 groups. In one group, the patients were between 65 and 74 years of age, and in the other group they were older than 75 years. Patients were treated with decompressive laminectomy or decompressive laminectomy plus discectomy. Both groups showed a significant improvement in their pain and ability to perform activities of daily living. Postoperative complications were also similar among these groups.

Among patients 60 years of age and older receiving instrumented arthrodesis of the lumbosacral spine, 57% reported good or excellent results, 27% reported fair results, and only 16% reported poor or worsening results.25 Within the entire cohort, 64% reported a decrease in pain and 63% reported improvement in overall function.25 Perhaps most importantly, 73% of those responding demonstrated at least a 50% improvement in their activities of daily living.25 Zheng et al.28 studied patients with an average age of 70 years undergoing posterior lumbar spinal surgery to treat a variety of degenerative spinal disorders. Using the modified low-back outcome scores, favorable outcomes were observed in 71% of patients. While additional degenerative disorders of the bones and joints predicted lower outcomes, 54% reported excellent outcomes, 29% good, 7% fair, and 10% poor. Interestingly, patient age, body mass index, history of hypertension, smoking status, diabetes, pulmonary disease, diagnosis of degenerative scoliosis, number of levels decompressed, or history of fusion procedure had a significant effect on the modified low-back outcome scores.52 Benz et al.7 studied a similar cohort and found no significant relationship between early postoperative complications and preexisting comorbidities. The study also found 60% of patients had an improvement of symptoms and 71% would repeat the surgery.

Spinal surgery has also been demonstrated to be effective among octogenarians.24,52 Thirty-nine patients at least 80 years of age underwent decompressive surgery for lumbar spinal stenosis. The survival rates were 94%, 80.8%, and 72.7% at 2, 3, and 6 years, respectively.52 Pain, as measured by the VAS, improved from a score of 8.84 ± 1.91 before surgery to one of 3.6 ± 2.35 at last follow-up. Activities of daily living, as measured by the Barthel Index, also improved from 62.8 ± 11.46 to 77.0 ± 11.9. Furthermore, individuals who cited no limitation in their walking ability increased by 32%, with 76% of all patients reporting satisfaction with the results of their surgery.52 As expected, minimally invasive lumbar spinal decompression has demonstrated similar efficacy in elderly populations.45 Among 57 patients with a mean age of 81 years, no major complications or deaths were reported.45 Mean VAS scores decreased from 5.7 to 2.2 for back pain and from 5.7 to 2.3 for leg pain. In total, 80% reported a decrease in back VAS pain scores. The mean ODI score decreased from 48 to 27, while the mean SF-36 physical function score increased from 26 to 48.45 No major complications occurred in this study, but patients did report urinary retention (6 patients), transient delirium (5), unintentional durotomy (3), fever (3), urinary tract infection (2), atrial fibrillation (1), constipation (1), and pneumonia (1).45

Complications

A search of the broader spine literature regarding age and surgery-related complications yielded the following results.54,55 Cloyd et al.44 found a 10% increase in mortality among individuals 80 years of age and older. The major complication rate was 35% with an OR of 9.2.42 Among 51 patients 60 years of age and older undergoing spinal deformity reconstructive surgery with a minimum 5-level fusion, 37% were found to have perioperative complications.19 Twenty percent had at least one major complication such as neurological defect, pulmonary embolism, pneumonia, myocardial infarction, and deep wound infection. Significant factors for complication included age and posterior pedicle subtraction osteotomy. These factors were also associated with additional blood transfusions. Daubs et al.55 also found that with every year increase in age, the risk of at least one major postoperative complication rose 23%. Furthermore, patients older than 69 years were

<table>
<thead>
<tr>
<th>Major Complication</th>
<th>Mean Percentage (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>dural tear</td>
<td>5.5 (0.4–15)</td>
</tr>
<tr>
<td>wound infection</td>
<td>5.25 (1–16)</td>
</tr>
<tr>
<td>pulmonary</td>
<td>5 (0.1–11)</td>
</tr>
<tr>
<td>renal</td>
<td>4.7 (1–20)</td>
</tr>
<tr>
<td>neurological</td>
<td>4.7 (1–11)</td>
</tr>
<tr>
<td>gastrointestinal</td>
<td>4.5 (1–8)</td>
</tr>
<tr>
<td>cardiac</td>
<td>3.7 (1–13)</td>
</tr>
</tbody>
</table>

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shown to be 9 times more likely to have a major complication than those younger than 69 years. Among patients undergoing pedicle subtraction osteotomy, the risk for at least one major complication was increased 7 times.11

Cassinelli et al.11 found that among 166 patients 65 years of age and older undergoing posterior lumbar decompression and fusion with or without instrumentation, only 5 major complications were noted. The authors found that medical comorbidities, advanced age, and the use of instrumentation did not significantly increase the rate of complications, indicating that posterior lumbar decompression and fusion is safe for elderly patients. In fact, the only risk for major complications was the decompression and fusion of 4 or more segments.11 Similarly, Ragab et al.11 found that among 118 patients older than 70 years of age undergoing decompressive lumbar surgery, advanced age did not increase morbidity or mortality.

The array of complications associated with spine surgery is diverse.12,33,55 Interestingly, Best and Sasso12 recently reported a 1.7% complication rate for decompression among 243 elderly patients, while a similar study by Wang et al.59 targeted patients 75 years of age and older and reported a complication rate of 3.3%. A study by Baron and Albert4 found that 70% of patients who underwent combined anteroposterior fusion had at least one complication, the most common being urinary tract infection. Additionally, 7.8% of patients developed a wound infection.

Pulmonary complications are not uncommon and in some studies are reported to be as high as 64%.31 The rate of deep vein thrombosis has been shown to vary depending on the surgical approach.16,44 Dearborn et al.16 found deep vein thrombosis rates to be 6% for anteroposterior fusions and 0.5% for posterior fusions. Rokito et al.44 found the rate to be 0.3% among 329 patients undergoing spinal fusion, while West and Anderson61 found the rate to be 14% among 41 patients undergoing posterior spinal fusion only. Cardiac complications are not very common.31 Baron and Albert4 reported that 1.8% of patients developed chest pain and 0.6% developed postoperative arrhythmia. Renal failure has been estimated to occur in 1.2% of all forms of surgery.11 Gastrointestinal complications are more common. Postoperative ileus was reported in 5%–12% of patients undergoing all spine procedures.7 Constipation has also been reported but is most likely medication related. A rare, yet potentially life-threatening complication is superior mesenteric artery syndrome, which was found in 0.5% of patients undergoing surgical correction of scoliosis.5

DeWald and Stanley17 found instrumentation-related complications to occur at a rate of 13% in the early postoperative period compared with 4%–32% in the late postoperative period. It is also noted that bone quality is a major factor in surgical success. Early instrumentation complications included epidural hematoma, compression fracture of the most cephalad instrumented vertebral body, and mild compression fracture of adjacent cephalad vertebral body. Late instrumentation complications include pseudarthroses with rod breakage, loosening of pedicle screws at the last instrument level, acute disc herniation, painful instrumentation, progressive junctional kyphosis at the cephalad level, late compression fractures, and progressive kyphosis.15,17

Strategies for Complication Avoidance: Preoperative Evaluation

The preoperative evaluation of the elderly patient with spinal deformity is important because surgical morbidity and mortality have been shown to be higher in this population. The patient and the physician need to recognize the age-related factors that contribute to the increase in complications in the elderly.13 Specifically, the presence of coexistent disease and reduced physiological reserve have largely been proven to affect outcomes in elderly patients.5,28,39 The mortality rate from myocardial infarction following noncardiac surgery has been estimated to be as high as 70% and has been reported to occur without recognized symptoms in 10% of elderly patients.16 The respiratory system is a major source of morbidity following deformity surgery. It has been reported that patients older than 70 years without preexisting lung disease have a 40% likelihood of abnormal pulmonary functioning.6 The elderly patient will more likely have poor renal functioning than any other system pathology.6,46 These findings can have important implications in the patient peri- and postoperatively because of volume dynamics.46 Malnutrition is often seen in elderly people; 30%–60% of geriatric patients in hospitals are malnourished.39 Moreover, some studies have evaluated malnutrition as a possible risk factor for nosocomial infections in those patients.39 In addition, other studies have reported that malnutrition in elderly surgical patients increases morbidity and mortality.50 The most common parameters that are used to evaluate the nutritional status are weight or albumin and sometimes bone mineral density.

Osteoporosis Evaluation

Osteoporosis is a complex metabolic disorder characterized by a decrease in bone mineral density that affects approximately 4–6 million women and 1–2 million men in the US.10 Among the elderly, osteoporosis-related vertebral compression fractures represent the most common spinal fractures in the elderly.48 Osteoporosis can also contribute to the development and progression of degenerative scoliosis in the elderly, and it is a significant risk factor for hardware instrumentation failure.34 However, it is important to note that since osteoporotic patients can present with more severe pathologies, they often require more aggressive surgical techniques, thus placing an already susceptible patient at an increased risk.17

In a survey of spine surgeons regarding osteoporosis and osteomalacia screening for fractures, fusion surgery, and pseudarthrosis, Dipaola et al.19 found that a large portion of the spine surgeons, including both orthopedic and neurosurgeons, do not perform routine osteoporosis workups, 60% obtained DEXA scans routinely, and 39% checked metabolic bone laboratory tests. The rates of osteopenia and osteoporosis in patients 50 years of age or older have been reported to be as high as 46% and 31%, respectively. It is therefore suggested that preoperative bone mineral density screening should be done routinely in the elderly population. Different tests have been used. A DEXA scan is a reliable way to assess the bone and determine its mineral content and blood samples for
vitamin D, parathyroid hormone, and calcium levels. From the analyses of Dipaola et al., it appears that spine surgeons prefer the use of the DEXA scan over a blood workup. Being aware of all risk factors helps to optimize patients’ outcomes and surgical planning.

Minimally Invasive Techniques

Minimally invasive spine surgical techniques have recently been used in the context of adult spinal deformity. Considering that adult spinal deformity surgery has been associated with blood loss ranging from 360 to 7000 ml for instrumented fusions, deformity surgery may be prohibitive in the elderly. It has been argued that given the relatively high complication rates associated with surgery for lumbar scoliosis (56%–75%) and the high unplanned reoperation rates (18%–58%), and that given the theoretically higher complication rates associated with advanced age and increasing medical comorbidities, the decision to perform surgery in the elderly patient with spinal deformity must be made very carefully. The case may be made against operative treatment in this group or for only short segment intervention.

Minimally invasive spine surgery techniques have evolved to the point at which they may be useful for the correction of deformity. They are associated with significantly less blood loss than open procedures (when compared with historical controls). When compared with open procedures, they also may result in reduced muscle damage, reduced postoperative pain medication requirements, and reduced muscle dysfunction. In the past, minimally invasive anterior approaches were considered “technically demanding” and theoretically associated with longer operative times. Nevertheless, as experience has increased with techniques such as the lateral transpsoas approach for discectomy and fusion and the percutaneous, presacral approach for discectomy and fusion, operative times have been demonstrated that are certainly comparable to open techniques. Newer percutaneous unconstrained pedicle screw systems that use freehand rod passage and appropriate contouring of the rod allow for minimally invasive multilevel fixation. In summary, minimally invasive deformity correction seems clearly preferable considering the reduced blood loss and acceptable operative times when compared with traditional open approaches. This may be particularly advantageous in the elderly and other populations with coexisting medical comorbidities.

Conclusions

As life expectancy increases and the population continues to age, the number of elderly patients seeking surgical correction of scoliosis is expected to increase. Adult spinal deformity surgery should not be regarded as a “cure.” Most elderly patients obtained favorable outcomes with low operative mortality following spinal surgery. It is important to clearly understand the risk factors and complications for this population to optimize patient outcomes. Complications can be decreased with a thorough presurgical evaluation, assessment of the presence of osteoporosis, and comprehensive preoperative and postsurgical medical management. Minimally invasive techniques and early mobilization should be considered.

Future clinical trials should be conducted to answer the question about whether minimally invasive versus open correction is the best option for this population. Clinical studies with long-term follow-up need to be conducted to assess the best way to manage surgical complications and strategies to avoid these complications.

Disclosure

Dr. Acosta is a consultant for Stryker Spine.

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