

## Review Article

# Spine surgery in geriatric patients: Sometimes unnecessary, too much, or too little

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## Abstract

**Background:** Although the frequency of spinal surgical procedures has been increasing, particularly in patients of age 65 and over (geriatric), multiple overlapping comorbidities increase their risk/complication rates. Nevertheless, sometimes these high-risk geriatric patients are considered for "unnecessary", too much (instrumented fusions), or too little [minimally invasive surgery (MIS)] spine surgery.

**Methods:** In a review of the literature and reanalysis of data from prior studies, attention was focused on the increasing number of operations offered to geriatric patients, their increased comorbidities, and the offers for "unnecessary" spine fusions, including both major open and MIS procedures.

**Results:** In the literature, the frequency of spine operations, particularly instrumented fusions, has markedly increased in patients of age 65 and older. Specifically, in a 2010 report, a 28-fold increase in anterior discectomy and fusion was observed for geriatric patients. Geriatric patients with more comorbid factors, including diabetes, hypertension, coronary artery disease (prior procedures), depression, and obesity, experience higher postoperative complication rates and costs. Sometimes "unnecessary," too much (instrumented fusions), and too little (MIS spine) surgeries were offered to geriatric patients, which increased the morbidity. One study observed a 10% complication rate for decompression alone (average age 76.4), a 40% complication rate for decompression/limited fusion (average age 70.4), and a 56% complication rate for full curve fusions (average age 62.5).

**Conclusions:** Increasingly, spine operations in geriatric patients with multiple comorbidities are sometimes "unnecessary," offer too much surgery (instrumentation), or too little surgery (MIS).

**Key Words:** Geriatric patients, instrumentation, minimally invasive, spinal surgery, unnecessary

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## INTRODUCTION

The incidence of spinal surgery, including instrumented fusions, is increasing, and progressively involves patients of age 65 and older (geriatric). Older patients, however,

frequently harbor multiple overlapping comorbidities that increase their susceptibility to the major risks and complications associated with spinal surgery, particularly when involving extensive instrumented fusions. This study offers a selective review of the geriatric spinal literature,

while also focusing on three areas of great import. First, sometimes geriatric patients are scheduled by surgeons (first opinions) for spinal operations they do not need (unnecessary) according to second spinal surgeons (second opinions). Second, sometimes geriatric patients are subjected to “too much surgery” consisting of multilevel instrumented fusions with/without bone morphogenetic protein (INFUSE: Medtronic, Memphis, TN, USA). Third, sometimes geriatric patients undergo “too little surgery” or minimally invasive surgery (MIS) that fails to adequately decompress neural structures.<sup>[6,7,9,10]</sup>

## MATERIALS AND METHODS

This study combines a search of the literature with a review of several personal series to specifically assess the indications, comorbidities, outcomes, and complications for patients 65 years of age or older undergoing spinal surgery. Specific attention was additionally paid to comorbid factors which increased the susceptibility of these geriatric patients to increased morbidity or mortality following “unnecessary”, too much (instrumented fusions), or too little (MIS) spine surgery.

## RESULTS

### Frequency of spine surgery and comorbidities in the geriatric age group

An increase in spine surgery was reported in the USA between the years 1978 and 1985, with different rates of spinal procedures being observed across different geographical areas, and/or within states.<sup>[4,19]</sup> In Davis’ annual national survey of hospitalizations (1979–1985), cervical spine operations increased by 45%, cervical fusions by 70%, lumbar surgery by 33%, and lumbar fusions by 60%.<sup>[4]</sup> Utilizing the Medicare database (1984–1990), a 20% greater incidence of laminectomy and disc removal was noted in the state of Utah compared with the national average; there was also a 50% disparity in surgical rates for different areas within Utah itself.<sup>[19]</sup> In a more recent assessment of the National Hospital Discharge Survey from 1990 to 2004, the greatest increase in spinal fusions occurred in patients 65 years of age or older who exhibited a 28-fold increase in anterior discectomy and fusion (ADF) procedures.<sup>[16]</sup> Deyo *et al.* observed that spinal surgery, particularly for lumbar stenosis, is one of the fastest growing procedures in the USA.<sup>[5]</sup> Although the overall frequency of surgery declined from 2002 to 2007, the frequency of complex fusions increased 15-fold.<sup>[5]</sup>

### American Society of Anesthesiologists grades, complications and age

Assigning American Society of Anesthesiologists (ASA) grades (e.g. grades 1–5) to patients undergoing spinal procedures, which strongly reflect patients’ preoperative

comorbid factors and overall health status, may be utilized to better select patients for spinal surgery, as higher ASA grades correlate with greater postoperative morbidity/mortality.<sup>[12]</sup> Utilizing the Scoliosis Research Society Morbidity and Mortality database for 2007 (22,857 patients), the overall complication rate was 8.4% for those with degenerative spinal disease (9,409 patients), scoliosis (6,782 patients), spondylolisthesis (2,144 patients), and other disorders.<sup>[12]</sup> Complication rates/morbidity increased with the preoperative ASA grades 1–5: grade 1, 5.4%; grade 2, 9%; grade 3, 14.4%; grade 4, 20.3%; and grade 5, 50%. Similarly, mortality rates increased with higher ASA grades.

Patients aged 65 and older experience higher complication rates particularly with instrumented fusions, in large part, due to their increased attendant medical comorbidities. In one series involving 87 patients undergoing elective thoracolumbar surgery for degenerative spondylotic disease, the overall complication rate was 67%: 50% minor (e.g. superficial wound infection, urinary tract infection, superficial phlebitis) and 17.8% major (e.g. life-threatening: infection, pulmonary embolism, neurological deficits).<sup>[28]</sup> Higher complication rates positively correlated with advanced age, hypertension, and fusions, but surprisingly, not with obesity [40.8% Body Mass Index (BMI) of  $\geq 30$  or above] or even morbid obesity (11.5% BMI of  $\geq 40$  or above).<sup>[28]</sup>

**Conclusions:** The higher the ASA grade, the greater the complications in spinal surgery.

### Additions to the complication rate with detailed co-morbidities: Advanced age, obesity, coronary artery disease, and antidepressant medications

Other series correlated increased morbidity following spinal surgery with these and additional comorbid factors. Alternatively, Walid *et al.*, in their retrospective analysis of how patients were chosen for inpatient (578) versus outpatient (97 cases) spinal surgery found that obesity (BMI > 30), which occurred in 2.8% of inpatients compared with 1% of outpatients, was more highly correlated with the risk of infection, and other chronic diseases.<sup>[26]</sup> Other comorbid factors and chronic diseases favoring inpatient operations included: advanced age (average 55 vs. 49), diabetes (19% vs. 10%), coronary artery disease (19.7% vs. 1.3%), coronary artery procedures (15.9% vs. 3.8%), and antidepressant medications (25.4% vs. 11.6%).<sup>[26]</sup>

In a separate study, Walid and Robinson further determined that severe obesity along with advanced age and female gender correlated with increased major comorbidities and greater costs for spinal surgery.<sup>[27]</sup> They evaluated major comorbidities and utilized the age-adjusted Charlson Comorbidity Index Scores to retrospectively assess 816 patients, averaging 54 years of age, undergoing spinal procedures from 2005 to 2008:

167 lumbar microdiscectomy (LMD 20.5%), 492 anterior cervical decompression/fusions (ADF 60.3%), and 157 lumbar decompression/fusion (LDF 19.2%). For example, costs for lumbar discectomy/fusion were 32% less without comorbidities (\$52,249), increasing to \$55,900 with depression, \$53,504 with diabetes, and up to \$68,782 with combined diabetes and depression.<sup>[27]</sup> Lumbar fusions resulted in significantly greater hospital charges (\$16,472; 32% increased over baseline), and costs rose substantially with patients' additional major comorbidities.<sup>[27]</sup>

Comorbidities similarly increased the surgical costs for ADF. The cost averaged \$25,153 without any comorbidities, but increased for ADF with obesity (\$25,633), with diabetes (\$25,826), and with combined obesity and diabetes (\$34,943).<sup>[27]</sup>

**Depression and diabetes**, respectively, increased morbidity following spinal surgery in two other series. Sinikallio *et al.* demonstrated that preoperative and postoperative depression placed 96 patients, averaging 62 years of age, at greater risk for poorer outcomes (documented utilizing the 21 Beck Depression Inventory Oswestry Disability Questionnaire, Visual Analog Scale), 24 months following lumbar surgery for spinal stenosis.<sup>[24]</sup> In Freedman *et al.*'s series, diabetic patients with spinal stenosis benefited from surgery when compared with non-diabetics, but were typically older and developed more complications.<sup>[11]</sup>

**Conclusion:** Obesity, advanced age, depression, and diabetes – all increased the complication rates and costs of spinal surgery.

### Advanced age and other comorbid factors produce a 24–66% complication rate in cervical spine surgery

Advanced age and other comorbid factors correlated with age-increased morbidity associated with cervical spine surgery. In one series involving 81 patients (averaging 57 years of age; range 32–88 years) with cervical spondylotic myelopathy (CSM), complications in 18.5% of cases were more prevalent in the “significantly older” patients with more comorbidities and more Classification of Diseases-Ninth Revision-Clinical Modification (ICD-9) codes.<sup>[13]</sup> In an analysis of the National Inpatient Sample, posterior approaches to the cervical spine correlated with greater morbidity and mortality rates compared with anterior surgery (posterior cervical fusion morbidity 15.35% and mortality 1.44% versus anterior cervical discectomy/fusion morbidity 4.14% and mortality 0.26%).<sup>[17]</sup> Comorbid factors that increased the complication rate included pulmonary, renal and circulatory diseases, more commonly noted in older patients. In another series involving a prospective evaluation of 119 patients undergoing cervical spine surgery, the overall complication rate was 44.5% within the initial 30 postoperative days.<sup>[2]</sup> The complication rates were highest for circumferential (66%) followed by posterior cervical surgery (49%: C5 palsy/

wound infection), and finally by anterior cervical surgery (26.8%: anterior vocal cord paresis/dysphagia).<sup>[2]</sup>

*Patients over 80 compared with less than 80 had similar complication rates in cervical spine surgery*

A contrary study involving 37 patients aged 80 or over versus 124 patients under the age of 80, undergoing decompressive surgery for CSM, found that the older patients had shorter durations of preoperative symptoms, more severe preoperative myelopathy (lower Japanese Orthopedic Association (JOA) scores, and therefore more neurologically impaired going into surgery), lower postoperative JOA scores (at 6 postoperative months: lesser recoveries), but comparable frequencies of comorbidities and postoperative complications, when compared with younger patients.<sup>[18]</sup>

*On the contrary, many spine surgeons would associate greater perioperative morbidity with anterior rather than posterior cervical surgery*

Other spinal surgeons believe that anterior cervical operations incur a higher morbidity/mortality than posterior cervical surgery. Increased comorbid risk factors attributed to anterior cervical procedures include the potential for esophageal trauma, recurrent laryngeal nerve palsy, respiratory complications attributed to tracheal edema, carotid artery injury (risk of stroke/vascular compromise), and graft-/plate-related complications, to name a few. Therefore, the observed greater morbidity seen with posterior spinal approaches in these studies must correlate with the more advanced age and greater attendant comorbid factors seen in the older/geriatric patients undergoing more extensive, multilevel posterior approaches: greater neurological compromise, more multilevel disease, more prolonged duration of symptoms, more advanced vascular, pulmonary, and other systemic disorders. An added consideration should include the notation that if posterior operations include the utilization of lateral mass or pedicle screws (not approved by the Food and Drug Administration or FDA), these devices alone may account for a significant increased risk of neural and/or vascular (vertebral artery) injuries. Alternatively, the perioperative complications attributed to laminectomies with/without attendant wire-based fusion would eliminate these “instrumentation” and “surgeon” failures.

**Conclusion:** In geriatric patients, more frequent and complex preoperative comorbid factors and the choice of operative approaches (anterior, posterior, or circumferential) may correlate with higher complication rates.

### Unnecessary spinal surgery in the geriatric age group

*“Unnecessary” spinal surgery in the geriatric age group (author's series) approached 20%*

The premise of “unnecessary” spinal surgery, as described

by Epstein and Hood, was based upon the observation that one spine surgeon may decide that a patient needs surgery, while another surgeon (e.g. a second opinion) might decide that surgery is “unnecessary.”<sup>[9]</sup> Criteria for “unnecessary” surgery included the presence of pain alone, the absence of a focal neurological deficit, and the absence of significant (abnormal) radiographic abnormalities, including X-rays (plain/dynamic), MR, and/or CT studies. The “unnecessary” category also included black discs.

In the original study, 47 (17.2%) of 274 patients seen in the office in 2010 by the first author were scheduled for “unnecessary” spinal surgery by outside surgeons.<sup>[9]</sup> Proposed “unnecessary” procedures included 21 (23.1%) of 91 anterior cervical operations, most of which involved multiple levels: 18 ADFs involving 1–4 levels (four 1-level, eight 2-level, five 3-level, and one 4-level ADF fusions), 2 multilevel laminectomy/fusions, and 1 posterior cervical discectomy. Proposed procedures also included 26 (14.2%) of 183 often multilevel lumbar operations; this included a few 1-level, but mostly 2–5 level posterior lumbar interbody fusions (PLIFs) (eleven 1-level, seven 2-level, three 3-level, four 4-level, one 5-level PLIF fusions). Furthermore, multiple major comorbidities were observed in 29 of the 47 patients averaging 50.5 years of age: hypertension (16), psychiatric disease (13), morbidly obese (10), high cholesterol (10), diabetes (8), asthma (7), and cardiac stents (3).

*Patients 65 and older and complication rates in spinal surgery*  
Reassessment of the same data addressing only patients 65 and older revealed that 7 of 47 geriatric patients were advised to have “unnecessary” spinal surgery. The three males and four females averaged 73 years of age (range 65–80 years). Two were scheduled for cervical and five for lumbar operations; one cervical and four lumbar operations involved multiple levels [Table 1]. In these 7 patients, 19 major overlapping comorbidities were noted [Table 2].

**Conclusion:** “Unnecessary” spinal surgery was recommended for 17.2% of 274 patients from all age groups seen in consultation over 1 year. Out of the 47 patients over the age of 65, 7 patients with 19 comorbidities were scheduled for “unnecessary” operations; 5 of 7 involved multiple levels.

### Too much surgery

*Sometimes too much surgery in the geriatric age group leads to 50–80% complication rates*

Extensive instrumented spinal fusions, increasingly being performed in patients 65 and older, result in higher morbidity and mortality rates. In Campbell *et al.*'s prospective analysis of 30-day postoperative morbidity associated with 128 anterior, posterior, or 360° instrumented thoracic and/or lumbar procedures,

**Table 1: "Unnecessary" spinal operations offered in 7 patients aged 65 or older**

Operations proposed	Number of patients
Cervical spine operations	
C3–C7 laminectomy/fusion	1
1-Level ADF	1
Lumbar operations	
1-Level PLIF	1
2-Level PLIF	2
3-Level PLIF	2
5-Level PLIF	1
<b>Total operations</b>	<b>7</b>

ADF: Anterior cervical discectomy and fusion, PLIF: Posterior lumbar interbody fusion

**Table 2: 19 Overlapping comorbidities in 7 patients aged 65 and older offered "unnecessary" spinal surgery**

Comorbidity	Number of patients
Osteoporosis	4
Diabetes	3
Elevated cholesterol	3
Hypertension	3
Cardiac stents	2
Obesity	2
Psychiatric disorders	1
Asthma	1
<b>Total comorbidities</b>	<b>19</b>

the following variables were correlated: the preoperative diagnosis, medical comorbidities, BMI, surgical approach, length of stay (LOS), and complications.<sup>[5]</sup> Of the 128 patients, 59.4% (76 patients) exhibited at least one complication that varied according to the operative approaches: the complication rate for anterior procedures was 83.3%, for 360° procedures it was 72.3%, while for posterior procedures it was lower (49.3%). Therefore, anterior and 360° approaches “were statistically more likely to encounter complications.”

### Increased readmission rates and costs

To compare morbidity, readmission rate, and costs, Deyo *et al.* performed a retrospective cohort analysis of Medicare claims from 2002 to 2007 (32,152 patient database) for patients undergoing lumbar decompression alone, simpler fusion (1–2 levels/one approach), or complex fusions (>2 levels and/or combined anterior and posterior surgery).<sup>[5]</sup> They found that the incidence of life-threatening complications increased from 2.3% for decompressions alone to 5.6% for complex fusions. Rehospitalization rates increased from 7.8% for decompression alone to 13% for complex fusions, while mean hospital charges increased from \$23,724 for decompression alone to \$80,088 for complex fusions.<sup>[5]</sup>

### *Complication rates of 10–56% for multilevel lumbar decompressions with and without fusion*

In Transfeldt *et al.*'s study, three surgical treatments for age-stratified patients with degenerative scoliosis and radiculopathy were evaluated with a 2-year follow-up utilizing patient-based questionnaires (SF-36, Oswestry Disability Index, Roland Morris Scores).<sup>[25]</sup> For patients undergoing decompression alone, averaging 76.4 years of age, the complication rate was 10%. For patients undergoing decompression/limited fusion (1-2 levels), averaging 70.4 years of age, the complication rate was 40%. However, for those undergoing multilevel full-curve fusions, averaging a lower 62.5 years of age, the highest complication rate of 56% was observed. Presumptively, had the average age for the latter group been higher, the complication rate would have risen even further. Notably, the less extensive procedures (decompression alone or decompression with limited fusion) yielded significant improvement on the postoperative Oswestry Disability Index, while the full fusion group did not.

### *Reoperation rates in patients over 65*

Few spinal series focus on reoperation rates (need for two or more spinal operations) for patients undergoing extensive spinal surgery/instrumentation, particularly in patients aged 65 and older. In one retrospective study of 72 patients, averaging 68.7 years of age, multilevel spinal fusions were performed in patients who were followed an average of 29.4 postoperative months.<sup>[21]</sup> Poor outcomes, based on the Visual Analog Scales and Oswestry Disability Index, were confirmed in 50% of patients. The high 50% failure and additional 34.7% reoperation rates were largely attributed to the advanced age of these patients, and their prevalence of underlying osteoporosis. Osteoporotic bone led to implant loosening in 35 patients (8 required secondary surgery), and adjacent segment degeneration in 26 patients (17 required additional surgery). This study called for less extensive instrumentation in older patients with spondylosis and osteoporosis.

In another study comparing primary versus revision posterior thoracic/lumbar spinal fusions, those having primary procedures were younger (averaging 51.23 years), had fewer average comorbid factors, and a 13.44% complication rate versus those having revision procedures who were slightly older (averaging 52.69 years) patients with average comorbid factors, who exhibited more procedure-related complications (16.02%).<sup>[15]</sup>

### *Reoperation rates in the cervical spine*

Reoperation rates for those undergoing cervical surgery differ. In a retrospective cohort evaluation of Washington State's 1998–2002 in-patient databases utilizing ICD-9 codes involving 12,338 cervical spine cases followed for an average of 2.3 years, the reoperation rate was a much lower 5.6% (688 patients).<sup>[14]</sup> Those requiring secondary surgery typically had underlying disc disease

with myelopathy, but unlike many of the thoraco-lumbar series, were younger. Furthermore, anterior fusions correlated with lower reoperation rates, while posterior approaches led to higher reoperation rates, longer lengths of stay, and greater hospital costs/charges.

### *Use of INFUSE*

*Instrumented fusions with INFUSE used “on” or “off-label” (author's series):* Extensive instrumented fusions are increasingly being performed in all age groups utilizing INFUSE (Bone Morphogenetic Protein, Medtronic, Memphis TN, USA) either “on-label” or “off-label.” In an earlier study, we focused on patients from all age groups undergoing 177 spinal fusions (cervical, thoracic, lumbar including anterior, posterior, and 360 procedures) utilizing INFUSE at one institution in 2010 either “on-label” or “off-label.”<sup>[10]</sup> The “on-label” use, or FDA-approved use of INFUSE, occurs when it is combined with type I collagen in a Lumbar Tapered Fusion Cage (LT-Cage, Medtronic, Memphis, TN, USA) to perform anterior lumbar interbody fusions (ALIF). Although it is commonly acknowledged that INFUSE is used “off-label” (e.g. in a non-FDA approved fashion), our study documented a 96% (170/177) incidence of “off-label” use, while only 4% (7/177) was utilized for “on-label” ALIF.<sup>[10]</sup>

*INFUSE, patient age and complications:* The same database was reassessed looking only for patients 65 years of age or older.<sup>[10]</sup> We found that 36 (20.3%) out of the original 177 patients undergoing instrumented fusions utilizing INFUSE were in the geriatric age group [Table 3].<sup>[10]</sup> These 36 patients averaged 72 years of age (range 65–85 years) and included 22 males and 14 females. The long duration of surgery confirmed the extensive nature of most of these procedures: average operating room time of 6.3 hours (range 3.5–12 hours). Notably, only 1 (2.7%) procedure was an “on-label” ALIF, while 35 (97.2%) were “off-label” operations. The latter included (typically multilevel) 15 thoracic and/or lumbar laminectomies/fusions (TLF), one 360 anterior/posterior thoracolumbar fusions (360 TLF), 11 posterior lumbar interbody fusions (PLIF), 7 transforaminal lumbar interbody fusions (TLIF), and 1 extreme lateral interbody fusion (XLIF) [Table 3].

*INFUSE and reoperation rates and costs in geriatric aged patients:* Two or more operations (reoperations) were required in 15 (41.7%) of these 36 patients aged 65 and older [Table 4]. Ten reoperations included 3 or more level fusions, while the remaining five reoperations consisted of 1–2 level fusions. To reduce this high reoperation rate in the future, improved patient selection, particularly avoiding geriatric patients with significant osteoporosis and other major comorbidities, plus eliminating or limiting the use of INFUSE with its reported complications (e.g. seromas, hematomas, etc.), would be warranted.<sup>[8]</sup>

For 36 patients aged 65 and older, there were also significant costs incurred by performing single or multiple spinal instrumented fusions utilizing INFUSE [Table 5].<sup>[10]</sup> The total cost of INFUSE was \$908,066, with an average per case cost of \$25,024. Only the total cost of screws (\$1,324,319) exceeded the cost of INFUSE. Other costs, which were not far behind, included allograft spacers (\$820,006), cages (\$876,995), and bone graft supplements (\$357,712) [Table 5].

**Conclusion:** Sometimes too much surgery, particularly extensive instrumented spinal fusions, increases the

morbidity and mortality rates for patients 65 and older. The additional use of INFUSE “off-label” also increases perioperative morbidity (e.g. seromas) and likely contributes to the need for secondary operative intervention.

### Minimally invasive surgery, age and complication rates

#### *Sometimes too little surgery in the geriatric age group*

One of the biggest problems in evaluating morbidity and mortality associated with MIS spinal surgery, including the application of interspinous process fusion devices, microendoscopic procedures, or percutaneous pedicle screw fixation, is the paucity of negative reports or reports of complications in the spinal literature. This may be attributed to several factors; the medicolegal exposure, as cases reported in the literature can be utilized against the author(s) in a US court of law, the lack of incentive to publish negative data (reflecting the source of grant support or cultural bias), and perhaps most critically, many complications occur within the much larger “community” of spinal surgeons, outside university settings, where they are more apt not to be reported/published in the literature.

#### *Use of X-STOP*

Several instances of complications associated with placing the X-STOP device in older patients have been reported. Two studies revealed complications occurring in geriatric patients undergoing three minimally invasive (outside) spinal procedures: the application of interspinous process devices, microendoscopic procedures, and

**Table 3: Initial instrumented spinal fusions utilizing INFUSE and subsequent reoperation rates for 36 patients aged 65 and older**

Operation type with INFUSE	"On-label" or "off-label"	Number of patients (1 <sup>st</sup> surgery)	Reoperations (two or more Operations)	Levels of reoperations (two or more)
TLF*	Off-label	15	7	Multiple levels
ALIF	On-label	1	1	3
360 TLF	Off-label	1	1	ALIF 2-level TLF 9-level
PLIF	Off-label	11	4	1 1 2 3
TLIF	Off-label	7	1	1
XLIF	Off-label	1	1	2

TLF: Thoracic and/or lumbar laminectomy/fusion, 360 TLF: Anterior and posterior instrumented thoracic and/or lumbar fusion, ALIF: Anterior lumbar interbody fusion, PLIF: Posterior lumbar interbody fusion, TLIF: Transforaminal lumbar interbody fusion, XLIF: Extreme lateral interbody fusion

**Table 4: Frequency and levels of reoperations performed in 36 patients aged 65 years or older undergoing initial instrumented spinal fusions utilizing INFUSE**

Variable	Number of patients
Reoperation (two or more operations) rate	15 (41.7%) of 36
3 or More level fusions	10
1–2 Level fusions	5
3 Or more level geriatric reoperations	10 cases
T10–S1/2-level ALIF	1
T10–L5	1
T11–S1	1
L2–S1	3
L3–S1	3
L2–L5	1
1–2 Level geriatric reoperations	5 cases
L4–S1	1
L2–L4	1
L2–L3	1
L4–L5	1
L5–S1	1

**Table 5: Costs specifically incurred for performing 36 geriatric instrumented fusions utilizing INFUSE**

Variable	Costs of fusion materials
INFUSE total costs	\$908,066
Average INFUSE cost/case	\$25,024
Total cost of screws	\$1,324,219
Average cost screws/case	\$40,131
Range screws/case	4–18
Costs of other fusion products	\$1,427,504
Allograft spacer	\$820,000
Rods	\$160,933
3D heads	\$65,901
Locking caps	\$30,976
Screw sets	\$139,190
Connectors	\$115,437
Crosslink's	\$25,527
Blockers	\$69,540
Cost of 1–7 cages used in 12 cases	\$876,995
Additional bone supplements used	\$357,712
Allograft bone chips	\$2,134
Demineralized bone matrix (5 types)	\$123,444
Beta tricalcium phosphate	\$193,806
Silicated calcium phosphate	\$38,328

percutaneous instrumented fusions (MIS).<sup>[6,7]</sup> In the first study, two patients, aged 81 and 65 years, each with two major comorbid factors (hypertension/depression, and hypertension/diabetes), underwent the placement of X-STOP devices (Medtronic); both developed infections that required multiple weeks of postoperative intravenous antibiotics.<sup>[6]</sup> A third patient, over 70 years old, with six major comorbid factors [diabetes, hypertension, atrial fibrillation, mechanical mitral and aortic valve replacements (on Warfarin), and peripheral vascular disease] had a two-level L3–L4 and L4–L5 X-STOP placed for stenosis. Within a few days, Warfarin was restarted because of the mechanical heart valves. He developed a cauda equina syndrome attributed to a hematoma that was removed on postoperative day 9; unfortunately, he remained severely paraparetic. One questions why this patient had surgery in the first place.<sup>[6]</sup> In a second study, an 83-year-old male with three major comorbidities (hypertension, diabetes, severe osteoporosis) had an X-STOP placed at an outside hospital at the L4–L5 level to address severe stenosis.<sup>[7]</sup> Immediately postoperatively, he developed a bilateral complete foot drop. No emergency laminectomy was performed. The device was left in place until it extruded 3 months later; the device was then removed, but they still did not perform a laminectomy. Nine months following the original surgery, a second surgeon performed an L4–L5 laminectomy and the patient recovered partial function.

Similar problems with the X-STOP device have been reported by Bowers *et al.*<sup>[11]</sup> They evaluated nine patients with severe spinal stenosis and four with moderate stenosis (including 5 with grade I spondylolisthesis), who had X-STOP (Medtronic) devices placed at the L4–L5 (9 patients) and L3–L4/L4–L5 levels (4 patients); patients were followed an average of 43 months.<sup>[11]</sup> Post-procedure, 77% of patients complained of recurrent pain, while a 38.4% complication rate was observed: 3 spinous process fractures and 2 cases of new radiculopathy/neurological deficit. Based on the morbidity from this study, the authors recommended avoiding over-distraction, avoiding patients with poor bone density, and avoiding those with severe foraminal stenosis.

#### *Microendoscopic procedures and age*

More typically, positive rather than negative reports concerning MIS microendoscopic procedures are published. One positive study directly compared open surgical decompression (26 patients) versus MIS microendoscopic techniques (23 patients) to treat patients with neurogenic claudication at one institution.<sup>[23]</sup> Multiple variables were assessed; average age, number of levels, preoperative ASA status, morbidity, mortality, LOS, and postoperative disposition. Despite “slightly longer operative times” associated with MIS, these procedures were attended by less blood loss, shorter LOS, and less use of “support services” on discharge.

Alternatively, a study citing negative outcomes following microendoscopic (MIS) procedures included four patients, all under the age of 65.<sup>[6]</sup> In two cases, the surgeon missed the disc herniation (one far lateral, the other a routine disc was missed but a cerebrospinal fluid leak was created), a postoperative infection was missed in a third case, while a massive cerebrospinal fluid fistula was missed in the fourth case, resulting in a permanent cauda equina syndrome.

#### *Extreme lateral interbody fusions*

Another study reported the advantages of XLIFs performed in patients 80 years of age or older.<sup>[20]</sup> Forty had single-site XLIF performed prospectively versus 20 who had previous open PLIF procedures. No clinically significant differences were noted in clinical data, diagnosis, and comorbidities between the two groups. The complication rate, blood loss/transfusion rate, and LOS were significantly lower in the MIS XLIF group who also left the hospital an average of 4 days earlier than patients having PLIF. Nevertheless, the author reviewed an outside case involving a high thoracic/lumbar XLIF that resulted in a severe hemiparesis and a cerebrospinal fluid fistula; secondary surgery was required to repair the durotomy, but the deficit failed to resolve. There must a number of similar cases that remain unreported.

There are the studies that emphasize the need for technical expertise before utilizing MIS approaches. The study of Selznik, Shamji, and Isaacs reported MIS interbody fusions, including the use of percutaneous screw placement (TLIF, PLIF) for revision lumbar surgery.<sup>[22]</sup> Their study included 43 consecutive MIS TLIF and PLIF procedures, performed primarily (60%) versus secondarily (40%). More durotomies were reported for “revision” cases involving both PLIF and TLIF patients. Despite this, they noted, “no patients had a major complication,” but added the warning that “these outcomes demand significant experience before attempting minimally invasive revision surgery in the lumbar spine.”<sup>[22]</sup> Perhaps reflecting a greater lack of expertise with the percutaneous placement of pedicle screws in the surgical “community,” two females over the age of 65, with multiple comorbidities, recently underwent (outside) L4–L5 microendoscopic decompressions with bilateral percutaneous pedicle/screw fusions, resulting in unilateral, immediate postoperative foot drops (personal communication).

**Conclusion:** Sometimes too little or minimally invasive spine procedures, including application of interspinous process fusion devices (e.g. X-STOP), microendoscopic procedures, or percutaneous pedicle screw fixation, increase the morbidity and mortality for patients in the geriatric age group. Nevertheless, we cannot discount the fact that surgeon inexperience, lack of judgment, and poor patient selection likely contribute to these high “anecdotal” complications.

## CONCLUSIONS

The frequency of spinal surgery, in general, and instrumented fusions, in particular, in the USA, has markedly increased over the past few decades, particularly in the geriatric age group.

We have to critically reassess why more patients aged 65 and older are undergoing increasingly frequent and extensive spinal procedures, including multilevel-instrumented fusions. For these older individuals, with more attendant major comorbid factors, careful consideration of perioperative risks versus postoperative benefits may prompt a reduction in the number, extent, and cost of these procedures. We need to better select patients and more stringently monitor our operative criteria, so that “unnecessary” procedures, those performed in patients with pain alone but no neurological deficits or radiographic abnormalities, could be avoided. When we choose patients for surgery, these decisions should be age- and comorbidity-appropriate, avoiding “too much” (instrumented fusions) as well as “too little” (e.g. MIS) surgery where feasible.

Presently, there is a critical “epidemic” of spine surgery in the USA and it is having a great “negative” impact on patients aged 65 and older. As these “patients” may be our parents, and/or ourselves, or our progeny now or in the future, we need to be proactive in containing this “contagion.”

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