The impact of BMI on operating room time, blood loss, and hospital stay in patients undergoing spinal fusion

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\textbf{ABSTRACT}

Objective: Obesity affects not only the health of an individual but society as a whole and especially the healthcare system. Healthcare providers are faced with challenges to deliver adequate care in this resource-limited environment, assure safety, and accommodate the increasing population of overweight patients. The effects of increased body mass index (BMI) on clinical outcomes, complications, health care resource utilization, effectiveness of minimally invasive approaches, and perioperative parameters in spine surgeries have all been previously studied, but the majority of these findings are conflicting rather than conclusive. The main objective of this study was to analyze the impact of BMI on perioperative outcomes in patients undergoing one- to two-level elective TLIF procedures for degenerative spine conditions and to identify the need to modify internal hospital operational planning, team organization, and patient flow processes to accommodate patients who are overweight.

Patients and methods: A single-center retrospective case-review study was completed. The study included 172 consecutive patients who underwent elective one- or two-level transforaminal lumbar interbody fusions (TLIF). The patients were categorized as obese if they had BMI value that was equal to or greater than 30 kg/m\textsuperscript{2}. Outcome measures included surgical and non-operative operating room (OR) time, length of stay (LOS), and estimated blood loss (EBL). Multiple regression analyses were performed to determine if BMI had an effect on perioperative parameters while controlling for independent variables.

Results: BMI did not have a statistically significant effect on surgical (\(p = 0.13\)) and non-operative OR time (\(p = 0.82\)). Obese patients remained hospitalized on average 0.45 ± 0.25 days longer (\(p = 0.037\)) and lost 71.8 ± 26.3 mL more blood (\(p = 0.007\)).

Conclusions: Obesity is associated with longer hospitalization and more intraoperative blood loss, but may have no impact on surgical and non-operative OR times in patients undergoing one- and two-level TLIFs.

1. Introduction

According to Centers for Disease Control and Prevention, the prevalence of obesity is 36.5\% among adults in the U.S. with even higher rates among middle age and older adults [1]. Obesity affects not only the health of an individual but the society as a whole and especially the healthcare system. An annually economic impact was estimated to be 2 trillion dollars globally [2] and more than $190 billion in the U.S [3]. Healthcare providers are faced with challenges to deliver adequate care in this resource-limited environment, assure safety, and accommodate the increasing population of overweight patients [4–7]. A 33\% increase in obesity prevalence is expected by 2030 [8].

Samartzis et al. [9] have previously studied the role of obesity and five pathomechanisms responsible for low back pain in overweight patients, including excessive compressive loading, vascular insufficiency, inflammatory response, metabolic disorder, and gene-environment interaction. Overweight patients therefore have a higher prevalence of low back pain [10,11] and spinal conditions that require multiple surgeries [12].

The effects of increased BMI on clinical outcomes [13–17], complications [13,14,18–22], utilization of health care recourses [23], the effectiveness of minimally invasive approach [24,25], and perioperative parameters [14,16,17,22,26–30] in spine surgeries have been previously studied. However, the majority of these findings are conflicting rather than conclusive. The main objective of this study was to analyze the impact of BMI on perioperative outcomes in patients...
undergoing one- to two-level elective TLIF procedures for degenerative spine conditions and to identify the need to modify internal hospital operational planning, team organization, and patient flow processes to accommodate patients who are overweight.

2. Patients and methods

A single-center retrospective case-review study was completed and included 172 consecutive patients who underwent elective one- or two-level TLIFs between 2011 and 2018 at a community hospital in Colorado. Only lumbar spine (L1–S1) surgeries performed for a diagnosis of symptomatic degenerative disc disease conditions, including spinal stenosis and spondylolisthesis, were included. All patients underwent open TLIF procedures with bilateral pedicle screw placement using three-dimensional image guidance.

The patients were categorized as obese if they had BMI value that was equal to or greater than 30 kg/m². The other variables analyzed in this study include age, gender, previous surgeries, American Society of Anesthesiologists (ASA) score, number of fusion levels, complications, surgical and non-operative OR time, EBL, and LOS. Surgical time was defined as incision to closure time and non-operative OR time included patient arrival, positioning, preparation, anesthesia time, and time through the patient leaving the operating room.

2.1. Statistical analysis

Chi-square analysis was used to compare categorical values and Student’s t-test was performed to differentiate between continuous variables. Multiple regression analysis was performed to determine if BMI had an effect on the outcomes of interest including surgery and non-operative OR time, EBL, and LOS while controlling for independent variables.

3. Results

A group comparison and selected baseline demographic and clinical characteristics are presented in Table 1. Fifty-three (30.8%) patients had BMI ≥30, including 30 patients who were moderately obese (30–35), 15 severely obese patients (35–40), 7 very severely obese patients (40–45), and one morbidly obese patient (45–50). In the comparison group of 119 (69.2%) patients, one patient was severely underweight (16–18.5), 63 patients had healthy weight (18.5–25), and 54 patients were overweight (25–30).

### Table 2

<table>
<thead>
<tr>
<th>Multiple regression analysis - surgery time. ASA - American Society of Anesthesiologists; BMI – body mass index; SEM - standard error of the mean.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate (min)</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>BMI 10.6</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Female gender</td>
</tr>
<tr>
<td>Previous decompression 0.07</td>
</tr>
<tr>
<td>Previous fusion 21.8</td>
</tr>
<tr>
<td>Two-level surgeries 59.0</td>
</tr>
<tr>
<td>Complications 13.8</td>
</tr>
<tr>
<td>ASA score 2 5.6</td>
</tr>
<tr>
<td>ASA score 3 4.2</td>
</tr>
<tr>
<td>ASA score 4 −52.1</td>
</tr>
<tr>
<td>Surgeon −62.7</td>
</tr>
<tr>
<td>163.0</td>
</tr>
</tbody>
</table>

The two groups were comparable in terms of demographic and clinical patient parameters with the exception of ASA scores, which were highly statistically significant (p < 0.0001). Although BMI is directly reflected in ASA scores, obese patients had a significantly higher comorbidity burden. Student t-tests revealed that EBL (p = 0.019) and LOS (p = 0.003) were significantly higher in the BMI > 30 kg/m² compared with the BMI < 30 kg/m² patient group. However, non-operative OR and surgical times were not different between the groups.

### Table 1

<table>
<thead>
<tr>
<th>Selected demographic, clinical parameters, and surgical characteristics. Values are presented as means with standard deviations or percentage in parentheses. Student t-tests were used for all calculations comparing the two groups except where noted (*), in which a chi-square test was performed. ASA - American Society of Anesthesiologists; BMI – body mass index; F- female; M – male, TLIF – transforaminal lumbar interbody fusion.</th>
<th>Total</th>
<th>BMI &lt; 30</th>
<th>BMI ≥30</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients (n)</td>
<td>172</td>
<td>119 (69.2%)</td>
<td>53 (30.8%)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI 27.9 ± 5.9 (15-47)</td>
<td>24.8 ± 3.1</td>
<td>34.9 ± 4.5</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>Age 64.0 ± 12.2</td>
<td>65.0 ± 11.4</td>
<td>64.0 ± 12.1</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>F/M ratio 83/89</td>
<td>56/63</td>
<td>27/26</td>
<td>&lt; 0.0001</td>
<td></td>
</tr>
<tr>
<td>ASA score 2.4 ± 0.61</td>
<td>2.21 ± 0.58</td>
<td>2.74 ± 0.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous surgeries None</td>
<td>136 (79.1%)</td>
<td>91 (76.5%)</td>
<td>45 (84.9%)</td>
<td>0.37*</td>
</tr>
<tr>
<td>Decompression</td>
<td>30 (17.4%)</td>
<td>24 (20.2)</td>
<td>6 (11.3%)</td>
<td></td>
</tr>
<tr>
<td>Fusion 6 (3.5%)</td>
<td>4 (3.3%)</td>
<td>2 (3.8%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TLIF levels 1.5 ± 0.5</td>
<td>1.5 ± 0.5</td>
<td>1.4 ± 0.5</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>One-level 91 (52.9%)</td>
<td>61 (51.2%)</td>
<td>30 (56.6%)</td>
<td>0.62*</td>
<td></td>
</tr>
<tr>
<td>Two-level 81 (47.1%)</td>
<td>58 (48.7%)</td>
<td>23 (43.4%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intraoperative complications 2 (1.2%)</td>
<td>1 (0.8%)</td>
<td>1 (1.9%)</td>
<td>0.52*</td>
<td></td>
</tr>
<tr>
<td>Surgery time 178.4 ± 50.9</td>
<td>177.5 ± 52.6</td>
<td>180.4 ± 47.2</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>Non-operative OR time 60.3 ± 17.7</td>
<td>59.3 ± 16.8</td>
<td>62.7 ± 19.6</td>
<td>0.26</td>
<td></td>
</tr>
<tr>
<td>EBL 197.2 ± 125.2</td>
<td>179.0 ± 120.8</td>
<td>238.1 ± 203.1</td>
<td>0.019</td>
<td></td>
</tr>
<tr>
<td>LOS 3.0 ± 1.65</td>
<td>2.7 ± 1.5</td>
<td>3.6 ± 1.9</td>
<td>0.003</td>
<td></td>
</tr>
</tbody>
</table>

The BMI did not have a statistically significant effect on surgical time (p = 0.13) as surgeries on obese patients lasted an average of 10.6 ± 7 min longer compared to non-obese patients (Table 2). The following factors were found to be statistically significant: two-level surgeries (< 0.00001) added an average of 59 ± 6 min and surgical times varied significantly (p < 0.00001 to p = 0.2) depending on the surgeon: -62.7 ± 37.4–163.0 ± 37.6 min. Although not statistically significant, previous fusion surgeries added 21.8 ± 16.7 min to surgery time (p = 0.19) and patients with ASA scores of 4 tended to have shorter surgeries by 52.1 ± 31.3 min on average (p = 0.09).

Similarly, BMI did not have a statistically significant effect (p = 0.82) on non-operative OR time (Table 3), however, depending on the surgeon it varied from -24.6 ± 15.7 min to 11.5 ± 8.0 min.
Obese patients remained hospitalized an average of 0.45 ± 0.25 days longer than non-obese patients (Table 4), which was statistically significant (p = 0.23). Obese patients who were undergoing fusion surgery were obese, which is consistent with the fact that obesity represents a risk factor for back pain associated with degenerative disc disease.

We analyzed perioperative outcomes in a well-defined patient population undergoing one- to two-level TLIF surgeries for symptomatic degenerative disc disease conditions including spinal stenosis and spondylolisthesis. Statistical analysis revealed that BMI did not have any effect on surgical or non-operative OR time, rather other factors were responsible for the increase including two-level surgeries, surgeon, or ASA scores. Surgical OR times were significantly shorter for procedures performed by spine fellowship-trained surgeons. Although other authors reported contradicting results demonstrating that higher BMI does increase surgical times, they analyzed microdiscectomies, anterior lumbar interbody fusions, included various surgical procedures, or did not differentiate between open and minimally invasive approach, did not control for surgical procedures or the number of levels, or comprised a very small cohort of patients. Several studies did, however, utilize large databases and reported that BMI was associated with significant increases in surgical time.

Multiple regression analysis demonstrated a statistically significant increase in EBL and LOS when comparing obese and non-obese patients. Controlling for other sources of variability revealed that EBL was also affected by surgeon and the number of surgical levels, whereas LOS was affected by complications, ASA scores, the number of surgical levels, individual surgeon preferences, and even female gender. Some studies were in agreement that higher BMI increases LOS and EBL, but these authors mainly focused on clinical outcomes or complications and did not account for potential confounding variables. Interestingly, the authors that specifically analyzed LOS and EBL in obese patients undergoing spinal surgeries reported no differences. Andreshak et al. reported no statistically significant differences in EBL or LOS for obese compared with non-obese patients undergoing lumbar fusion surgeries: 1027 mL vs. 1064 mL and 6.5 vs. 6.4 days, respectively. However, the authors did not account for potential confounding factors, the most important being surgical levels, which may have caused an underestimation of the effect. In addition, the reported EBL and LOS values significantly exceeded values reported in our study. Similar results with very high amounts of blood loss and no statistically significant differences were presented by Vaidya et al. but the authors compared obese vs. morbidly obese patients.

4.1. Limitations

The main limitation of our study was that although we analyzed a well-defined patient cohort consisting of 172 patients, the study might still be underpowered to detect the surgical and non-operative time differences, especially since only 30.8% of patients in our study were obese with a mean BMI of 34.9. The small number of severely obese patients adds further caution regarding the generalizability of these findings. In addition, other factors that were not analyzed in this study may influence the outcomes including the pathology itself, grade of the spinal canal or foraminal stenosis, severity of lysis, bone density for screw placement, or intervertebral distraction during cage placement.

(p < 0.00001 to p = 0.64). ASA scores of 4 added 15.9 ± 13.1 min on average but this was not statistically significant (p = 0.23). ASA scores of 4 added 15.9 ± 13.1 min on average but this was not statistically significant (p = 0.23).
Notwithstanding the limitations and that generalizability of these results to other spine procedures and the impact to cost and resource utilization should be explored further, the results of this study provide a comprehensive evaluation of the effect that BMI imposes on perioperative outcomes.

5. Conclusions

Obesity was associated with longer hospitalization and more intraoperative blood loss, but may have no impact on surgery and nonoperative OR times in patients undergoing one- and two-level transforaminal lumbar interbody fusions.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Acknowledgments

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References

[31] residents B.