

A review article on the benefits of early mobilization following spinal surgery and other medical/surgical procedures

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Abstract

Background: The impact of early mobilization on perioperative comorbidities and length of stay (LOS) has shown benefits in other medical/surgical subspecialties. However, few spinal series have specifically focused on the “pros” of early mobilization for spinal surgery, other than in acute spinal cord injury. Here we reviewed how early mobilization and other adjunctive measures reduced morbidity and LOS in both medical and/or surgical series, and focused on how their treatment strategies could be applied to spinal patients.

Methods: We reviewed studies citing protocols for early mobilization of hospitalized patients (day of surgery, first postoperative day/other) in various subspecialties, and correlated these with patients’ perioperative morbidity and LOS. As anticipated, multiple comorbid factors (e.g. hypertension, high cholesterol, diabetes, hypothyroidism, obesity/elevated body mass index, hypothyroidism, osteoporosis, chronic obstructive pulmonary disease, coronary artery disease and other factors) contribute to the risks and complications of immobilization for any medical/surgical patient, including those undergoing spinal procedures. Some studies additionally offered useful suggestions specific for spinal patients, including prehabilitation (e.g. rehabilitation that starts prior to surgery), preoperative and postoperative high protein supplements/drinks, better preoperative pain control, and early tracheostomy, while others cited more generalized recommendations.

Results: In many studies, early mobilization protocols reduced the rate of complications/morbidity (e.g. respiratory decompensation/pneumonias, deep venous thrombosis/pulmonary embolism, urinary tract infections, sepsis or infection), along with the average LOS.

Conclusions: A review of multiple medical/surgical protocols promoting early mobilization of hospitalized patients including those undergoing spinal surgery reduced morbidity and LOS.

Key Words: Decreased cost, early mobilization, length of stay, prehabilitation, reduced morbidity, rehabilitation, spinal surgery

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INTRODUCTION

A review of multiple studies' early mobilization protocols, involving hospitalized medical/surgical patients, indicates getting out of bed "early" (e.g. out of bed the day of surgery [OOBDS] or the first postoperative day or soon thereafter (OOBFD)) reduces perioperative morbidities and length of stay (LOS) [Table 1]. Risks of perioperative complications (morbidity/mortality) increase with the number of attendant comorbid factors including; hypertension, diabetes, obesity/elevated body mass index (BMI), hypothyroidism, osteoporosis, chronic obstructive pulmonary disease (COPD), coronary artery disease (CAD) and other factors. If early mobilization

protocols "work", then the incidence of various perioperative/postoperative complications should be reduced (e.g. deep venous thrombosis (DVT)/pulmonary embolism (PE), pneumonia (PN)/atelectasis (AT), urinary tract infections (UTIs), sepsis, myocardial infarction (MI), stroke(S), , and others). The reduction of the LOS also decreases attendant hospital costs, while freeing up beds for other patients (increasing hospital revenue).

Reinventing the culture of postoperative care

Here we reassess the "culture" surrounding early mobilization of medical/surgical intensive care unit (ICU) patients and/or those who have recently undergone spinal

Table 1: Reviewing benefits of early mobilization

Topic	Summary
Introduction	A review of multiple studies' early mobilization protocols, involving hospitalized medical/surgical patients, indicates that early mobilization of hospitalized patients (e.g., out of bed the day of surgery (OOBDS), the first postoperative day (OOBFD), or soon thereafter) should reduce perioperative morbidities and length of stay (LOS).
Reinventing the culture of postoperative care	Instigating early mobilization protocols, requires changing our hospital culture to get patients OOBDS, the first postoperative day (OOBFD), or as soon as feasible, to decrease both morbidity and LOS.
Role of prehabilitation, protein drinks, and earlier rehabilitation in improving outcomes and reducing LOS in spine surgery	Utilizing both prehabilitation and early rehabilitation yielded better outcomes and shorter LOS in patients undergoing lumbar decompression for degenerative disease. ^[15] This study raises major issues that we all fail to address, the first of which is the poor nutritional status especially of many of our older (geriatric) patients. Using protein drinks the day before surgery and continuing it afterward is an excellent idea, and probably should be started even earlier. Preoperative prehabilitation and better pain control is also a great idea, but may be more difficult to institute (e.g., time, money). Here too, as in other studies, early postoperative mobilization also contributed to better outcomes and shorter LOS.
Benefits of early mobilization in spinal surgery	Early spinal surgery and postoperative mobilization are both critical to the optimal management of patients following spinal cord injury. ^[18] Prolonged bed rest was associated with the greatest number of complications.
Early mobilization of spinal cord injury patients: Decreased morbidity and LOS	Early tracheostomy for patients undergoing anterior cervical surgery for a spinal cord injury allowed for early mobilization that decreased the complication rate while not increasing the incidence of wound/instrumentation infections (< 1%). ^[2]
Early tracheostomy allows for early mobilization following acute spinal cord injuries, and decreases morbidity and LOS	Mobilizing patients undergoing TKR or THR the day of surgery vs. the first postoperative day was both safe and effective, and significantly reduced the LOS for more than 70% of patients. ^[16]
Benefits of early mobilization in other medical/surgical subspecialties	For children undergoing lung resections, Kaminski <i>et al.</i> , documented the benefits of early respiratory therapy (mask positive expiratory pressure, expiratory rib cage compression, coughing) and physiotherapy vs. controls; the study patients exhibited fewer instances of atelectasis, vs. more children in the control group required postoperative fiberoptic bronchoscopy. ^[12]
Early mobilization (day of surgery) decreases LOS For Total joint replacement (TJR) surgery	Utilization of a "Mobility Team" (critical care nurse, nursing assistant, and physical therapist) to start earlier physical therapy in a respiratory ICU setting proved to get patients out of bed earlier (average 5 vs. 11 days), resulted in more frequent therapy in the ICU (91% vs. 13%), correlated with lower complication rates, and shorter LOS in the ICU (5.5 vs. 6.9 days), and overall hospital LOS (11.2 vs. 14.5). ^[13]
Benefits of respiratory therapy and early physiotherapy for children undergoing lung resections	For adult cardiac patients undergoing surgery in the Zhu <i>et al.</i> study, the impact of fast-track cardiac care was specifically aimed at early extubation (hence early mobilization) to reduce the LOS in intensive care units (ICU), and thereby reduce the total hospital LOS; fast-track care did reduce LOS in the ICU, but not in the hospital (e.g., still a cost savings). ^[19]
Early ICU mobility therapy minimizes LOS for adults with respiratory failure	
Impact of fast-track cardiac care including early extubation and early mobilization on mortality, morbidity, LOS, and cost	

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Table 1: Continued

Topic	Summary
Benefits of early mobilization of intensive care unit patients on mechanical circulatory support following cardiac surgery	Freeman <i>et al.</i> previously observed that following cardiac surgery, ICU patients on mechanical circulatory support were kept in bed. ^[10] In this study, the institution of early extubation and early mobilization on the day of surgery (e.g., including range of motion exercises, dangling at the bedside, out of bed (OOB) to a chair) or the first postoperative day (e.g., including OOB to chair 2-3 times/day, and walking in the room/hall) reduced the complication rate and LOS.
Better recovery following bariatric surgery utilizing early mobilization	Utilization of the ERABS protocol for patients undergoing different types of bariatric procedures proved safe/effective, carried a low morbidity (4.4% mostly respiratory) and mortality rate (1 patient: PE), acceptable LOS (average 0.69-2.3 days), and low (2.7%) 30-day readmission rate. ^[11] Despite multiple comorbid factors, an ERABS protocol could be effectively applied in bariatric patients.
Physician accountability in reducing costs and/or LOS increases surgeons' awareness of costs of implanted vs. Explanted ("wasted") instrumentation for single-level anterior discectomy and fusion (ACDF)	Operative waste/explanted devices occurred in 24 (27.6%) patients, and cost an additional \$32,850, or 9.2% of the total cost of all implanted devices. ^[8]
Surgeon education reduces the cost/frequency of explantation for single level ACDF at one institution	Waste/explantation, or the cost of instrumentation placed during single level ACDF but removed prior to closure, was reduced in 2010 through surgeon education from 20% to 5.8%. ^[9]
Reduction of unnecessary LOS while improving care by making physicians accountable	Caminiti <i>et al.</i> observed more than 20% of hospital LOS is inappropriate, wastes resources, and increases iatrogenic risk. ^[5] In a randomized controlled trial involving 12 wards and 3498 patients, a physician-physician protocol was introduced to reduce unnecessary LOS without impacting quality of care (e.g., readmission rates/mortality). The strategy of direct physician-physician accountability successfully reduced unnecessary LOS without impacting outcome quality (readmission rates/mortality).
Major factors impacting hospital costs for spinal surgery Hospital costs attributed to extent of neuromuscular scoliosis surgery	The hospital, operating room, and hospital bed/stay costs of performing "neuromuscular scoliosis" (NMS) surgery in 74 patients were predominantly attributed to more extensive disease/more total levels fused, and increased LOS. ^[7]
Endocrine abnormalities (diabetes, hypothyroidism) increase LOS for patients undergoing spinal surgery	HbA1c elevation (DM) and hypothyroidism together increase LOS and hospital costs particularly for females undergoing lumbar/decompression/fusion. ^[17] For hypothyroid females, aged 70 and over, there is a further increase in LOS/hospital costs associated with anterior cervical fusions.
Complications (based on comorbidities) and optimal selection of patients impacts LOS for patients undergoing spine surgery	Bekelis <i>et al.</i> developed a "validated model for outcome prediction" based on individual patient characteristics using a NSQUIP database (2005-2010) that included patients undergoing 2719 anterior approaches (19.9%), 565 corpectomies (4.1%), and 1757 fusions (12.9%). ^[3] The 30-day postoperative complication rate included "0.05% for stroke, 0.2% for MI, 0.25% for death, 0.3% for infection, 1.37% for UTI, 0.6% for DVT, 0.29% for PE, and 3.15% for return to the operating room."
Can the frequency of complications following spine surgery, which lengthen LOS, be predicted?	
Obese class III spinal patients increase complications and LOS for spinal surgery	Utilizing the ACS-NSQIP database (2005-2010), consisting of 10, 387 patients undergoing different types of fusions/decompressions/discectomies, those with class III (≥ 40 kg/m ² : 6.9%) obesity had higher complications rates (wound, urinary, pulmonary complications), required longer operative times, and exhibited longer LOS. ^[4] The authors recommended; "surgeons should be aware of the increased risk of multiple complications for class III obese patients with BMI ≥ 40 kg/m ² ."
Timing of cervical surgical admission significantly impacts LOS	Patients admitted over the weekend, whether undergoing ACF, PF, or ACPF for cervical trauma exhibited longer LOS and total hospital costs when compared with patients with similar trauma admitted during the week. ^[14] Notably, ACF patients treated on the weekend had significantly higher wound infection rates, cardiac complications, and urinary tract infections. Of interest, there was no difference in the mortality rates for any of the procedures within the different cohorts.
Outcomes of cervical trauma surgery based on weekday vs. weekend admissions	
Reduction of LOS and costs in other surgical specialties Prophylactic gastrostomy for head and neck cancer	When Hughes <i>et al.</i> evaluated 165 patients with head/neck cancer undergoing chemotherapy/radiation, preventive gastrostomies significantly decreased hospital admissions/readmission, and LOS, thereby reducing cost and increasing bed availability (increasing income). ^[11]
Increased Morbidity/Mortality and LOS Attributed to Sepsis: A Reason to Curtail Unnecessary Hospitalization	In the de Kraker <i>et al.</i> study, they evaluated the unnecessary deaths and hospital costs due to sepsis attributed to prolonged LOS; organisms included methicillin-resistant <i>Staphylococcus aureus</i> (MRSA) and third-generation cephalosporin-resistant <i>Escherichia coli</i> (G3CREC). ^[6] The authors concluded that sepsis caused by MRSA and G3CREC was responsible for greater morbidity, higher mortality, and millions of dollars in wasted costs for these unnecessarily prolonged LOS.

surgery. To accomplish this goal, we reviewed multiple early mobilization protocols along with other factors within these protocols that contributed to a reduction in both morbidity and LOS. Early mobilization was variously defined, but optimally included getting patients OOBDS, the first postoperative day (OOBFD), or very soon thereafter. We paid particular attention to the “pros” of proactive maneuvers associated with early mobilization, and realized that we must educate our patients, our families, our nurses, and ourselves, to improve patients’ health and reduce LOS.

Role of prehabilitation, protein drinks, and earlier rehabilitation in improving outcomes and reducing LOS in spine surgery

Nielsen *et al.* assessed whether prehabilitation in addition to early rehabilitation would improve outcomes following spinal surgery.^[15] Utilizing a randomized design, 60 patients undergoing elective spinal procedures for degenerative disease were treated with both preoperative “prehabilitation” and early postoperative rehabilitation. Of these, 28 had both (e.g. prehabilitation/rehabilitation), while 32 had only standard care. Prehabilitation started 2 months prior to surgery, and involved a stringent exercise regimen, medications for adequate pain control, and protein drinks the day prior to surgery. Early postoperative rehabilitation involved; adequate pain management (with self-administered epidural analgesia), redoubled/intensified mobilization (2-fold more often than routine), and postoperative protein supplements. Postoperative findings included; those in the treatment group exhibited better outcomes versus controls (e.g. mobilization 1-6 days vs. 3-13), and had shorter LOS (average 5 (range 3-9) vs. average 7 (range 5-15) days). Although no changes were noted regarding postoperative complications, adverse events, and low back radiating pain, patients in the study enjoyed greater postoperative satisfaction.

Benefits of early mobilization in spinal surgery

Early mobilization of spinal cord injury patients decreased morbidity and LOS

In Wang *et al.* retrospective analysis of patients who sustained acute spinal cord injuries, the interval between surgery and patient mobilization was correlated with postoperative complications and LOS.^[18] Medical records of 102 patients with acute spinal injuries were evaluated, and the dates following injury to the dates of admission, operation, and mobilization were recorded. Prolonged bed rest was associated with the greatest number of complications.

Early tracheostomy allows for early mobilization following acute spinal cord injuries, and decreases morbidity and LOS

Babu *et al.* observed that after spinal cord injury, patients often require not only anterior cervical spine fixation (ACSF), but also tracheostomies.^[2] However,

the tracheostomies are often delayed by the concern for infecting the ACSF site and instrumentation. This then prolongs immobilization and thereby increases the risk of further deterioration (e.g. especially pulmonary complications). In this study, the beneficial impact of early tracheostomy and, hence, early mobilization was confirmed. Of 1184 patients undergoing ACSF, 20 (1.7%) had postoperative tracheostomies performed an average of 6.9 days (STDEV 4.2) postoperatively (range 0-17 days); half were performed within 6 days, and only 1 resulted in a wound infection. Furthermore, for both groups, there was only a 1% cross-infection rate, with none involving contamination of implants. However, late tracheostomy significantly increased the complication rate (e.g. 9 of 10 PNs occurred prior to delayed tracheostomy).

Benefits of early mobilization in other medical/surgical subspecialties

Early mobilization (day of surgery) decreases LOS for total joint replacement surgery

Tayrose *et al.* noted that utilizing a protocol that required early mobilization following total joint replacement (TJR) enhanced postoperatively recovery, while reducing costs and LOS.^[16] Their protocol required physical therapy (PT) on the day of surgery for either total hip replacement (THR) or total knee replacement (TKR). The study included 900 patients divided into two groups; Group 1 underwent rapid PT started in the recovery room (RR), while Group 2 patients had the standard PT initiated the day after surgery. They observed a significant reduction in total LOS (3.9 days) for Group 1 versus a longer LOS (4.4 days) for the Group 2 patients. Cost savings were attributed to the decreased LOS and, therefore, lesser utilization of in-hospital resources when patients underwent PT in the RR the day of THR or TKR replacement surgery.

Benefits of respiratory therapy and early physiotherapy for children undergoing lung resections

Kaminski *et al.* evaluated the benefits of early respiratory therapy (e.g., including mask positive expiratory pressure, expiratory rib cage compression, and coughing) and physiotherapy (e.g. arm lifting and walking in <4 postoperative hours/and continued for 3 times/day) in 52 children undergoing lung resections versus 71 controls (who did not receive these early therapies).^[12] The treatment group exhibited fewer instances of AT, while more children in the control group required postoperative fiberoptic bronchoscopy. Of interest, no differences were encountered in the average time of drainage/chest tube utilization or LOS.

Early ICU mobility therapy minimizes LOS for adults with respiratory failure

Utilizing a prospective cohort, Morris *et al.* instituted an active early mobility/PT (“Mobility Team”) protocol versus the “usual care” (control group) to treat patients

with acute respiratory decompensation who required mechanical ventilation at the time of admission to a medical ICU.^[13] The “Mobility Team”, consisting of the critical care nurse, nursing assistant, and physical therapist, were supposed to initiate the protocol within 48 h of mechanical ventilation. The main outcome measure for those receiving PT was survival until discharge from the hospital. Although clinical variables were similar for both patient groups, the “More PT Protocol” patients were out of bed earlier (5 vs. 11 days on average), had more frequent therapy in the ICU (91% vs. 13% on average), exhibited lower complication rates, had shorter LOS in the ICU (5.5 vs. 6.9 days on average), and shorter overall hospital LOS (11.2 vs. 14.5 on average). Nevertheless, although there were no significant complications attributed to early mobilization, no cost difference (survivors + nonsurvivors) between the “Mobility Team” vs. “Usual” groups could be confirmed.

Impact of fast-track cardiac care including early extubation and early mobilization on mortality, morbidity, LOS, and cost

For adult cardiac patients undergoing surgery in the Zhu *et al.* study, the impact of fast-track cardiac care was specifically aimed at early extubation, and hence early mobilization, to reduce the LOS in ICUs, and total hospital LOS.^[19] To compare the safety/efficacy of fast track versus not fast-track care in adult cardiac surgical patients, the study utilized multiple major databases (e.g. Cochrane, MEDLINE, EMBASE, CINAHL) to identify randomized controlled trials of adults undergoing cardiac bypass, or aortic/mitral valve replacements. In addition to early extubation (and hence early mobilization) to get patients out of surgical ICUs, fast-track interventions also included the use of low-dose opioid-based general anesthesia. Although both groups demonstrated comparable risks of mortality (first postoperative year), and similar postoperative morbidities/complications (e.g. the same rates of MI, reintubation (<24 h), acute renal failure, major bleeding, major sepsis, and wound infections), fast-track care did reduce LOS in the ICU, but not in the hospital (e.g. still a cost savings). Of interest, only one high quality randomized controlled trial showed that early extubation was cost-effective.

Benefits of early mobilization of intensive care unit patients on mechanical circulatory support following cardiac surgery

Freeman *et al.* previously observed that following cardiac surgery, if ICU patients on mechanical circulatory support were kept in bed, it increased their risk of venous thromboembolism (DVT)/pulmonary emboli (PE), poorer/reduced pulmonary function that increased risk of PN, longer LOS, further deconditioning, and a greater need for postoperative rehabilitation.^[10] To counteract the multiple risks of prolonged bed rest, the authors introduced a protocol including early extubation and early mobilization. The protocol on the day of surgery included range of motion exercises, dangling at the

bedside, and being out of bed (OOBDS) to a chair. The protocol of getting out of bed the first postoperative day included OOBFD to a chair 2-3 times/day, and walking in the room/hall. Both protocols of early extubation/mobilization successfully reduced the number of the complications and LOS for this patient population.

Better recovery following bariatric surgery utilizing early mobilization

Awad *et al.* noted few protocols like the “Enhanced Recovery After Bariatric Surgery (ERABS)” were utilized in patients undergoing bariatric surgery.^[11] In their series of 226 patients with median BMI of 44.9, patients underwent laparoscopic gastric bypasses (66%), sleeve gastrectomies (21%), and gastric bands (13%). The protocol tracked comorbidities (hypertension (40%), diabetes mellitus (34%), sleep apnea (24%) limited mobility (9%)), morbidity, mortality, readmission rates, and effectiveness of early mobilization. Postoperatively, no anastomoses leaked, 4.4% of patients developed mostly respiratory complications, and one died of a massive pulmonary embolus despite preoperative-inferior vena cava filter (IVC) filter placement. Respective mean LOS for bypasses was 1.88 days, for sleeves 2.30 days, and for bands 0.69 days; six patients (2.7%) required readmission within 30 days.

Physician accountability in reducing costs and/or LOS

Increasing surgeons’ awareness of costs of implanted vs. explanted (“wasted”) instrumentation for single-level anterior discectomy and fusion

Epstein, Schwall, and Hood evaluated the costs of devices (plates, screws, spacers) implanted versus explanted (wasted or removed prior to closure) during 87 single-level anterior cervical discectomy and fusion surgical procedures (ACDF) performed over one year at a single institution.^[8] Costs to the hospital (without overhead) for implants included: screws (\$103,572: 84 patients); plates (\$120,694: 85 patients); allograft spacers (\$92,776: 64 patients); cages (\$38,821: 9 patients); and autografts (no charge; 14 patients); the total was \$355,863. Wasted dollars (\$32,850) spent on wasted/explanted devices included: 37 screws (\$11,014: 17 patients); 7 plates (\$12,743: 5 patients); and 8 allograft spacers (\$9093: 7 patients). The authors concluded that operative waste/explanted devices were encountered in 24 (27.6%) patients, costing an additional \$32,850, or adding 9.2%, to the cost of the implanted devices.

Surgeon education reduces the cost/frequency of explantation for single level ACDF at one institution

Epstein, Schwall, and Hood then demonstrated how making surgeons aware of waste/explantation (the cost of implanting devices but removing them prior to closure) occurring during single-level ACDF would substantially reduce costs.^[9] The authors prospectively assessed the costs/frequency of wasting/explanting devices utilized to

perform single-level ACDF over one year at one institution, before and after surgeon education. Explantation costs/frequencies for the first 4 months of 2010 versus the last 8 months were compared before and after surgeon education. Prior to education, instrumentation was explanted in 45.5% of cases versus after education, which occurred in only 16% of the cases. The explantation rate ((explanted devices/implanted devices) ×100) was lower following education for: screws (12.5-7.7%), plates (9.4-0%), and allograft spacers (7.1-2.9%). Finally, the overall cost of explanted devices was lowered after surgeon education from 20% to 5.8%.

Reduction of unnecessary LOS while improving care by making physicians accountable

Caminiti *et al.* observed that more than 20% of hospital LOS is inappropriate, wastes resources, and increases iatrogenic risk.^[5] In a randomized controlled trial involving 12 wards and 3498 patients, a physician-physician protocol was introduced to reduce unnecessary LOS without impacting quality of care (e.g. measured by readmission rates/mortality). Physicians were informed if their discharges were compatible with the “Delay Tool”, and received their own LOS data (e.g. as audited by ward physicians). Over 12 months, more than 50% of LOS were considered appropriate, and most delayed discharges were attributed to nonmedical problems. Overall, the LOS was significantly reduced by 16% for the “intervention vs. control group”. Furthermore, outcomes, as measured by readmission, or mortality rates within 30 days of discharge, showed no significant differences between the two groups. The authors concluded that utilizing a strategy of direct physician-physician accountability successfully reduced unnecessary LOS without impacting outcome quality (readmission rates/mortality).

Major factors impacting hospital costs for spinal surgery

Hospital costs attributed to extent of neuromuscular scoliosis surgery.

Diefenbach *et al.* evaluated whether the hospital, operating room, and hospital bed/stay costs of performing “neuromuscular scoliosis” (NMS) surgery in 74 patients could be reduced.^[7] Surgical costs reflected the degree/extent of surgical correction (e.g. posterior approaches (76%) with pedicle screws (75%)), LOS (averaged 8 days (range 3-47 days)), and extent of postoperative care. The total surgical cost was \$50,096 ± \$23,998 while other average costs included implant costs (\$13,916), room/ICU costs (\$12,483), and bone grafts costs (\$6398). Increased total costs were predominantly attributed to more extensive disease/more total levels fused, and increased LOS.

Endocrine abnormalities (Diabetes, Hypothyroidism) Increase

LOS for Patients Undergoing Spinal Surgery

Walid and Zaytseva noted that prior studies correlated increased LOS for spine surgery with diabetes, but that these studies did not include assessment of attendant hypothyroidism.^[17] Here, the authors reviewed charts (2005 and 2008) of patients who were diabetic and/or hypothyroid undergoing spinal surgery, and evaluated how outcomes and surgical costs correlated with diabetes alone, hypothyroidism alone, or with both risk factors. Surgery included lumbar microdiscectomy (N = 237), anterior cervical decompression and fusion (N = 339), and lumbar decompression and fusion (N = 211). Patients average age was 54.5 years, and for 653 patients glycosylated hemoglobin (HbA1c) levels measured; 32.5% had an HbA1c level ≥ 6.1% and 4.3% had high HbA1c levels and hypothyroidism (this combination increased with age). Those undergoing lumbar decompressions/fusions with both comorbid factors demonstrated an increased LOS and hospital costs. Alternatively, for HbA1c elevation or hypothyroidism, the average LOS was 5 days, but both comorbidities increased the average LOS to 8 days. The average hospital cost without these comorbidities was \$52,449; diabetes increased the cost to \$56,176; both comorbidities (DM/hypothyroidism) further increased the average hospital cost to \$71,352. The authors concluded that cost and LOS increased with age, female gender, and lumbar decompression/fusion, but further increased LOS and cost were observed for hypothyroid females aged ≥ 70 years undergoing anterior cervical decompression/fusion.

Complications (based on comorbidities) and optimal selection of patients impacts LOS for patients undergoing spine surgery

Can the frequency of complications following spine surgery, which lengthen LOS, be predicted?

Bekelis *et al.* modeled the frequency of complications following spinal surgery using the National Surgical Quality Improvement Program (NSQIP) between 2005 and 2010.^[3] This retrospective cohort study of 13,660 patients (NSQIP database) included 2719 anterior approaches (19.9%), 565 corpectomies (4.1%), and 1757 fusions (12.9%). Thirty-day postoperative complications included; “0.05% for S, 0.2% for MI, 0.25% for death, 0.3% for infection, 1.37% for UTI, 0.6% for DVT, 0.29% for PE, and 3.15% for return to the operating room.” Patients who had greater than a 3-day postoperative stay were at increased risk due to the following variables/comorbidities: advanced age, larger operations (fusion, corpectomy), poorer preoperative medical condition (“weight loss, dialysis, peripheral vascular disease, CAD, COPD, diabetes”), higher BMI, more severe neurological deficits inhibiting mobility, and bleeding disorders. The authors developed a “validated model for outcome prediction” based on individual patient characteristics.

Obese class III spinal patients increase complications and LOS for spinal surgery

Buerba *et al.* identified 10,387 patients undergoing spinal surgery from the American College of Surgeons (ACS)-NSQIP database (2005-2010) who were considered “class III obese” (≥ 40 kg/m²: 6.9%).^[4] Their aim was to correlate the impact of class III obesity on perioperative spinal complications, and LOS for patients undergoing anterior lumbar fusions (ALF 4.5%), posterior fusions (PF 17.9%), transforaminal or posterior lumbar interbody fusions (TLIF/PLIF 6.3%), discectomies (40.7%), and decompressions (30.5%). Complications and outcomes at 30 postoperative days included PE, DVT, death, system-specific complications (wound, pulmonary, urinary, central nervous system, cardiac), sepsis, and whether patients had ≥ 1 complications. Other variables evaluated were the operating room time, number of blood transfusions, LOS, and reoperation rates. Patients were split into four BMI groups: nonobese (18.5-29.9 kg/m²), obese I (30-34.9 kg/m²: 25.6%), obese II (35-39.9 kg/m²: 11.5%), and obese III (≥ 40 kg/m²: 6.9%). Patients who were obese in categories I and III had more urinary complications, obese II and III patients had more wound infections/complications, but only obese III patients, had longer operative times and LOS, with greater pulmonary complications.

Timing of cervical surgical admission significantly impacts LOS

Outcomes of cervical trauma surgery based on weekday vs. weekend admissions

In Nandyala *et al.* retrospective study based on a 34,122 Nationwide Inpatient Sample (2002-2011), the outcomes of cervical trauma surgery (anterior cervical fusions (ACF 11.5%), posterior cervical fusion (PCF 19.9%), or combined fusions (anterior posterior cervical fusion (APCF) 17.2%)) were analyzed for patients admitted/operated on during the week versus over a weekend.^[14] Variables evaluated included clinical data/status, comorbid factors, LOS, costs, mortality, and outcomes. In general, those admitted over the weekend were younger, and included more males with fewer comorbidities versus those admitted during the week. For patients undergoing ACF, the weekend admission LOS was 4.4 days longer and cost more (additional \$10,045) versus patients admitted during the week; they also demonstrated higher infection rates, more cardiac complications, and urinary infections versus those ACF patients admitted on a weekday. Patients undergoing PCF admitted over the weekend also had longer LOS (average 2.6 days longer) and cost more as well (\$10,227 additional vs. weekday patients). Similarly, APCF patients admitted over the weekend had longer LOS (average 4.2 days longer), and also cost more (increased \$11,301) versus those admitted during the week. Of interest, there was no difference in the mortality rates for any of the procedures within the different cohorts.

Reduction of LOS and costs in other surgical specialties

Prophylactic gastrostomy for Head and Neck cancer

When Hughes *et al.* evaluated patients with head/neck cancer undergoing chemotherapy/radiation, they considered the benefits of prophylactic gastrostomy to maintain nutritional status, and potentially improve patient outcomes.^[11]

Prophylactic gastrostomies were performed in 165 patients undergoing radical chemoradiation for head/neck cancers; this resulted in fewer complications, fewer admissions/readmissions, and shorter LOS versus those not receiving gastrostomies. The authors concluded that preventive placement of gastrostomy tubes for this patient population significantly decreased hospital admissions/readmission rates and LOS, thereby reducing hospital costs, and increasing bed availability (increasing income).

Increased morbidity/mortality and LOS attributed to sepsis: a reason to curtail unnecessary hospitalization

The de Kraker *et al.* study involving 31 countries participating in the European Antimicrobial Resistance Surveillance System (EARSS), assessed the unnecessary deaths and hospital costs due to sepsis attributed to prolonged LOS.^[6] Sepsis was attributed to methicillin-resistant *Staphylococcus aureus* (MRSA) and third-generation cephalosporin-resistant *Escherichia coli* (G3CREC). The excess 30-day mortality and LOS due to MRSA or G3CREC (2007) were as follows: 27,711 MRSA sepsis led to 5503 excess deaths, 255,683 excess days (LOS), and cost 44.0 Euros (\$63.1 million dollars), while the 15,183 G3CREC sepsis led to 2712 excess deaths, 120,065 excess days (LOS), and cost 18.1 Euros (\$29.7 million dollars). The authors concluded that sepsis caused by MRSA and G3CREC was responsible for greater morbidity, higher mortality, and millions of dollars in wasted costs for these unnecessarily prolonged LOS.

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