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# The Effect of Inpatient Step Count on Complications in the Elderly Patient After Adult Spinal Deformity Surgery

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## ABSTRACT

**Background:** The number of elderly patients undergoing adult spinal deformity (ASD) surgery has increased with the advent of new techniques and more nuanced understanding of global malalignment as patients age. The relationship between inpatient physical activity after ASD surgery and postoperative complications in elderly patients has not been reported; thus, we sought to investigate this relationship.

**Methods:** We performed a medical record review of 185 ASD patients older than 65 years (age: 71.5 ± 4.7; body mass index: 30.0 ± 6.1, American Society of Anesthesiologists: 2.7 ± 0.5, and levels fused: 10.5 ± 3.4). We derived the number of feet walked over the first 3 days after surgery from physical therapy documentation and evaluated for association with 90-day perioperative complications. Patients who sustained an incidental durotomy were excluded from the study.

**Results:** The 185 patients were divided into groups based on whether they were among the 50th percentile for number of feet walked (62 ft). Walking less than 62 ft after ASD surgery was associated with higher incidence of postoperative complications (54.3%, $P = 0.05$), cardiac complications (34.8%, $P = 0.03$), pulmonary complications (21.7%, $P = 0.01$), and ileus (15.2%, $P = 0.03$). Patients who developed any postoperative complication (106 ± 172 vs 211 ± 279 ft, $P = 0.001$), ileus (26 ± 49 vs 174 ± 248 ft, $P = 0.001$), deep venous thrombosis (23 ± 30 vs 171 ± 247 ft, $P = 0.001$), and cardiac complications (58 ± 94 vs 192 ± 261 ft) walked less than patients who did not.

**Conclusion:** Elderly patients who walked less than 62 ft in the first 3 days after ASD surgery have a higher rate of postoperative complications, specifically pulmonary and ileus compared with those patients who walked more. Steps walked after ASD surgery may be a helpful and practical addition to the surgeon's armamentarium for monitoring the recovery of their patients.

**Clinical Relevence:** Monitoring the steps walked by patients after ASD surgery can be a practical and useful tool for surgeons to track and improve their patients' recovery.

**Level of Evidence:** 3.

Complications

Keywords: step count, steps, postoperative, deformity, mobility, ambulation, ileus, pulmonary complication

## INTRODUCTION

Ambulation and physical activity are associated with decreased lifelong all-cause morbidity and mortality and improved quality of life.[1] Due to this association, patients are highly encouraged to live a nonsedentary lifestyle, especially the elderly. An aging patient experiencing a sedentary lifestyle develops a plethora of comorbidities, such as diabetes, hypertension, and low back pain. Some of these patients experience lower back pain due to the development of adult spinal deformity (ASD), which often requires surgical intervention. The number of elderly patients undergoing ASD surgery has increased with the advent of new techniques and a more nuanced understanding of global malalignment as patients age. Complex spinal realignment surgery is a procedure associated with a high complication rate and frequent returns to the operating room (OR).[2] Complex spine surgeries can pose a risk to elderly patients and exposes them to many other potential complications that are difficult to predict. Furthermore, age has often been referenced as a large risk factor for complications after ASD surgery. Due to the high risk of complication in these patients, optimization of the postoperative course has been heavily researched.

Several studies have demonstrated the effect of ambulation in the first week after spine surgery on long-term patient disability, physical function, and postoperative complications; however, the relationship between inpatient physical activity after ASD surgery and postoperative complications in elderly patients has not been fully explored.[3–14] The ability of the elderly patient to independently walk as early as possible following ASD surgery may decrease the perioperative complication rate. The present study examines the correlation in clinical outcomes of elderly patients with their ability to ambulate. Specifically, we investigate surgical characteristics, perioperative complications, and unplanned 90-day returns to the OR.

# METHODS

## Study Design

A retrospective review of spinal surgery patients from 2015 to 2021 at a single institution was conducted. Patients aged ≥65 years undergoing surgery for ASD with 5 or more levels fused and pelvic fixation were included. Patients who sustained an incidental durotomy during their surgery were excluded. Body mass index (BMI), numbers of levels fused, use of navigation or robotic guidance, operative time, and estimated blood loss (EBL) were recorded from the anesthesia and operative reports. Intraoperative complications were obtained from the operative reports and included neuromonitoring changes, delayed extubation, and whether or not anesthesia had stopped the case. Radiation dosage was obtained from radiology reports. Perioperative complications and length of stay (LOS) were recorded from discharge summary notes. Total feet walked during the first 3 days of the inpatient stay were obtained from physical therapy progress notes. During each episode of physical therapy, distance walked was recorded and aggregated into total distance walked for each particular day and was subsequently added to determine overall distance walked during patients' first 3 postoperative days.

A comprehensive review of surgical and medical specialty provider notes from the date of surgery to 90-day follow-up was completed to screen for postoperative complications including neurological deficit, ileus, venous thromboembolic events, including pulmonary embolism (PE) and deep vein thrombosis (DVT), surgical site infections (SSIs) or other wound complications, and returns to the OR within 90 days. Ileus was defined as the absence of flatus and/or passage of stool past 48 hours from the time of surgery and required radiographic confirmation of intestinal dilation on abdominal plain radiographs.

## Statistical Analysis

Patients were split into 2 groups based on whether they were in the 50th percentile of total feet walked during the first 3 postoperative days. A subanalysis of patients with more than 2 L of blood loss was conducted by splitting patients into 2 groups based on whether they were able to ambulate at all during their first 3 days postoperation. Demographics, intraoperative characteristics, and perioperative outcomes were compared across groups using $\chi^2$ analysis and independent samples $t$ test, with significance set at $P = 0.05$. Linear regression was run utilizing the 50th percentile of total feet walked to determine whether it is a predictive factor of postoperative complications. Differences in number of feet walked were compared among those who developed a complication and those who did not, utilizing independent samples $t$ test with significance set at $P = 0.05$.

# RESULTS

## Patient Population

A total of 185 patients aged 65 years or older who underwent spine surgery with 5 or more levels fused and pelvic fixation without incidental durotomy were identified. The mean age for the entire cohort was 71.5 ± 4.7 years. Men accounted for 28.0% of the sample, and 72.0% were women. The average BMI was 30.6 ± 6.1 kg/m$^2$, and 4.2% were smokers. Average number of levels fused was 10.5% ± 3.4%, and 47.1% were revision procedures. Average LOS was 8.3 ± 4.9 days, operative time was 468.0 ± 165.7 minutes, and EBL was 2013.5 ± 1419.0 mL. Within the cohort, the mean number of feet walked within 3 days of the procedure was 165.5 ± 243.8 ft.

The 185 patients were divided into groups based on whether they were among the 50th percentile for number of feet walked (62 ft). Those who walked more than or equal to 62 ft were similar in age (71.6 ± 4.6 vs 71.4 ± 4.8 years, $P = 0.84$), levels fused (10.2 ± 3.4 vs 10.8 ± 3.4, $P = 0.2$), percent women (67.5% vs 75.3%, $P = 0.3$), and percent smokers (4.3% vs 4.3%, $P = 0.99$) compared with those who walked less than 62 ft. Patients who walked more than 62 ft were more likely to have a larger BMI (30.0 ± 6.7 vs 28.0 ± 5.3 kg/m$^2$, $P = 0.035$) compared with those who did not (Table 1).

Among operative characteristics, patients who walked more than or equal to 62 ft were more likely to have a shorter operative time (424.0 ± 144 vs 512.9 ± 173 minutes, $P = 0.001$) and LOS (6.8 ± 2.5 vs 9.5 ± 5.5 days, $P = 0.001$). All other operative characteristics were similar between groups, including interbody device placements (57.6% vs 66.7%, $P = 0.2$), anterior lumbar interbody fusions (5.4% vs 11.8%, $P = 0.12$), lateral lumbar interbody fusions (6.5% vs 4.3%, $P = 0.5$), transforaminal lumbar interbody fusions (43.5% vs 47.3%, $P = 0.6$), ponte osteotomy (64.1% vs 59.1%, $P = 0.49$), EBL (1882 ± 1248 vs 2210 ± 1578 mL, $P = 0.08$), overall interoperative complications (9.8% vs 16.1%, $P = 0.2$), intraoperative neuromonitoring

**Table 1.** Demographic characteristics ($N$ = 185).

| Variable | <62 ft Walked ($n$ = 93; 50.3%) | ≥62 ft Walked ($n$ = 92; 49.7%) | $P$ Value |
|---|---|---|---|
| Age, y | 71.4 ± 4.8 | 71.6 ± 4.6 | 0.84 |
| Women | 70 (75.3%) | 63 (68.5%) | 0.3 |
| Body mass index | 28.0 ± 5.3 | 30.0 ± 6.7 | **0.035** |
| Levels fused | 10.8 ± 3.4 | 10.2 ± 3.4 | 0.2 |

*Note:* Data presented as mean ± SD or $n$ (%).

changes (3.3% vs 5.4%, $P$ = 0.48), delayed extubation (8.7% vs 9.7%, $P$ = 0.82), and anesthesia use had to stop the case (3.3% vs 1.1%, $P$ = 0.31)(Table 2).

The cohort that ambulated more than 62 ft was less likely to develop a postoperative complication (35.9% vs 50.5%, $P$ = 0.044), cardiac complication (13.0% vs 25.8%, $P$ = 0.028), pulmonary complication (1.1% vs 14%, $P$ = 0.001), and postoperative ileus (1.1% vs 9.7%, $P$ = 0.01) than those who did not. There were no differences between groups with regard to neurological complications (4.3% vs 9.7%, $P$ = 0.16), DVT/PE (1.1% vs 6.5%, $P$ = 0.056), urinary complications (6.5% vs 7.5%, $P$ = 0.79), mechanical complications (0.0% vs 1.1%, $P$ = 0.32), SSIs (2.2% vs 5.4%, $P$ = 0.25), and return to the OR within 90 days (2.2% vs 5.4%, $P$ = 0.25). A comparison of the between those who walked more than 62 ft and those who did not can be found in Table 3.

Binary logistic regression analysis was completed using whether a patient was able to walk more than 62 ft during the first 3 operative days. Our regression demonstrated that walking less than 62 feet after ASD surgery was associated with higher incidence of postoperative complications (54.3%, $P$ = 0.05), cardiac complications (34.8%, $P$ = 0.03), pulmonary complications (21.7%, $P$ = 0.01), and ileus (15.2%, $P$ = 0.03).

When comparing the walking distance of those who developed complications, we found that those who had a postoperative complication walked significantly less than those who did not (106.4 ± 279.1 vs 210.5 ± 279.1 ft, $P$ = 0.002). Similar differences were found between those who developed a cardiac complication (57.9 ± 93.6 vs 191.5 ± 261.4 ft, $P$ = 0.001), DVT (23.4 ± 30.0 vs 171.1 ± 246.8 ft, $P$ = 0.001), or postoperative ileus (26.3 ± 49.4 vs 173.5 ± 248.1 ft, $P$ = 0.001) compared with those who did not (Table 2). There were no significant differences in the walking distance between those who developed a neurological complication (79.1 ± 109.3 vs 172.0 ± 250 ft , $P$ = 0.186), pulmonary complication (58.4 ± 186.5 vs 174.3 ± 246.3 ft, $P$ = 0.087), urinary complication (165.0 ± 294.9 vs 165.6 ± 240.5 ft, $P$ = 0.995), or SSI (44.9 ± 72.7 vs 170.3 ± 247.0 ft, $P$ = 0.183) compared with those who did not. In addition, it was found that those who mobilized earlier were less likely to require acute or subacute rehabilitation (35.9% vs 71.1%, $P$ < 0.001).

## Massive Blood Loss Subanalysis

A total of 62 patients within the cohort experienced an EBL greater than 2 L. The average age of this cohort was 71.4 ± 4.4 years. Men accounted for 25.4% of the sample, and 74.6% were women. The average BMI was 27.2 ± 6.1, and 3.2% were smokers. Average number of levels fused was 11.2% ± 3.3%, and 42.9% were revision procedures. Average LOS was 9.2 ± 5.4 days, operative time was 503.5 ± 162.0 minutes, and EBL was 3550.0 ± 1299.2 mL. Within the cohort, the mean number of feet walked within 3 days of the procedure was 135 ± 214.

The cohort of 62 patients was split into 2 groups based on whether they were able to mobilize during their first 3 days after surgery. Those who were able to mobilize ($n$ = 46) were similar in demographics to those who were not

**Table 2.** Surgical characteristics ($N$ = 185).

| Variable | <62 ft Walked ($n$ = 93; 50.3%) | ≥62 ft Walked ($n$ = 92; 49.7%) | $P$ Value |
|---|---|---|---|
| Osteotomy | 55 (59.1%) | 59 (64.1%) | 0.49 |
| Interbody device placed | 62 (66.7%) | 53 (57.6%) | 0.2 |
| Estimated blood loss, mL | 2210 ± 1578 | 1832 ± 1248 | 0.08 |
| Operative time, min | 513 ± 173 | 424 ± 144 | **0.001** |
| Intraoperative complications | 15 (16.1%) | 9 (9.8%) | 0.2 |
| Neuromonitoring changes | 5 (5.4%) | 3 (3.3%) | 0.48 |
| Anesthesia stopped the case | 1 (1.1%) | 3 (3.3%) | 0.31 |
| Delayed extubation | 9 (9.7%) | 8 (8.7%) | 0.82 |

*Note:* Data presented as mean ± SD or $n$ (%).

**Table 3.** Complications in the 90-d postoperative period *N* = 185).

| Variable (*N* = 185) | <62 ft Walked (*n* = 93; 50.3%) | ≥62 ft Walked (*n* = 92; 49.7%) | *P* Value |
|---|---|---|---|
| Postoperative complications | 47 (50.5%) | 33 (35.9%) | **0.044** |
| Cardiac complications | 24 (25.8%) | 12 (13.0%) | **0.028** |
| Neurological complications | 9 (9.7%) | 4 (4.3%) | 0.16 |
| Deep vein thrombosis/pulmonary embolism | 6 (6.5%) | 1 (1.1%) | 0.056 |
| Pulmonary complications | 13 (14.0%) | 1 (1.1%) | **0.001** |
| Postoperative ileus | 9 (9.7%) | 1 (1.1%) | **0.01** |
| Urinary complications | 7 (7.5%) | 6 (6.5%) | 0.79 |
| Mechanical complications | 1 (1.1%) | 0 (0%) | 0.32 |
| Surgical site infection | 5 (5.4%) | 2 (2.2%) | 0.25 |
| Return to operating room within 90 d | 5 (5.4%) | 2 (2.2%) | 0.25 |
| Length of stay, d | 9.5 ± 5.5 | 6.8 ± 2.5 | 0.001 |
| Discharge to rehabilitation | 64 (71.1%) | 33 (35.9%) | **0.001** |

*Note:* Data presented as mean ± SD or *n* (%). Statistically significant findings are in boldface.

(*n* = 16), including age (71.6 ± 4.8 vs 70.9 ± 3.2 years, *P* = 0.6), percent women (76.1% vs 68.8%, *P* = 0.6), BMI (26.4 ± 6.1 vs 29.2 ± 5.9 kg/m$^2$, *P* = 0.12), smokers (4.3% vs 0.0%, *P* = 0.4), and levels fused (11.2 ± 3.5 vs 11.3 ± 3.2, *P* = 0.94). No differences in interbody device (58.7% vs 75%, *P* = 0.25), anterior lumbar interbody fusion (6.5% vs 18.8%, *P* = 0.15) , lateral lumbar interbody fusion (2.2% vs 0.0%, *P* = 0.6), transforaminal lumbar interbody fusion (52.2% vs 50.0%, *P* = 0.9), ponte osteotomy (67.4% vs 68.8%, *P* = 0.9), overall intraoperative complications (28.3% vs 12.5%, *P* = 0.2), neuromonitoring changes (0.0% vs 6.3%, *P* = 0.09), or anesthesia stopping the case (6.5% vs 0.0%, *P* = 0.3) were observed between groups. Patients who ambulated had lower LOS (8.0 ± 2.8 vs 13.1 ± 8.9, *P* = 0.045) and were more likely to have delayed extubation after surgery (23.9% vs 0%, *P* = 0.031) compared with those who were not able to ambulate. Patients who ambulated had lower rates of postoperative cardiac complications (8.7% vs 31.3%, *P* = 0.003) and postoperative ileus (0.0% vs 31.3%, *P* = 0.001) than those who did not. No other differences in overall postoperative complications (41.3% vs 56.3%, *P* = 0.3), neurological complications (2.2% vs 12.5%, *P* = 0.1), DVT/PE (2.2% vs 6.3%, *P* = 0.4), pulmonary complications (4.3% vs 18.9%, *P* = 0.07), urinary complications (4.3% vs 12.5%, *P* = 0.25), mechanical complications (2.2% vs 0.0%, *P* = 0.55), SSI (2.2% vs 12.5%, *P* = 0.1), or return to the OR within 90 days (4.3% vs 0.0%, *P* = 0.4) were observed. A comparison of the cohorts in our subanalysis can be found in Table 4.

## DISCUSSION

Due to the association between mobility and patient longevity, patient postoperative mobility continues to be explored by different fields in the medical community both as an outcome and a predictor of potential complications.[15] The present study contributes to the potential use of ambulation as a tool surgeons and physicians can use to gauge patient progress after surgery. We reported that patients who walked more than 62 ft during their

**Table 4.** . Comparison of patients with estimated blood loss greater than 2L based on if they were able to mobilize within the first 3 days after surgery.

| Variable (*N* = 62) | 0 ft Walked (*n* = 16; 24.8%) | Mean Distance Walked: 135 ft (*n* = 46; 75.2%) | *P* Value |
|---|---|---|---|
| Demographics | | | |
| Age, y | 70.9 ± 3.2 | 71.6 ± 4.8 | 0.3 |
| Body mass index | 29.2 ± 5.9 | 26.4 ± 6.1 | 0.12 |
| Levels fused | 11.3 ± 3.2 | 11.2 ± 3.5 | 0.94 |
| Surgical characteristics | | | |
| Osteotomy performed | 11 (68.8%) | 31 (67.4%) | 0.9 |
| Interbody device placed | 12 (75.0%) | 27 (58.7%) | 0.25 |
| Estimated blood loss, mL | 4015 ± 1484 | 3400 ± 1218 | 0.11 |
| Operative time, min | 567 ± 209 | 480 ± 140 | 0.14 |
| Perioperative complications | | | |
| Postoperative complications | 9 (56.3%) | 19 (41.3%) | 0.3 |
| Cardiac complications | 5 (31.3%) | 4 (8.7%) | **0.03** |
| Neurological complications | 2 (12.5%) | 1 (2.2%) | 0.1 |
| Deep vein thrombosis/pulmonary embolism | 1 (6.3%) | 1 (2.2%) | 0.4 |
| Pulmonary complications | 3 (18.9%) | 2 (4.3%) | 0.07 |
| Postoperative ileus | 5 (31.3%) | 0 (0%) | **0.001** |
| Urinary complications | 2 (12.5%) | 2 (4.3%) | 0.25 |

*Note:* Data presented as mean ± SD or *n* (%). Statistically significant findings are in boldface.

first 3 postoperative days were less likely to develop a postoperative complication, cardiac complication, pulmonary complication, and postoperative ileus than those unable to walk more than 62 ft.

We do note that LOS was significantly larger in patients with a lower activity status; however, the authors recognize that activity status may just be a single factor for why patients may not be discharged.

Cardiac complications included acute blood loss anemia, hypotension, atrial fibrillation, pulmonary hypertension, and non–ST-elevation myocardial infarction. Because of the extensive nature of the surgery, heavy blood loss is likely to occur, prompting a higher length of hospital stay and other difficulties. Although our results show the correlation between cardiac complications and limited postoperative mobility, it is likely that complications related to intraoperative blood loss have a causative effect on the ability of the patient to ambulate. Furthermore, postoperative physical therapy protocol includes the avoidance of activities whenever the patient experiences light headedness and dizziness.

Pulmonary complications that were observed included pulmonary edema, atelectasis, and hypoxic respiratory failure. Patients who were unable to walk more than 62 ft within the first 3 days after spine surgery were 100% more likely to have been diagnosed with a pulmonary complication or postoperative ileus than those who were able to. Pulmonary physiotherapy has been shown to reduce pulmonary complications after surgery due to the cardiopulmonary effort that the patient must exert.[16] Much like physiotherapy, ambulation can produce the cardiopulmonary effort required to withstand potential respiratory complications such as atelectasis and pulmonary edema. Although patients who ambulated more were less likely to develop a DVT or PE, our results were not significant despite the heavy association of DVT/PE with remaining sedentary after surgery; however, those who developed DVT were found to be significantly less ambulatory than those who did not. Potential confounders would be the ability for patients to mobilize without physical therapy and the use of sequential compression devices. Our results coincide with other studies that have evaluated the effect of early postoperative mobility on complications. In a study by Zakaria et al, it was reported that mobility on postoperative day 1 led to a reduction in 30/90-day readmission, urinary tract infections, urinary retention, and postoperative ileus after spine surgery.[4] Similarly, Hueng et al demonstrated that elderly patients who ambulated within 4 hours after lumbar decompression and fusion had lower rates of postoperative ileus and urinary retention compared with those who were able to ambulate between 4 and 24 hours.[5] Adogwa et al described lower incidence of pneumonia and overall postoperative complications among elderly ASD patients who ambulated early on during their postoperative course.[8] Several studies have expanded upon the effect of postoperative mobility by examining patient-reported outcomes and quality of life. A prospective study by Gilmore et al found that patients who were able to ambulate more during their first week after spine surgery had significantly higher functional scores at 6 months.[3]

The primary limitation of the study is the validity of utilizing physical therapy notes to capture overall patient mobility. Although notes have detailed reports of mobility and exercises the patient performs during their visit, there will be times when patients ambulate on their own, and thus this study may undercapture the true value of a patient's step count. A wearable pedometer during the inpatient stay would be of pronounced use when looking to further expand this upon the current study. As wearable technology continues to be innovated and integrated into health care, the ability of physicians to capture reliable data on patient mobility and assess physical function will grow. Physician scientists may want to examine the efficacy of data that smart phone technologies continue to passively collect from each individual.[13,17] At our institution, there is no established pain protocol among the cohort; thus, patients may have variable pain regimens that affect their ability to ambulate. Another limitation that cannot be excused is the causal or correlative effect paradigm. Patients may develop a complication that results in the inability to ambulate; deciphering which came first is a more nuanced task. Lastly, the retrospective nature of the study exposes the data to observer bias during statistical analysis.

## CONCLUSION

Elderly patients who walked less than 62 ft in the first 3 days after ASD surgery had a higher rate of postoperative complications, specifically pulmonary complications and ileus compared with those patients who walked more. Steps walked after ASD surgery may be a helpful and practical addition to the surgeon's armamentarium for monitoring the recovery of their patients. Optimizing tools via technological integration for capturing data on patient mobility after surgery could be of great use to improve patient-centered care.

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