Association between baseline cognitive impairment and postoperative delirium in elderly patients undergoing surgery for adult spinal deformity

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OBJECTIVE Postoperative delirium is common in elderly patients undergoing spine surgery and is associated with a longer and more costly hospital course, functional decline, postoperative institutionalization, and higher likelihood of death within 6 months of discharge. Preoperative cognitive impairment may be a risk factor for the development of postoperative delirium. The aim of this study was to investigate the relationship between baseline cognitive impairment and postoperative delirium in geriatric patients undergoing surgery for degenerative scoliosis.

METHODS Elderly patients 65 years and older undergoing a planned elective spinal surgery for correction of adult degenerative scoliosis were enrolled in this study. Preoperative cognition was assessed using the validated Saint Louis University Mental Status (SLUMS) examination. SLUMS comprises 11 questions, with a maximum score of 30 points. Mild cognitive impairment was defined as a SLUMS score between 21 and 26 points, while severe cognitive impairment was defined as a SLUMS score of ≤ 20 points. Normal cognition was defined as a SLUMS score of ≥ 27 points. Delirium was assessed daily using the Confusion Assessment Method (CAM) and rated as absent or present on the basis of CAM. The incidence of delirium was compared in patients with and without baseline cognitive impairment.

RESULTS Twenty-two patients (18%) developed delirium postoperatively. Baseline demographics, including age, sex, comorbidities, and perioperative variables, were similar in patients with and without delirium. The length of in-hospital stay (mean 5.33 days vs 5.48 days) and 30-day hospital readmission rates (12.28% vs 12%) were similar between patients with and without delirium, respectively. Patients with preoperative cognitive impairment (i.e., a lower SLUMS score) had a higher incidence of postoperative delirium. One- and 2-year patient reported outcomes scores were similar in patients with and without delirium.

CONCLUSIONS Cognitive impairment is a risk factor for the development of postoperative delirium. Postoperative delirium may be associated with decreased preoperative cognitive reserve. Cognitive impairment assessments should be considered in the preoperative evaluations of elderly patients prior to surgery.

<https://thejns.org/doi/abs/10.3171/2017.5.SPINE161244>

KEY WORDS delirium; cognitive impairment; spine surgery; Saint Louis Mental Status test; elderly; degenerative scoliosis; deformity

POSTOPERATIVE delirium is common in elderly patients and associated with the development of other comorbidities, including loss of functional independence and increased health care costs.² Previous studies have implicated screening for risk factors as a way to prevent pre- and postoperative delirium and therefore reduce the health care burden of this complication.^{7,23,24}

Preoperative measures of cognitive status can be used to identify at-risk patients, therefore decreasing health care resource utilization and costs. The Saint Louis University Mental Status (SLUMS) examination is a 30-point screening questionnaire that tests orientation, memory, attention, and executive functions. As an alternative to the Mini-Mental State Examination (MMSE) cognitive function

ABBREVIATIONS CAM = Confusion Assessment Method; MMSE = Mini-Mental State Examination; SLUMS = Saint Louis University Mental Status; SNF = skilled nursing facility.

SUBMITTED October 28, 2016. **ACCEPTED** May 30, 2017.

INCLUDE WHEN CITING Published online November 10, 2017; DOI: 10.3171/2017.5.SPINE161244.

test, SLUMS has been used to assess preoperative cognitive impairment.^{3,9,12} Previous studies have shown that cognitive impairment within the surgical population is associated with prolonged hospital stays, increased postoperative complications, and even death.^{8,14} In turn, preoperative mental health status has been shown to be one of the positive predictors of better outcomes after spinal surgery.²⁸ However, the role of preoperative cognitive impairment in the development of postoperative delirium in elderly patients undergoing spine surgery has not yet been delineated.

The aim of this study was to investigate the relationship between baseline cognitive status and postoperative delirium in geriatric patients undergoing surgery for degenerative scoliosis.

Methods

Patient Selection

This was a retrospective study of 82 adult patients undergoing elective spinal surgery for correction of adult degenerative scoliosis at a major academic medical center. Institutional review board approval was obtained prior to the study's initiation. We included patients 65 years and older with 1) back pain and/or radiculopathy, 2) radiographic evidence of thoracolumbar deformity, 3) failed nonsurgical treatment, and 4) history of multilevel lumbar decompression and fusion. Patients were excluded if they had severe coexistent pathology that could confound assessment of operative outcome or were unwilling to participate in the study. All patients had a minimum of 2 years of follow-up.

The evaluated demographic variables included patient age, sex, and body mass index. Comorbidities included hypertension, diabetes, cerebrovascular disease, coronary artery disease, congestive heart failure, atrial fibrillation, and prior myocardial infarction. Smoking status was also determined.

Assessment of Delirium Status

Preoperative cognition was assessed using the validated SLUMS examination.^{4,26} The SLUMS test comprises 11 questions, with a maximum score of 30 points. Mild cognitive impairment was defined as a SLUMS score between 21 and 26 points, while severe cognitive impairment was defined as a SLUMS score of ≤ 20 points. Normal cognition was defined as a SLUMS score of ≥ 27 points. Delirium was assessed daily using the Confusion Assessment Method (CAM) and rated as absent or present on the basis of the CAM.¹¹ The incidence of delirium was compared between patients with and without baseline cognitive impairment.

Postoperative Complications

We assessed postoperative complications for each patient included in the study. Surgical complications were defined as complications that were a direct result of the surgery. These complications included instrumentation failure requiring a revision procedure, surgical site infections (positive wound culture or antibiotics started), uncontrolled pain, new-onset sensory/motor deficits, or other

surgical complications. Nonsurgical complications were defined as complications that were a result of medical conditions not directly related to surgery. These complications included deep vein thrombosis, pulmonary embolism, myocardial infarction, chest pain, fever, and other medical complications.

30-Day Hospital Readmission Rate

We reviewed the hospital chart of each readmission to determine the cause of readmission. Unplanned readmissions were defined as either surgical or nonsurgical complications. Planned readmissions were defined as either a staged or rescheduled procedure. For staged procedures, patients were discharged with the expectation that they would be readmitted for the subsequent stage of the procedure. A rescheduled procedure occurred when the patient was admitted on the day of surgery, but surgery was cancelled and rescheduled within a month and the patient discharged. Planned readmissions were not included in the final data analysis and were not used to calculate the surgical readmission rates. Only unplanned hospital readmissions were included in the final analysis.

Postoperative Functional Status

Postoperative functional status variables included postoperative duration to first ambulation (i.e., number of days), distance ambulated on the 1st day of ambulation, distance ambulated at discharge, length of hospital stay, disposition status (i.e., discharge to home, a skilled nursing facility [SNF], or an acute rehabilitation facility), and the 30-day readmission rate.

Statistical Analysis

Parametric data were expressed as the mean $\pm$ SD and compared using the Student t-test. Nonparametric data are expressed as the median (interquartile range) and compared via the Mann-Whitney U-test. All tests were 2-sided and statistically significant at $p < 0.05$. All statistical analysis was performed using JMP (version 12; SAS Institute Inc.).

Results

Eighty-two elderly patients (57 patients with cognitive impairment and 25 patients without impairment) were included in this ambispective study (Table 1). There was a significant difference in age between groups (74.73 ± 6.38 years for patients with cognitive impairment vs 71.80 ± 5.79 years for patients without impairment; $p = 0.04$). There was no significant difference in body mass index between the cohorts (28.30 ± 6.70 kg/m² for patients with cognitive impairment vs 29.42 ± 4.41 kg/m² for patients without impairment; $p = 0.37$). The percentage of male patients was similar between cohorts (42.36% of patients with cognitive impairment vs 36.00% of patients without impairment; $p = 0.34$). There were no significant differences in the prevalence of other comorbidities such as hypertension, congestive heart failure, cerebrovascular disease, prior myocardial infarction, atrial fibrillation, diabetes, and smoking status. There was a significant difference in

TABLE 1. Baseline characteristics of elderly patients undergoing decompression and fusion surgery for correction of adult degenerative scoliosis

Characteristic	Cognitively Impaired	Not Impaired	p Value
No. of patients	57	25	
Patient age, mean $\pm$ SD, yrs	74.73 $\pm$ 6.38	71.80 $\pm$ 5.79	0.04
Body mass index, mean $\pm$ SD, kg/m ²	28.30 $\pm$ 6.70	29.42 $\pm$ 4.41	0.37
Male sex	42.36	36.00	0.34
Smoker	3.50	0.00	0.15
Congestive heart failure	5.26	4.00	0.80
Coronary artery disease	26.31	8.00	0.02
Cerebrovascular disease	7.01	8.00	0.88
Prior myocardial infarction	7.01	8.00	0.84
Hypertension	61.40	56.00	0.65
Atrial fibrillation	0.00	4.00	0.32
Diabetes	26.31	20.00	0.56

Both patient cohorts had similar baseline characteristics. Values are shown as the percentage of patients unless indicated otherwise.

coronary artery disease between the cohorts (26.31% of patients with cognitive impairment vs 8.00% of patients without impairment; $p = 0.02$).

The median (interquartile range) number of fusion levels was 6 (3–11). The duration of surgery ranged from 240 minutes to 480 minutes, with no correlation between severity of cognitive impairment and duration of surgery. Estimated blood loss ranged from 670 ml to 845 ml.

Incidental durotomy was not statistically different between cohorts (7.00% of patients with cognitive impairment vs 8.00% of patients without impairment; $p = 0.88$) (Table 2). There were no incidences of nerve root injury or spinal cord injury.

Postoperative Complications Profile

The incidences of delirium (19.29% of patients with cognitive impairment vs 8.00% of patients without impairment; $p = 0.01$), pneumonia (8.77% of patients with cognitive impairment vs 0.00% of patients without impairment; $p = 0.02$), and urinary tract infection (6.00% of patients with cognitive impairment vs 0.00% of patients without impairment; $p = 0.01$) were significantly higher in the cognitively impaired cohort (Table 2).

There were no significant differences in the incidence of ileus (7.01% of patients with cognitive impairment vs 8.00% of patients without impairment; $p = 0.88$), deep vein thrombosis (1.75% of patients with cognitive impairment vs 0.00% of patients without impairment; $p = 0.32$), pulmonary embolism (0.00% of patients with cognitive impairment vs 1.00% of patients without impairment; $p = 0.32$), hematoma (0.00% of patients with cognitive impairment vs 0.00% of patients without impairment; $p = 0.99$), sensorimotor deficits (1.75% of patients with cognitive impairment vs 4.00% of patients without impairment; $p = 0.61$), and myocardial infarction (0.00% of patients with cogni-

TABLE 2. Cohort-specific postoperative complication rates

Variable	Cognitively Impaired	Not Impaired	p Value
No. of patients	57	25	
Operative			
Intraop durotomy	7.00	8.00	0.88
Nerve root injury	0.00	0.00	1.00
Spinal cord injury	0.00	0.00	1.00
Postop			
Delirium	19.29	8.00	0.01
Ileus	7.01	8.00	0.88
Pneumonia	8.77	0.00	0.02
Urinary tract infection	6.00	0.00	0.01
Deep vein thrombosis	1.75	0.00	0.32
Pulmonary embolism	0.00	1.00	0.32
Hematoma	0.00	0.00	0.99
Sensorimotor deficits	1.75	4.00	0.61
Myocardial infarction	0.00	0.00	0.99
≥ 1 complication	39.00	20.00	0.15

Values are shown as the percentage of patients.

Bold values indicate statistical significance.

tive impairment vs 0.00% of patients without impairment; $p = 0.99$) (Table 2). The incidence of at least 1 postoperative complication was 48% higher in the cognitively impaired cohort; however, this finding was not statistically significant (39.00% of patients with cognitive impairment vs 20.00% of patients without impairment; $p = 0.15$).

Ambulation Status and Discharge Variables

The mean $\pm$ SD number of postoperative days from surgery to first ambulation was not significantly different between groups (1.50 $\pm$ 0.91 days for patients with cognitive impairment vs 1.76 $\pm$ 1.09 days for patients without impairment; $p = 0.30$). The distance walked at first ambulation was 27% farther in the nonimpaired cohort (95.08 $\pm$ 124.32 feet for patients with cognitive impairment vs 131.64 $\pm$ 111.55 feet for patients without impairment; $p = 0.19$). Similarly, at discharge, the patients without impairment ambulated 22% farther compared with patients without cognitive impairment (166.60 $\pm$ 141.68 feet for patients with cognitive impairment vs 214.20 $\pm$ 138.10 feet for patients without impairment; $p = 0.16$) (Table 3).

There was no significant difference in the average length of hospital stay between cohorts (5.33 $\pm$ 2.39 days for patients with delirium vs 5.48 $\pm$ 2.18 days for patients without delirium; $p = 0.78$) (Table 3). Compared with patients with cognitive impairment, the majority of patients without impairment were discharged directly home, with only a minority of patients requiring an additional stay at a postacute care facility (47.36% of patients with cognitive impairment vs 68.00% of patients without impairment were discharged home, $p = 0.08$; 49.12% patients with cognitive impairment vs 28.00% of patients without impairment were discharged to an SNF, $p = 0.06$; and 3.50%

TABLE 3. Total and cohort-specific differences in postoperative functional status

Variable	Delirium	No Delirium	p Value
No. of patients	57	25	
Surgery to ambulation, days	1.50 ± 0.91	1.76 ± 1.09	0.30
Distance walked on ambulatory Day 1, feet	95.08 ± 124.32	131.64 ± 111.55	0.19
Distance walked on day of discharge, feet	166.60 ± 141.68	214.20 ± 138.10	0.16
Length of stay, days	5.33 ± 2.39	5.48 ± 2.18	0.78
Discharge to home	47.36	68.00	0.08
Discharge to SNF	49.12	28.00	0.06
Discharge to acute rehabilitation facility	3.50	4.00	0.91
30-day readmission rate	12.80	12.00	0.73

Values are shown as the mean ± SD or percentage of patients.

of patients with cognitive impairment vs 4.00% of patients without impairment were discharged to an acute rehabilitation facility, $p = 0.91$) (Table 3). There was no significant difference in the 30-day unplanned readmission rate (12.80% of patients with cognitive impairment vs 12.00% of patients without impairment; $p = 0.73$) (Table 3).

Discussion

In this retrospective cohort study of elderly patients (> 65 years old) who underwent elective spinal surgery for adult degenerative scoliosis, we demonstrated that patients with preoperative cognitive impairment were at a greater than 2-fold risk of developing postoperative delirium.

Often undiagnosed, preoperative cognitive impairment has been previously shown to negatively affect surgical outcomes. In a retrospective study of 1771 surgical patients with impaired preoperative cognitive function, Gajdos et al. observed that impaired sensorium significantly independently increases postoperative morbidity and mortality.⁸ Robinson et al. found that in a prospective study of 186 elderly surgical patients, baseline cognitive impairment is associated with increased complications, length of stay, and long-term mortality.²¹ O'Brien et al. also found in a narrative review of adult patients undergoing surgery that postoperative cognitive dysfunction was associated with prolonged cognitive impairment, resulting in a longer length of hospital stay and increased 1-year mortality rates.¹⁸ Furthermore, in an ambispective study of 130 patients with Parkinson's disease undergoing deep brain stimulation, Abboud et al. found that the type of cognitive impairment (e.g., attention, visuospatial) was specifically associated with longer postoperative hospitalization, postoperative confusion, or poorer long-term outcomes.¹ In a prospective study of 37 patients undergoing total knee arthroplasty, Rodriguez et al. found that at 3 months postoperatively, all patients with cognitive impairment had at least 1 complication such as myocardial infarction, tran-

sient ischemia, atelectasis, excessive bleeding, postoperative desaturation, and compartment syndrome.²² Analogous to the aforementioned studies, our study showed similar negative associations between baseline cognitive impairment and the incidence of 1 or more postoperative complications, including ileus, pneumonia, deep vein thrombosis, and sensorimotor deficits.

Delirium is a postoperative complication that previously has been associated with cognitive impairment. In an ambispective study of 560 elderly surgical patients (> 70 years old), Inouye et al. observed that postoperative delirium was associated with lower preoperative cognitive performance, greater immediate postoperative cognitive impairment, and greater long-term cognitive decline.¹⁰ In another prospective study of 109 patients who underwent surgery for acute hip fracture, Koskderelioglu et al. found that cognitive impairment and depressive mood were the most strongly associated with postoperative delirium.¹³ Additionally, in a retrospective study of 107 patients undergoing elective cardiac surgery, Veliz-Reissmüller et al. found that patients with lower preoperative MMSE scores had an increased risk of developing postoperative delirium. Moreover, the authors found that delirious patients had a significant decline in postoperative MMSE scores compared with their nondelirious counterparts.²⁷ In a retrospective study of 102 patients undergoing coronary artery bypass grafting, Oldham et al. observed that mild cognitive impairment independently predicts postoperative delirium and delirium severity.¹⁹ Additionally, in a retrospective study of 688 adult surgical patients, Sprung et al. found that mild cognitive impairment was associated with an increased frequency of postoperative delirium.²⁵ Similarly, our study demonstrated that baseline cognitive impairment resulted in a 2-fold increase in postoperative incidence of delirium, implicating baseline cognitive status as a risk factor for developing postoperative delirium.

Compounded with the risk associated with preoperative cognitive impairment, postoperative delirium is associated with complications and negative outcomes. In a retrospective study of 578,457 elderly patients undergoing lumbar spine surgery, Fineberg et al. found that postoperative delirium was associated with increased length of stay and increased mortality.⁵ Similarly, in a retrospective study of elderly patients undergoing major surgery, Raats et al. observed that patients with postoperative delirium were more likely to have an increase in adverse events, length of hospital stay, and mortality.²⁰ In a retrospective study of patients undergoing surgery for aortic stenosis, Maniar et al. also found that postoperative delirium was associated with longer initial intensive care unit and hospital stays and intensive care unit readmissions. Moreover, Maniar et al. showed that postoperative delirium was associated with increased 30-day and 1-year mortality.¹⁶ In a retrospective study of 656 cardiac surgery patients, Mangusan et al. found that postoperative delirium was associated with increased length of stay and increased prevalence of falls, discharge to a nursing facility, and need for home health services or inpatient physical therapy, thereby suggesting decreased postoperative functional capacity.¹⁵ Although no difference in functional status was observed

and length of stay was comparable, we found that a greater percentage of patients with cognitive impairment required additional stay at a postacute care facility (i.e., SNF or acute rehabilitation facility).

Lastly, the increased incidence of postoperative complications and negative outcomes in patients with delirium is associated with increased health care utilization and costs. Franco et al., in a retrospective study of 500 patients undergoing surgery, found average direct health care costs to be higher in patients with delirium compared with patients without delirium (\$11,762.51 vs \$9,415.95).⁶ In a retrospective study of 116 patients undergoing surgery for hip fracture, Zywił et al. observed a mean incremental increase of \$8,286 in episode-of-care cost in patients with delirium compared with patients without delirium.²⁹ In another retrospective study of 500 patients undergoing surgical resection for esophageal malignancy, Markar et al. found that patients with delirium had an increased length of hospital stay and significant increase in cost compared with the nondelirium group (\$28,222.80 ± \$13,017.7 vs \$22,702.2 ± \$9,689.2; $p < 0.05$), thereby suggesting that the identification of at-risk patients prior to surgery may facilitate timely interventions and result in lower health care utilization rates and costs.¹⁷

This study has limitations, with ensuing possible implications in its interpretation. First, the data were obtained using chart reviews. Thus, they are limited by the information recorded during the episode of care and are subject to the weaknesses of a retrospective analysis. Second, cognitive status was only measured using one tool, SLUMS. This limits our ability to compare results to studies that used alternative methods to determine mental status. Lastly, the reviewed cohort size was small and possibly underpowered, thereby limiting our ability to make any definitive conclusions. Despite these limitations, the study suggests that baseline cognitive impairment is associated with increased incidence of postoperative delirium in elderly patients following surgery for correction of adult degenerative scoliosis.

Conclusions

Cognitive impairment is a risk factor for the development of postoperative delirium. Postoperative delirium may be associated with decreased preoperative cognitive reserve. Cognitive impairment assessments should be considered in the preoperative evaluations of elderly patients prior to surgery.

References

1. Abboud H, Floden D, Thompson NR, Genc G, Oravitanakul S, Alsallom F, et al: Impact of mild cognitive impairment on outcome following deep brain stimulation surgery for Parkinson's disease. **Parkinsonism Relat Disord** 21:249–253, 2015
2. American Geriatrics Society Expert Panel on Postoperative Delirium in Older Adults: Postoperative delirium in older adults: best practice statement from the American Geriatrics Society. **J Am Coll Surg** 220:136–148, 148.e1, 2015
3. Cruz-Oliver DM, Malmstrom TK, Roegner M, Tumosa N, Grossberg GT: Cognitive deficit reversal as shown by changes in the Veterans Affairs Saint Louis University Mental Status (SLUMS) examination scores 7.5 years later. **J Am Med Dir Assoc** 15:687.e5–687.e10, 2014
4. Feliciano L, Horning SM, Klebe KJ, Anderson SL, Cornwell RE, Davis HP: Utility of the SLUMS as a cognitive screening tool among a nonveteran sample of older adults. **Am J Geriatr Psychiatry** 21:623–630, 2013
5. Fineberg SJ, Nandyala SV, Marquez-Lara A, Oglesby M, Patel AA, Singh K: Incidence and risk factors for postoperative delirium after lumbar spine surgery. **Spine (Phila Pa 1976)** 38:1790–1796, 2013
6. Franco K, Litaker D, Locala J, Bronson D: The cost of delirium in the surgical patient. **Psychosomatics** 42:68–73, 2001
7. Freter S, Dunbar M, Koller K, MacKnight C, Rockwood K: Risk of pre- and post-operative delirium and the Delirium Elderly At Risk (DEAR) tool in hip fracture patients. **Can Geriatr J** 18:212–216, 2015
8. Gajdos C, Kile D, Hawn MT, Finlayson E, Henderson WG, Robinson TN: The significance of preoperative impaired sensorium on surgical outcomes in nonemergent general surgical operations. **JAMA Surg** 150:30–36, 2015
9. Howland M, Tatsuoka C, Smyth KA, Sajatovic M: Detecting Change over Time: A comparison of the SLUMS examination and the MMSE in older adults at risk for cognitive decline. **CNS Neurosci Ther** 22:413–419, 2016
10. Inouye SK, Marcantonio ER, Kosar CM, Tommet D, Schmitt EM, Trivison TG, et al: The short-term and long-term relationship between delirium and cognitive trajectory in older surgical patients. **Alzheimers Dement** 12:766–775, 2016
11. Inouye SK, van Dyck CH, Alessi CA, Balkin S, Siegel AP, Horwitz RI: Clarifying confusion: the confusion assessment method. A new method for detection of delirium. **Ann Intern Med** 113:941–948, 1990
12. Kaya D, Isik AT, Usarel C, Soysal P, Ellidokuz H, Grossberg GT: The Saint Louis University Mental Status Examination is better than the Mini-Mental State Examination to determine the cognitive impairment in Turkish elderly people. **J Am Med Dir Assoc** 17:370.e11–370.e15, 2016
13. Koskderelioglu A, Onder O, Gucuyener M, Altay T, Kayali C, Gedizlioglu M: Screening for postoperative delirium in patients with acute hip fracture: assessment of predictive factors. **Geriatr Gerontol Int**, 2016
14. Lee YS, Kim YB, Lee SH, Park YS, Park SW: The prevalence of undiagnosed presurgical cognitive impairment and its postsurgical clinical impact in older patients undergoing lumbar spine surgery. **J Korean Neurosurg Soc** 59:287–291, 2016
15. Mangusan RF, Hooper V, Denslow SA, Travis L: Outcomes associated with postoperative delirium after cardiac surgery. **Am J Crit Care** 24:156–163, 2015
16. Maniar HS, Lindman BR, Escallier K, Avidan M, Novak E, Melby SJ, et al: Delirium after surgical and transcatheter aortic valve replacement is associated with increased mortality. **J Thorac Cardiovasc Surg** 151:815–823, 823.e1–823.e2, 2016
17. Markar SR, Smith IA, Karthikesalingam A, Low DE: The clinical and economic costs of delirium after surgical resection for esophageal malignancy. **Ann Surg** 258:77–81, 2013
18. O'Brien H, Mohan H, Hare CO, Reynolds JV, Kenny RA: Mind over matter? The hidden epidemic of cognitive dysfunction in the older surgical patient. **Ann Surg** 265:677–691, 2017
19. Oldham MA, Hawkins KA, Yuh DD, Dewar ML, Darr UM, Lysy T, et al: Cognitive and functional status predictors of delirium and delirium severity after coronary artery bypass graft surgery: an interim analysis of the Neuropsychiatric Outcomes After Heart Surgery study. **Int Psychogeriatr** 27:1929–1938, 2015
20. Raats JW, van Eijnden WA, Crolla RM, Steyerberg EW, van der Laan L: Risk factors and outcomes for postoperative

- delirium after major surgery in elderly patients. **PLoS One** **10**:e0136071, 2015
21. Robinson TN, Wu DS, Pointer LF, Dunn CL, Moss M: Pre-operative cognitive dysfunction is related to adverse postoperative outcomes in the elderly. **J Am Coll Surg** **215**:12–18, 2012
22. Rodriguez RA, Tellier A, Grabowski J, Fazekas A, Turek M, Miller D, et al: Cognitive dysfunction after total knee arthroplasty: effects of intraoperative cerebral embolization and postoperative complications. **J Arthroplasty** **20**:763–771, 2005
23. Santos FS, Velasco IT, Fráguas R Jr: Risk factors for delirium in the elderly after coronary artery bypass graft surgery. **Int Psychogeriatr** **16**:175–193, 2004
24. Seo JS, Park SW, Lee YS, Chung C, Kim YB: Risk factors for delirium after spine surgery in elderly patients. **J Korean Neurosurg Soc** **56**:28–33, 2014
25. Sprung J, Roberts RO, Knopman DS, Petersen RC, Weingarten TN, Schroeder DR, et al: Perioperative delirium and mild cognitive impairment. **Mayo Clin Proc** **91**:273–274, 2016
26. Tariq SH, Tumosa N, Chibnall JT, Perry MH III, Morley JE: Comparison of the Saint Louis University mental status examination and the mini-mental state examination for detecting dementia and mild neurocognitive disorder—a pilot study. **Am J Geriatr Psychiatry** **14**:900–910, 2006
27. Veliz-Reissmüller G, Agüero Torres H, van der Linden J, Lindblom D, Eriksdotter Jönköping M: Pre-operative mild cognitive dysfunction predicts risk for post-operative delirium after elective cardiac surgery. **Aging Clin Exp Res** **19**:172–177, 2007
28. Wilson CA, Roffey DM, Chow D, Alkherayf F, Wai EK: A systematic review of preoperative predictors for postoperative clinical outcomes following lumbar discectomy. **Spine J** **16**:1413–1422, 2016
29. Zywił MG, Hurley RT, Perruccio AV, Hancock-Howard RL, Coyte PC, Rampersaud YR: Health economic implications of perioperative delirium in older patients after surgery for a fragility hip fracture. **J Bone Joint Surg Am** **97**:829–836, 2015

Disclosures

Dr. Karikari is a consultant for NuVasive.

Author Contributions

Conception and design: Adogwa. Acquisition of data: Adogwa, Elsamadicy. Analysis and interpretation of data: Adogwa, Elsamadicy. Drafting the article: Adogwa, Vuong, Fialkoff. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Adogwa. Administrative/technical/material support: Cheng, Karikari, Bagley. Study supervision: Adogwa, Bagley.

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