Published in final edited form as:
J Am Geriatr Soc. 2018 March ; 66(3): 584–589. doi:10.1111/jgs.15261.

Preoperative Cognitive Impairment as a Predictor of Postoperative Outcomes in a Collaborative Care Model

Kahli Zietlow, MD[1], **Shelley R. McDonald, DO, PhD**[1], **Richard Sloane, MPH**[2], **Jeffrey Browndyke, PhD**[3], **Sandhya Lagoo-Deenadayalan, MD, PhD**[4], and **Mitchell T. Heflin, MD, MHS**[1,2]

[1]Division of Geriatrics, Department of Internal Medicine, Duke University Health Systems, Durham, NC

[2]Center for Aging, Duke University Health Systems, Durham, NC

[3]Division of Geriatric Behavioral Health, Department of Psychiatry, Duke University Health Systems, Durham, NC

[4]Department of Surgery, Duke University Health Systems, Durham, NC

Abstract

Background/Objectives—One-third of elective surgeries are performed on older adults, and one-quarter of these adults have cognitive impairment (CI), which is associated with increased postoperative morbidity and mortality. The Perioperative Optimization of Senior Health (POSH) program is a Duke University-initiated comanagement model between surgery, anesthesia, and geriatrics. The objective of this analysis is to compare postoperative outcomes in POSH patients with and without CI.

Corresponding author: Kahli Zietlow, MD; Division of Geriatrics, Department of Internal Medicine, Duke University Health System; Address: GRECC (182) VAMC, 508 Fulton Street, Durham, NC 27705; Tel: 919-286-6932; Fax: 919-286-6823; Kahli.Zietlow@Duke.edu.

Conflict of Interest Disclosures

K Zietlow: Dr. Zietlow reports no conflicts of interest.
SR McDonald: Dr. McDonald reports grant support from the VA Office of Academic Affiliation for a Specialty Care Education Center of Excellence to develop the VA POSH program.
R Sloane: Mr. Sloane reports no conflicts of interest.
J Browndyke: Dr. Browndyke reports no conflicts of interest.
S Lagoo-Deenadayalan: Dr. Lagoo-Deenadayalan reports no conflicts of interest.
MT Heflin: Dr. Heflin reports 1) Author for Up to Date, Inc. and 2) Receives grant support from the VA Office of Academic Affiliation for a Specialty Care Education Center of Excellence to develop the VA POSH program.

Author Contributions

K Zietlow: Dr. Zietlow had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Dr. Zietlow contributed to the conception and design of the study, the data analysis, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.
S McDonald: Dr. McDonald contributed to the design of the study, the data analysis, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.
R Sloane: Mr. Sloane contributed to the design of the study, the data analysis, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.
J Browndyke: Dr. Browndyke contributed to the design of the study, the data analysis, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.
S Lagoo-Deenadayalan: Dr. Lagoo-Deenadayalan contributed to the design of the study, the data analysis, the data interpretation, the manuscript drafting, and the critical revision of the manuscript.
MT Heflin: Dr. Heflin contributed to the conception and design of the study, the supervision, data acquisition, analysis and interpretation, the manuscript drafting, and the critical revision of the manuscript.

Design—Retrospective analysis of patients enrolled in a quality improvement program.

Setting—Tertiary academic center.

Participants—157 patients undergoing surgery and referred to POSH.

Measurements—The presence of CI was determined by a score <25/30 (adjusted for education) on the Saint Louis University Mental Status (SLUMS) Exam. Median length of stay (LOS), mean number of postoperative complications, rates of postoperative delirium (POD, %), 30-day readmissions (%), and discharge to home (%) were compared via bivariate analysis.

Results—70% of participants met criteria for CI (mean SLUMS score 20.3 for those with CI and 27.7 for those without). The non-CI and CI populations did not significantly differ in demographics, number of medications (including anticholinergics or benzodiazepines), or burden of comorbidities. Patients with and without CI had similar LOS (p=0.99), cumulative number of complications (p=0.70), and 30-day readmission (p=0.20). POD was more common in those with CI (31% vs. 24%), but the difference was not significant (p=0.34). Patients without CI had higher rates of discharge to home (80.4% and 65.1%, p=0.05).

Conclusions—Older adults referred to the POSH program with and without CI fared similarly on most postoperative outcomes. Patients with CI may benefit from perioperative geriatric comanagement. Questions remain regarding the validity of available measures of cognition in the preoperative period.

Keywords

cognitive impairment; older adults; postoperative outcomes; co-management

---

Approximately one-third of elective surgical procedures are performed on adults over 65 years of age, and this population carries a high burden of postsurgical morbidity and mortality.[1] As the population ages, an increasing number of surgeries will be performed on these higher risk older adults.[2] Traditional preoperative risk assessment tools, such as the American Society of Anesthesiologists' Physical Classification System (ASA Class), focus on medical factors associated with risk of adverse postoperative outcomes.[3] However, such tools do not account for risk factors unique to older adults, such as malnourishment, impaired mobility, cognitive impairment (CI), or frailty. Geriatric-specific risk stratification models demonstrate improved ability to predict outcomes in older adults.[1,4] A growing literature supports incorporation of tools used for geriatric assessment as part of the preoperative evaluation of older adults undergoing elective surgery.[5–7] The Perioperative Optimization of Senior Health (POSH) program is an innovative care model developed at Duke University, which aims not only to accurately assess surgical risk in older adults, but to improve clinical outcomes through early multi-disciplinary risk assessment and targeted interventions throughout the perioperative period.[8]

Cognitive ability is one of the most important perioperative risk indicators, and the prevalence of both mild CI and dementia are expected to rise.[9] Preoperative CI, whether mild CI or dementia, has been linked to higher rates of postoperative delirium (POD),[10,11] which, in turn, has been associated with increased morbidity and long-term declines in functional status and cognition.[12,13] Despite these findings, there is scarce and inconsistent literature exploring whether CI itself is an independent risk factor for other postoperative complications. In fact, patients with CI are often excluded from clinical trials.[14–18] The aim of our study was to compare postoperative outcomes in patients enrolled in the POSH program with and without CI, as assessed by the Saint Louis University Mental Status (SLUMS) Exam.[19] As a secondary aim, we explored whether performance on SLUMS was predictive of POD.

METHODS

POSH Quality Improvement Program Description

The Duke University POSH program is a quality improvement (QI) initiative that began in 2011. Patients referred to the POSH program undergo multidisciplinary preoperative assessment. At their preoperative appointment, patients are evaluated by a nurse, social worker, geriatrician, and an anesthesia advanced practice provider. The team collaborates to collect relevant demographic and medical data. In addition to a comprehensive physical exam, cognition is screened via the SLUMS, which is administered by a trained provider to ensure standardization of scoring. A plan is developed to provide medical optimization prior to surgery, with particular attention to issues relevant to the geriatric population. Examples of issues addressed include establishing advanced directives, ensuring vision and hearing aids are available in the hospital, optimizing nutritional status, and discontinuing inappropriate medications.

Postoperatively, patients are admitted to surgical services with collaborative care by the geriatrics consult team, who assists with delirium prevention and care, management of medical comorbidities, pain control, promotion of mobility, and minimization of polypharmacy. The POSH service description and planned analyses were reviewed by the Internal Review Board at Duke and determined to be exempt as a QI project.

Participants

POSH program patients evaluated between July 2014 and June 2015 were eligible for this analysis. Patients undergoing elective, inpatient surgery were referred to POSH when the decision was made to proceed with a surgical intervention. Referral was at the discretion of their surgeon. Suggested eligibility criteria for referral included anyone aged 85 or older, as well as patients between 65 and 85 years of age who met at least one qualifying criteria, including pre-existing diagnosis of mild CI or dementia, poor nutritional status (defined as ≥ 10 pounds unintentional weight loss in the preceding 12 months and/or body mass index ≤ 23), visual impairment (binocular vision of 20/70 or worse), multimorbidity (presence of ≥ 2 chronic medical conditions), and polypharmacy (≥ 5 prescription medications).

Measures

Presence or absence of CI was assessed via SLUMS, which is a 30-point, 11-item cognitive screening tool developed to detect possible cognitive decline.[19] Thresholds for SLUMS scores suggestive of CI are adjusted based on education level. In patients with at least a high school level of education, a score of 27 or higher suggests grossly intact cognition. A score of 21–26 suggests the presence of mild CI, and a score of ≤ 20 suggests more severe deficits that may be reflective of dementia. These SLUMS total score thresholds are adjusted for individuals with less than a high school education (e.g., 20–24 suggestive of mild CI; ≥ 19 suggestive of dementia). We created a dichotomous sample of participants with or without CI based on their SLUMS performance and education level, i.e. a score < 27 for patients with a high-school level of education or a score < 25 for patients without a high school education indicates the presence of CI.

We compared baseline characteristics of POSH patients with and without CI, including demographic data, smoking status, alcohol intake, use of visual/hearing aids, and presence of comorbidities associated with increased risk of CI, including anxiety, depression, diabetes, obesity, hypertension, prior stroke and/or transient ischemic attack, and coronary artery disease.[20] Comorbidities were ascertained from review of medical records and patient report. In addition, we compared scores on the cumulative index rating scale, which generates a severity score for the degree of illness in 13 different body systems, with a higher score indicating an overall higher burden of illness.[17,21] We compared baseline number of medications, use of benzodiazepines, and anticholinergic burden as assed by the Anticholinergic Cognitive Burden Scale.[22] Finally, we determined baseline number of deficiencies in activities of daily living (ADL) and instrumental activities of daily living (iADL) as self-reported by patients or accompanying family members. Information from preoperative POSH assessment was entered and managed using Research Electronic Data Capture (REDCap), which is a secure, web-based application that provides audit trails for data tracking and export procedures.[23]

Outcomes data was assessed via patient-level institutional data from clinical, operational, administrative, and billing systems. Medical record numbers were used to obtain the length of stay (LOS), readmissions, and discharge destination. All 7- and 30-day readmission data were verified by chart review. POD was diagnosed by the inpatient geriatrics consult team using the Confusion Assessment Method (CAM) criteria, or CAM-ICU if appropriate.[24] CAM assessments were performed daily by the geriatrics consult team. Post-operative complications were obtained using International Classification of Diseases, Ninth Revision (ICD-9-CM) codes associated with the index surgical hospitalization obtained from billing data. Bivariate analyses were conducted to determine whether the presence of CI was associated with LOS, all-cause readmission rates at 7 or 30 days, discharge to home, incidence of POD, and a composite outcome of common postoperative medical complications (other than POD) that occurred during the course of hospitalization. Finally, we assessed the predictive ability of SLUMS to assess POD risk using receiver operating characteristic (ROC) curves.

Statistical Analysis

The main analytic aim of this study was to describe and compare characteristics, performance measures, and clinical outcomes of POSH surgical patients by cognitive status category based on SLUMS score. Bivariate analyses between CI groups were conducted using a chi-square test for categorical variables and the parametric t-test for continuous variables (if normally distributed) or the non-parametric Wilcoxon rank-sum test (if not normally distributed). A secondary aim was to explore the most informative SLUMS cut-point in this sample to inform the likelihood of POD. ROC analysis was used to determine the SLUMS score with optimal cut-point, primarily guided by inspecting the relative c-statistic values. All analyses were conducted using SAS version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Participants

A total of 157 patients were included in this analysis. The majority of patients resided at home prior to surgery (98.8%). 73 patients (46.5%) underwent neurosurgical procedures, 69 (43.9%) underwent general (i.e. gastrointestinal, hepatopancreaticobiliary, colorectal, and vascular), 12 (7.6%) urologic, 1 (0.6%) orthopedic, 1 (0.6%) cardiac, and 1 (0.6%) thoracic. At our institution, 19366 urologic surgeries, 2191 general surgeries, and 634 spinal neurosurgeries were performed electively on adults over 65 during the study period, meaning 0.06%, 3.1%, 11.5% of patients from each respective service were referred to POSH. There was no difference in the distribution of surgical services in the CI and non-CI groups. Frequency of laparoscopic versus open procedures on the general surgery service were similar between CI and non-CI patients (21.7% versus 23.5% respectively, p=0.79).

Based on their total SLUMS score, 106 (67.5%) patients met criteria for CI. The mean SLUMS score was 20.3 (standard deviation (SD) 4.8) in patients with CI and 27.7 (SD 2.9) in those without. The study groups were similar in terms of demographics, substance use, past medical history, and medication use (Table 1). The study groups only significantly differed in functional status; 20.8% of patients with CI were dependent in at least 1 ADL, compared to 5.8% of patients without CI (p=0.02). The proportion of patients with deficiencies in one or more iADL did not significantly differ (47.1% vs. 56.6%, p=0.26). Additionally, a trend in visual impairment between CI and non-CI groups was observed (90.6% in patients with CI vs. 80.4% in those without, p=0.07).

Outcomes

The two populations did not significantly differ in terms of median LOS, or 7- and 30-day readmission rates (Table 2). The patients with CI had higher rates of POD (31.4% vs. 24.0%), but this difference was not statistically significant (p=0.34). Rates of individual medical complications, excluding POD, were very low and did not significantly differ between the two populations (Table 3). Likewise, a composite outcome of the total number of medical complications was not significantly different between the two groups. Patients with CI had a lower rate of discharge to home versus other destination (skilled nursing facility, assisted living facility, or hospice, 65.1 vs. 80.4%, p=0.05).

SLUMS as a Predictor of Postoperative Delirium

ROC curves revealed an equivocal predictive capacity of SLUMS for POD (Supplemental Figure 1). At the traditional cut-points of 27 and 25 (i.e., the cut-points for mild CI in patients with and without high school education, respectively), as well as 20 and 19 (i.e., the cut-points for dementia), the c-statistic was <0.60 for all reported values. The optimal predictive value for the SLUMS occurred at a score of 19 (0–19 vs. 20+), with a c-statistic of 0.54.

DISCUSSION

Available data suggests that preexisting CI predicts incident POD, which, in turn, can impair long-term cognitive functioning.[10,15,25] Preoperative CI has also been linked to the incidence of other adverse outcomes, including postoperative complications, longer LOS, and functional decline.[26–29] Nonetheless, there is limited data available on the association between preoperative CI and postoperative outcomes.[30,31] Furthermore, patients with CI are often excluded from clinical trials.[18]

In this analysis comparing patients with and without CI undergoing elective surgery, patients with CI had higher rates of discharge to facility compared to patients without CI. This is not a surprising outcome, since patients with CI would be less likely to function independently following surgery. Given the low rates of patients residing in ALF preoperative (1.2%), we do not think their prior home environment meaningfully impacted discharge destination.

Yet patients with CI did not have longer LOS or higher readmission rates compared to their cognitively intact counterparts. Likewise, patients with CI did not have significantly different rates of POD or other postoperative complications. There are a number of possible explanations for this finding. In our study population, the rate of CI was 64%, which is much higher than the rate of CI in the general population (estimated to be 20–25%). This high rate may represent preferential referrals of patients with CI from participating surgeons. Additionally, the fatigue of multiple provider visits, the stress of upcoming surgery, and/or the predisposing medical condition necessitating surgery may contribute to poor performance on cognitive screening, artificially inflating the rates of CI in the preoperative evaluation setting. Thus, it is possible that overestimation of rates of CI do not reflect clinically meaningful disease, hence the similar outcomes in patients with and without CI in our study population.

A second explanation is that patients may have benefited from the geriatric comanagement model, mitigating the risk of CI on postoperative adverse events. Using a multidisciplinary approach, POSH providers address and optimize geriatric syndromes, such as malnutrition and polypharmacy, prior to surgery. Postoperatively, geriatric comanagement allows for early and aggressive management of delirium, pain, mobility, nutrition, and multimorbidity, which may consequently improve patient outcomes, particularly in high-risk CI patients. Larger studies are needed to confirm these findings, however, if our results bear out, this indicates the critical importance of identifying preoperative CI. Identification of these individuals who traditionally carry a much higher perioperative risk will allow for targeted resource allocation and ideally risk mitigation via a geriatric comanagement model.

SLUMS is a brief, validated assessment tool that screens for mild CI and dementia.[19,32] SLUMS content emphasizes executive functioning and episodic memory, allowing earlier detection of subtle deficits associated with mild CI, as compared to the Mini-Mental State Examination.[33] SLUMS takes approximately 10 minutes to administer, making it a viable option in a busy preoperative setting, and has demonstrated similar diagnostic utility for mild CI and dementia compared to longer screening tests, such as the Montreal Cognitive Assessment test.[34] Despite the benefits of SLUMS, there is a paucity of data examining whether a person's performance on this cognitive screen is linked to health outcomes. A single study found that lower SLUMS scores were associated with increased risk of institutionalization and death in an ambulatory veteran population, but no studies have specifically examined the role of SLUMS in preoperative screening.[35] Our data suggest that preoperative SLUMS scores may have limited predictive capacity for POD, with the highest c-statistic on ROC being only 0.54.

This study must be considered in light of its limitations. This is a small, exploratory study, and may be underpowered to detect meaningful differences in outcomes of populations with and without CI. The imbalance of CI and non-CI sample sizes (i.e. two thirds of the study group having CI) further limits our ability to detect differences. Additionally, we had a highly-educated population, and over half of the study population was referred from neurosurgery services. This may limit the generalizability of the data.

In summary, CI is logically associated with adverse health outcomes for older adults in the perioperative period. Cognitive disorders affect patients' ability to properly manage medications, provide local wound care, and engage with ancillary providers such as physical therapists. Identification of higher risk individuals, particularly when considering comanagement with a geriatrics team, allows for appropriate resource utilization.

More research is needed to develop valid measures of CI that are sensitive enough to detect meaningful CI, but also brief enough to allow convenient deployment in a busy preoperative clinical setting. Moreover, specific cognitive domains, such as executive functioning, may have stronger predictive capacity for postoperative outcomes.[36,37] Understanding the relationship between these domains and risk of delirium would allow for improved identification of the highest risk patients, as well as allow for targeted optimization and resource allocation. Such strategies will help both surgeons and patients better understand perioperative risks and benefits, thereby encouraging effective shared decision-making models.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors would like to acknowledge Heather Whitson, MD for her assistance in reviewing this manuscript.

Funding sources: Eugene Stead Award, Department of Internal Medicine, Duke University Health Systems; The Brookdale Foundation, The Hartford Foundation, Health Resources and Services Administration (HRSA), and NIH/NHLBI HL109971.

Sponsor's Role

Sponsors provided funding for salary support, statistical analysis, and manuscript editing services.

References

1. Oresanya LB, Lyons WL, Finlayson E. Preoperative assessment of the older patient: a narrative review. JAMA. 2014; 311:2110–2120. [PubMed: 24867014]
2. Ortman, JM., Velkoff, VA., Hogan, H. An aging nation: the older population in the United States, Report number: P25-1140. United States Census Bureau; web site. https://www.census.gov/library/publications/2014/demo/p25-1140.html Updated May 316 30, 2017. Accessed June 18, 2017
3. American Society of Anesthesiologists (ASA). ASA Physical Status Classification System. ASA; web site. https://www.asahq.org/resources/clinical-information/asa-physical-status-classification-system. Last approved by the ASA House of Delegates on October 15, 2014. Accessed June 18, 2017
4. Tran Ba Loc P, du Montcel ST, Duron JJ, et al. Elderly POSSUM, a dedicated score for prediction of mortality and morbidity after major colorectal surgery in older patients. Br J Surg. 2010; 97:396–403. [PubMed: 20112252]
5. Chow WB, Rosenthal RA, Merkow RP, et al. Optimal preoperative assessment of the geriatric surgical patient: a best practices guideline from the American College of Surgeons National Surgical Quality Improvement Program and the American Geriatrics Society. J Am Coll Surg. 2012; 215:453–466. [PubMed: 22917646]
6. Cohen RR, Lagoo-Deenadayalan SA, Heflin MT, et al. Exploring predictors of complication in older surgical patients: a deficit accumulation index and the Braden Scale. J Am Geriatr Soc. 2012; 60:1609–1615. [PubMed: 22906222]
7. Partridge JS, Harari D, Martin FC, et al. The impact of pre-operative comprehensive geriatric assessment on postoperative outcomes in older patients undergoing scheduled surgery: a systematic review. Anaesthesia. 2014; 69:8–16. [PubMed: 24303856]
8. McDonald SR, Heflin MT, Whitson HE, Dalton TO, Lidsky ME, Liu P, Poer CM, Sloane RJ, Thacker JKM, White HK, Yanamadala M, Lagoo-Deenadayalan SA. Association of Integrated Care Coordination with Postsurgical Outcomes in High-Risk Older Adults: The Perioperative Optimization of Senior Health (POSH) Initative. JAMA Surg. :2017. accepted for publication September 24, 2017.
9. Kim S, Brooks AK, Groban L. Preoperative assessment of the older surgical patient: honing in on geriatric syndromes. Clin Interv Aging. 2014; 10:13–27. [PubMed: 25565783]
10. Ansaloni L, Catena F, Chattat R, et al. Risk factors and incidence of postoperative delirium in elderly patients after elective and emergency surgery. Br J Surg. 2010; 97:273–280. [PubMed: 20069607]
11. Raats JW, Steunenberg SL, de Lange DC, et al. Risk factors of post-operative delirium after elective vascular surgery in the elderly: a systematic review. Int J Surg. 2016; 35:1–6. [PubMed: 27613124]
12. Saczynski JS, Marcantonio ER, Quach L, et al. Cognitive trajectories after postoperative delirium. N Engl J Med. 2012; 367:30–39. [PubMed: 22762316]
13. Devore EE, Fong TG, Marcantonio ER, et al. Prediction of long-term cognitive decline following postoperative delirium in older adults. J Gerontol A Biol Sci Med Sci. 2017; [Epub ahead of print]. doi: 10.1093/gerona/glx030
14. Aykut K, Albayrak G, Guzeloglu M, et al. Preoperative mild cognitive dysfunction predicts pulmonary complications after coronary artery bypass graft surgery. J Cardiothorac Vasc Anesth. 2013; 27:1267–1270. [PubMed: 23953869]
15. Messerotti Benvenuti S, Patron E, Zanatta P, et al. Preexisting cognitive status is associated with reduced behavioral functional capacity in patients 3 months after cardiac surgery: an extension study. Gen Hosp Psychiatry. 2014; 36:368–374. [PubMed: 24684903]
16. Daigle CR, Schauer PR, Heinberg LJ. Bariatric surgery in the cognitively impaired. Surg Obes Relat Dis. 2015; 11:711–714. [PubMed: 26093770]
17. Miller MD, Paradis CF, Houck PR, et al. Rating chronic medical illness burden in geropsychiatric practice and research: application of the Cumulative Illness Rating Scale. Psychiatry Res. 1992; 41:237–248. [PubMed: 1594710]

18. Mundi S, Chaudhry H, Bhandari M. Systematic review on the inclusion of patients with cognitive impairment in hip fracture trials: a missed opportunity? Can J Surg. 2014; 57:E141–145. [PubMed: 25078940]
19. Tariq SH, Tumosa N, Chibnall JT, et al. 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. 2006; 14:900–910. [PubMed: 17068312]
20. Sindi S, Mangialasche F, Kivipelto M. Advances in the prevention of Alzheimer's disease. F1000Prime Rep. 2015; 7:50. [PubMed: 26097723]
21. Salvi F, Miller MD, Grilli A, et al. A manual of guidelines to score the modified cumulative illness rating scale and its validation in acute hospitalized elderly patients. J Am Geriatr Soc. 2008; 56:1926–1931. [PubMed: 18811613]
22. Boustani M, Campbell N, Munger S, et al. Impact of anticholinergics on the aging brain: a review and practical application. Aging Health. 2008; 4:311–320.
23. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform. 2009; 42:377–381. [PubMed: 18929686]
24. Inouye SK, van Dyck CH, Alessi CA, et al. Clarifying confusion: the confusion assessment method. A new method for detection of delirium. Ann Intern Med. 1990; 113:941–948. [PubMed: 2240918]
25. Koskderelioglu A, Onder O, Gucuyener M, et al. Screening for postoperative delirium in patients with acute hip fracture: assessment of predictive factors. Geriatr Gerontol Int. 2016; [Epub ahead of print]. doi: 10.1111/ggi.12806
26. Benedetti MG, Ginex V, Mariani E, et al. Cognitive impairment is a negative short-term and long-term prognostic factor in elderly patients with hip fracture. Eur J Phys Rehabil Med. 2015; 51:815–823. [PubMed: 25998064]
27. Kistler EA, Nicholas JA, Kates SL, et al. Frailty and short-term outcomes in patients with hip Fracture. Geriatr Orthop Surg Rehabil. 2015; 6:209–214. [PubMed: 26328238]
28. Pogliacomi F, Schiavi P, Defilippo M, et al. Total elbow arthroplasty following complex fractures of the distal humerus: results in patients over 65 years of age. Acta Biomed. 2016; 87:148–155. [PubMed: 27648996]
29. Culley DJ, Flaherty D, Fahey MC, et al. Poor Performance on a Preoperative Cognitive Screening Test Predicts Postoperative Complications in Older Orthopedic Surgical Patients. Anesthesiology. 2017; 127:765–774. [PubMed: 28891828]
30. Devore EE, Fong TG, Marcantonio ER, et al. Prediction of Long-term Cognitive Decline Following Postoperative Delirium in Older Adults. J Gerontol A Biol Sci Med Sci. 2017; [Epub ahead of print]. doi: 10.1093/gerona/glx030
31. Jones RN, Marcantonio ER, Saczynski JS, et al. Preoperative Cognitive Performance Dominates Risk for Delirium Among Older Adults. J Geriatr Psychiatry Neurol. 2016; 29:320–327.
32. Feliciano L, Horning SM, Klebe KJ, et al. Utility of the SLUMS as a cognitive screening tool among a nonveteran sample of older adults. Am J Geriatr Psychiatry. 2013; 21:623–630. [PubMed: 23567386]
33. Stewart S, O'Riley A, Edelstein B, et al. A preliminary comparison of three cognitive screening instruments in long term care: the MMSE, SLUMS, and MoCA. Clin Gerontol. 2012; 35:57–75.
34. Cummings-Vaughn LA, Chavakula NN, Malmstrom TK, et al. Veterans Affairs Saint Louis University Mental Status examination compared with the Montreal Cognitive Assessment and the Short Test of Mental Status. J Am Geriatr Soc. 2014; 62:1341–1346. [PubMed: 24916485]
35. Cruz-Oliver DM, Malmstrom TK, Allen CM, et al. The Veterans Affairs Saint Louis University mental status exam (SLUMS exam) and the Mini-Mental Status Exam as predictors of mortality and institutionalization. J Nutr Health Aging. 2012; 16:636–641. [PubMed: 22836706]
36. Smith PJ, Attix DK, Weldon BC, et al. Executive Function and Depression as Independent Risk Factors for Postoperative Delirium. Anesthesiology. 2009; 110:781–787. [PubMed: 19326492]

37. Rudolph JL, Jones RN, Grande LJ, et al. Impaired executive function is associated with delirium after coronary artery bypass graft surgery. J Am Geriatr Soc. 2006; 54:937–941. [PubMed: 16776789]

Table 1

Participant Baseline Characteristics

Variable	No Cognitive Impairment	Cognitivie Impairment	p-value
	N=51	N=106	
Demographic data N (%)			
Age, median	73.7 (5.8)	75.5 (7.5)	0.11
Male sex	23 (46.0)	53 (52.0)	0.49
High school grad	45 (88.2)	92 (86.8)	0.80
Medical history			
Current or prior smoker	23 (46.0)	58 (56.9)	0.21
Alcohol, 1+ drink per week	11 (22.0)	16 (15.1)	0.29
Vision impairment	41 (80.4)	96 (90.6)	0.07
Hearing impairment	16 (31.4)	46 (43.4)	0.15
BMI	29.5	28.2	0.20
Cumulative illness rating	7.8	8.7	0.14
Anxiety	15 (29.1)	31 (29.25)	0.98
Depression	15 (29.1)	34 (32.1)	0.74
Diabetes	12 (23.5)	25 (23.6)	0.99
Obesity	12 (23.5)	24 (22.6)	0.90
HTN	12 (23.5)	36 (34.0)	0.18
History of stroke or TIA	3 (5.9)	14 (13.2)	0.17
CAD	15 (29.4)	34 (32.1)	0.74
Pharmacy			
Medications, mean (SD)	12.0 (7.4)	12.4 (5.8)	0.70
Anticholinergic burden, mean (SD)	1.12 (1.8)	1.21 (1.65)	0.75
Benzodiazepine use	9 (17.7)	19 (18.1)	0.94
Functional status			
One or more deficiencies in ADLs	3 (5.6)	22 (20.8)	0.02
One or more deficiencies in instrumental ADLs	24 (47.1)	60 (56.6)	0.26

ADL = activities of daily living; CAD, coronary artery disease; HTN, hypertension; SD, standard deviation; TIA, transient ischemic attack.

Anticholinergic burden assessed from the Anticholinergic Burden Scale.[23] Benzodiazepine use is number of patients actively using one or more benzodiazepine.

Table 2

Outcomes Data

Utilizations/Complications	No Cognitive Impairment	Cognitive Impairment	p-value
	N=51	N=106	
Median LOS	4.0	4.0	0.99
Readmissions (7-day)	0 (0.0)	3 (2.83)	0.23
Readmission (30-day)	6 (11.8)	11 (10.4)	0.79
Discharge to home	41 (80.4)	69 (65.1)	0.05*
Postoperative delirium	12 (24.0)	33 (31.4)	0.34
Postoperative complications, number, mean (SD)	0.88 (0.55)	0.98 (0.65)	0.71

All abbreviations can be found in Table 1.

Table 3

Rates of Individual Postoperative Adverse Events, Other Than Postoperative Delirium

Complication	No Cognitive Impairment	Cognitive Impairment
	N=51	N=106
DVT/PE	1 (2.0)	1 (0.9)
Wound infection	0 (0)	2 (1.9)
Wound dehiscence	0 (0)	0 (0)
Urinary tract infection	0 (0)	3 (2.8)
Urinary retention	2 (3.9)	5 (4.7)
Pneumonia	2 (3.9)	2 (1.9)
Sepsis	1 (2.0)	4 (3.8)
Cardiac arrhythmia	3 (5.9)	9 (8.5)
Acute coronary syndrome	1 (2.0)	1 (0.9)
Cardiac arrest	1 (2.0)	2 (1.9)
Acute cerebral vascular accident	0 (0)	2 (1.9)
Ileus	1 (2.0)	1 (0.9)
Nausea/vomiting	7 (13.7)	7 (6.6)
Acute kidney injury	5 (9.8)	9 (8.5)
Hemorrhage	2 (3.9)	4 (3.8)
Hypoglycemia	0 (0)	0 (0)
Hyperglycemia	1 (2.0)	3 (1.9)
Falls	0 (0)	1 (0.9)
Pressure ulcers	0 (0)	0 (0)
Alcohol withdrawal	0 (0)	0 (0)

DVT/PE = deep vein thrombosis/pulmonary embolism; All other abbreviations can be found in Table 1.