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

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OBJECTIVES: To compare postoperative outcomes of individuals with and without cognitive impairment enrolled in the Perioperative Optimization of Senior Health (POSH) program at Duke University, a comanagement model involving surgery, anesthesia, and geriatrics.

DESIGN: Retrospective analysis of individuals enrolled in a quality improvement program.

SETTING: Tertiary academic center.

PARTICIPANTS: Older adults undergoing surgery and referred to POSH (N = 157).

MEASUREMENTS: Cognitive impairment was defined as a score less than 25 out of 30 (adjusted for education) on the St. Louis University Mental Status (SLUMS) Examination. Median length of stay (LOS), mean number of postoperative complications, rates of postoperative delirium (POD, %), 30-day readmissions (%), and discharge to home (%) were compared using bivariate analysis.

RESULTS: Seventy percent of participants met criteria for cognitive impairment (mean SLUMS score 20.3 for those with cognitive impairment and 27.7 for those without). Participants with and without cognitive impairment did not significantly differ in demographic characteristics, number of medications (including anticholinergics and benzodiazepines), or burden of comorbidities. Participants with and without cognitive impairment had similar LOS ($P = .99$), cumulative number of complications ($P = .70$), and 30-day readmission ($P = .20$). POD was more common in those with cognitive impairment (31% vs 24%), but the difference was not significant ($P = .34$). Participants without cognitive impairment had higher rates of discharge to home (80.4% vs 65.1%, $P = .05$).

CONCLUSION: Older adults with and without cognitive impairment referred to the POSH program fared similarly on most postoperative outcomes. Individuals with

cognitive impairment may benefit from perioperative geriatric comanagement. Questions remain regarding the validity of available measures of cognition in the preoperative period. *J Am Geriatr Soc* 2018.

Key words: cognitive impairment; older adults; postoperative outcomes; co-management

Approximately one-third of elective surgical procedures are performed on adults aged 65 and older, and this population has 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 (ASA) Physical Classification System, focus on medical factors associated with risk of adverse postoperative outcomes,³ but such tools do not account for risk factors unique to older adults such as malnourishment, impaired mobility, cognitive impairment, and frailty. Geriatric-specific risk stratification models are better able 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 that aims not only to assess surgical risk in older adults accurately, but also to improve clinical outcomes through early multidisciplinary 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 mild cognitive impairment (MCI) and dementia are expected to rise.⁹ Preoperative cognitive impairment, whether MCI or dementia, has been linked to higher rates of postoperative delirium (POD),^{10,11} which, in turn, has been associated with greater morbidity and long-term declines in functional status and cognition.^{12,13} Despite these findings, the literature

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exploring whether cognitive impairment itself is an independent risk factor for other postoperative complications is scarce and inconsistent, and individuals with cognitive impairment are often excluded from clinical trials.^{14–18} The aim of our study was to compare postoperative outcomes in individuals enrolled in the POSH program with and without cognitive impairment as assessed using the St. Louis University Mental Status (SLUMS) Examination.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 initiative that began in 2011. Individuals referred to the POSH program undergo multidisciplinary preoperative assessment. At their preoperative appointment, a nurse, social worker, geriatrician, and anesthesia advanced practice provider evaluate them. The team collaborates to collect relevant demographic and medical data. In addition to a comprehensive physical examination, cognition is screened using the SLUMS, which a trained provider administers to ensure standardization of scoring. A plan is developed to provide medical optimization before surgery, with particular attention to factors relevant to older adults. Examples of things addressed include establishing advance directives, ensuring that vision and hearing aids are available in the hospital, optimizing nutritional status, and discontinuing inappropriate medications.

Postoperatively, individuals are admitted to surgical services with collaborative care from the geriatrics consultation team, which assists with delirium prevention and care, management of medical comorbidities, pain control, promotion of mobility, and minimization of polypharmacy. The internal review board at Duke reviewed the POSH service description and planned analyses and determined them to be exempt as a quality improvement project.

Participants

POSH program participants evaluated between July 2014 and June 2015 were eligible for this analysis. Individuals 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 surgeons. Suggested eligibility criteria for referral included age 85 and older or aged 65 to 84 and meeting at least one qualifying criterion: preexisting diagnosis of MCI or dementia, poor nutritional status (≥ 10 pounds unintentional weight loss in preceding 12 months or body mass index ≤ 23.0 kg/m²), visual impairment (binocular vision $\leq 20/70$), multimorbidity (≥ 2 chronic medical conditions), and polypharmacy (≥ 5 prescription medications).

Measures

Presence or absence of cognitive impairment was assessed using SLUMS, which is a 30-point, 11-item cognitive

screening tool developed to detect possible cognitive decline.¹⁹ Thresholds for SLUMS scores suggestive of cognitive impairment are adjusted for education level. In individuals with at least a high school level of education, a score of 27 or higher suggests grossly intact cognition, a score of 21 to 26 suggests MCI, and a score less than 21 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 (20–24 suggestive of MCI; ≤ 19 suggestive of dementia). We created a dichotomous sample of participants with and without cognitive impairment based on their SLUMS performance and education level (cognitive impairment defined as < 27 for individuals with a high school level of education, < 25 for individuals without a high school education).

We compared baseline characteristics of POSH participants with and without cognitive impairment, including demographic data, smoking status, alcohol intake, use of vision and hearing aids, and presence of comorbidities associated with cognitive impairment, including anxiety, depression, diabetes, obesity, hypertension, prior stroke or transient ischemic attack, and coronary artery disease.²⁰ Comorbidities were ascertained from review of medical records and self-report. We also compared Cumulative Index Rating Scale scores, which is a severity score for degree of illness in 13 body systems, with higher scores indicating overall higher burden of illness.^{17,21} We compared baseline number of medications, use of benzodiazepines, and anticholinergic burden as assessed using the Anticholinergic Cognitive Burden Scale.²² Finally, we determined baseline number of deficiencies in activities of daily living (ADLs) and instrumental activities of daily living (IADLs) as participants or accompanying family members reported. Information from a preoperative POSH assessment was entered and managed using Research Electronic Data Capture (REDCap), a secure, web-based application that provides audit trails for data tracking and export procedures.²³

Outcomes data was assessed using individual-level institutional data from clinical, operational, administrative, and billing systems. Medical record numbers were used to obtain information on length of stay (LOS), readmissions, and discharge destination. All 7- and 30-day readmission data were verified using chart review. The inpatient geriatrics consultation team diagnosed POD using the Confusion Assessment Method (CAM) criteria or the CAM-ICU, if appropriate.²⁴ The geriatrics consultation team performed CAM assessments daily. Postoperative complications were identified according to *International Classification of Diseases, Ninth Revision, Clinical Modification* codes associated with the index surgical hospitalization obtained from billing data. Bivariate analyses were conducted to determine whether cognitive impairment was associated with LOS, all-cause 7- or 30-day readmission rates, 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 analytical aim of this study was to describe and compare characteristics, performance measures, and clinical outcomes of POSH participants undergoing surgery according to cognitive status category based on SLUMS score. Bivariate analyses of cognitive impairment groups were conducted using the chi-square test for categorical variables and the parametric t-test for continuous variables (if normally distributed) or the nonparametric 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 the optimal cut-point, primarily guided by inspecting relative c-statistic values. All analyses were conducted using SAS version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Participants

One hundred fifty-seven individuals were included in this analysis. The majority resided at home before surgery (98.8%). Seventy-three (46.5%) underwent neurosurgical procedures, 69 (43.9%) general (gastrointestinal, hepatopancreatobiliary, colorectal, vascular), 12 (7.6%) urological, 1 (0.6%) orthopedic, 1 (0.6%) cardiac, and 1 (0.6%) thoracic. At Duke University Health Systems, 19,366 urological surgeries, 2,191 general surgeries, and 634 spinal neurosurgeries were performed electively on

adults aged 65 and older during the study period, meaning that 0.06%, 3.1%, and 11.5% of individuals from each service, respectively, were referred to POSH. There was no difference in distribution of surgical services of participants with and without cognitive impairment. Frequency of laparoscopic and open procedures on the general surgery service was similar between participants with and without cognitive impairment (21.7% and 23.5% laparoscopic procedures respectively, $P=0.79$).

Based on their total SLUMS scores, 106 (67.5%) participants met criteria for cognitive impairment. Mean SLUMS score was 20.3 ± 4.8 in participants with cognitive impairment and 27.7 ± 2.9 in those without. The study groups were similar in terms of demographic characteristics, substance use, past medical history, and medication use (Table 1). The study groups differed significantly only in functional status; 20.8% of participants with cognitive impairment and 5.8% of participants without were dependent in at least 1 ADL ($P = .02$). The proportion of participants with deficiencies in one or more IADLs did not significantly differ (47.1% vs 56.6%, $P = .26$). Additionally, a nonsignificant difference in visual impairment was observed between participants with (90.6%) and without (80.4%) cognitive impairment ($P = .07$).

Outcomes

The two populations did not significantly differ in terms of median LOS, or 7- and 30-day readmission rates (Table 2). Participants with cognitive impairment had higher rates of POD (31.4% vs 24.0%), but this difference

Table 1. Participant Baseline Characteristics

Variable	No Cognitive Impairment, n = 51	Cognitive Impairment, n = 106	P-Value
Demographic data			
Age, median (SD)	73.7 (5.8)	75.5 (7.5)	.11
Male, n (%)	23 (46.0)	53 (52.0)	.49
High school graduate, n (%)	45 (88.2)	92 (86.8)	.80
Medical history			
Current or prior smoker, n (%)	23 (46.0)	58 (56.9)	.21
Alcohol, ≥ 1 drinks per week, n (%)	11 (22.0)	16 (15.1)	.29
Vision impairment, n (%)	41 (80.4)	96 (90.6)	.07
Hearing impairment, n (%)	16 (31.4)	46 (43.4)	.15
Body mass index, kg/m ² mean	29.5	28.2	.20
Cumulative Illness Rating Scale score, mean	7.8	8.7	.14
Anxiety, n (%)	15 (29.1)	31 (29.25)	.98
Depression, n (%)	15 (29.1)	34 (32.1)	.74
Diabetes, n (%)	12 (23.5)	25 (23.6)	.99
Obesity, n (%)	12 (23.5)	24 (22.6)	.90
Hypertension, n (%)	12 (23.5)	36 (34.0)	.18
History of stroke or transient ischemic attack, n (%)	3 (5.9)	14 (13.2)	.17
Coronary artery disease	15 (29.4)	34 (32.1)	.74
Pharmacy			
Number of medications, mean $\pm$ SD	12.0 $\pm$ 7.4	12.4 $\pm$ 5.8	.70
Anticholinergic burden, mean $\pm$ SD ^a	1.12 $\pm$ 1.8	1.21 $\pm$ 1.65	.75
Benzodiazepine use, n (%)	9 (17.7)	19 (18.1)	.94
≥ 1 ADL deficiencies, n (%)	3 (5.6)	22 (20.8)	.02
≥ 1 instrumental ADL deficiencies, n (%)	24 (47.1)	60 (56.6)	.26

^aAssessed using the Anticholinergic Burden Scale.²³

ADL = activity of daily living; SD = standard deviation.

Table 2. Outcome Data

Use and Complications	No Cognitive Impairment, n = 51	Cognitive Impairment, n = 106	P-Value
Length of stay, days, median	4.0	4.0	.99
7-day readmissions, n (%)	0 (0.0)	3 (2.8)	.23
30-day readmissions, n (%)	6 (11.8)	11 (10.4)	.79
Discharged to home, n (%)	41 (80.4)	69 (65.1)	.05
Postoperative delirium, n (%)	12 (24.0)	33 (31.4)	.34
Number of postoperative complications, mean $\pm$ standard deviation	0.88 $\pm$ 0.55	0.98 $\pm$ 0.65	.71

Table 3. Individual Postoperative Adverse Events Other Than Postoperative Delirium

Complication	No Cognitive Impairment, n = 51 n (%)	Cognitive Impairment, n = 106 n (%)
Deep vein thrombosis, pulmonary embolism	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)

was not statistically significant ($P = .34$). Rates of individual medical complications, excluding POD, were low and did not differ significantly 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. Participants with cognitive impairment had a lower rate of discharge to home (80.4%) than to other destinations (skilled nursing facility, assisted living facility, or hospice, 65.1%, $P = .05$).

SLUMS As a Predictor of Postoperative Delirium

ROC curves revealed an equivocal predictive capacity of SLUMS for POD (Figure S1). At the traditional cut-points

of 27 and 25 (cut-points for individuals with MCI with and without high school education, respectively), as well as 20 and 19 (cut-points for dementia), the c-statistic was less than 0.60 for all reported values. The optimal predictive value for the SLUMS was a score of 19 (0–19 vs ≥ 20 , c-statistic = 0.54).

DISCUSSION

Available data suggest that preexisting cognitive impairment predicts incident POD, which, in turn, can impair long-term cognitive functioning.^{10,15,25} Preoperative cognitive impairment has also been linked to the incidence of other adverse outcomes, including postoperative complications, longer hospital stay, and functional decline.^{26–29} Nonetheless, data on the association between preoperative cognitive impairment and postoperative outcomes are limited.^{13,30} Furthermore, individuals with cognitive impairment are often excluded from clinical trials.¹⁸

In this analysis comparing individuals with and without cognitive impairment undergoing elective surgery, individuals with cognitive impairment had higher rates of discharge to a facility than those without cognitive impairment. This is not a surprising outcome, because individuals with cognitive impairment would be less likely to function independently after surgery. Given the low rates of individuals residing in assisted living before surgery (1.2%), we do not think that prior home environment meaningfully affected discharge destination.

Participants with cognitive impairment did not have longer hospital stays or higher readmission rates than their cognitively intact counterparts. Likewise, participants with cognitive impairment 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 cognitive impairment was 64%, which is much higher than the rate of cognitive impairment in the general population (estimated to be 20–25%). This high rate may represent preferential referrals of individuals with cognitive impairment from participating surgeons. Additionally, the fatigue of multiple provider visits, the stress of upcoming surgery, and the predisposing medical condition necessitating surgery may have contributed to poor performance on cognitive screening, artificially inflating the rates of cognitive impairment in the preoperative evaluation setting. Thus, it is possible that overestimation of rates of cognitive impairment do not reflect clinically meaningful disease and hence the similar outcomes in individuals with and without cognitive impairment in our study population.

A second explanation is that participants may have benefited from the geriatric comanagement model, mitigating the effect of cognitive impairment on postoperative adverse events. Using a multidisciplinary approach, POSH providers address and optimize geriatric syndromes, such as malnutrition and polypharmacy, before surgery. Postoperatively, geriatric comanagement allows for early, aggressive management of delirium, pain, mobility, nutrition, and multimorbidity, which may improve outcomes, particularly in high-risk individuals with cognitive impairment. Larger studies are needed to confirm these findings, although if our results bear out, it will indicate the

importance of identifying preoperative cognitive impairment. Identification of these individuals, who traditionally have a much higher perioperative risk, will allow for targeted resource allocation and ideally risk mitigation using a geriatric comanagement model.

SLUMS is a brief, validated assessment tool that screens for MCI and dementia.^{19,31} SLUMS content emphasizes executive functioning and episodic memory, allowing earlier detection of subtle deficits associated with MCI than the Mini-Mental State Examination.³² SLUMS takes approximately 10 minutes to administer, making it a viable option in a busy preoperative setting, and has demonstrated diagnostic utility for MCI and dementia similar to that of longer screening tests, such as the Montreal Cognitive Assessment.³³ Despite the benefits of SLUMS, there is a paucity of data examining whether a person's performance is linked to health outcomes. A single study found that lower SLUMS scores were associated with greater risk of institutionalization and death in an ambulatory veteran population, but no studies have specifically examined the role of SLUMS in preoperative screening.³⁴ Our data suggest that preoperative SLUMS scores may have limited capacity to predict POD (highest c-statistic on ROC = 0.54).

This study must be considered in light of its limitations. It was a small, exploratory study and may have been underpowered to detect meaningful differences in outcomes of populations with and without cognitive impairment. The imbalance in the sample sizes of participants with and without cognitive impairment (two-thirds of the study group having cognitive impairment) further limits our ability to detect differences. In addition, we had a highly educated population, and more than half of the study population was referred from neurosurgery services. This may limit the generalizability of the data.

In summary, cognitive impairment is logically associated with adverse health outcomes for older adults in the perioperative period. Cognitive disorders affect one's ability to properly manage medications, care for wounds, 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 use.

More research is needed to develop valid measures of cognitive impairment that are sensitive enough to detect meaningful cognitive impairment but 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.^{35,36} Understanding the relationship between these domains and risk of delirium would allow for better identification of the highest risk individuals and for targeted optimization and resource allocation. Such strategies will help surgeons and patients better understand perioperative risks and benefits, encouraging effective shared decision-making models.

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Author Contributions: 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. Zietlow: Study concept and design, data analysis, data interpretation, manuscript drafting, critical revision of manuscript. McDonald, Sloane, Browndyke, Lagoo-Deenadayalan: Study design, data analysis, data interpretation, manuscript drafting, critical revision of manuscript. Heflin: Study concept and design; supervision; data acquisition, analysis, and interpretation; manuscript drafting; critical revision of manuscript.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

Figure S1. Relationship between SLUMS score and rates of postoperative delirium

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