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Poor Performance on a Preoperative Cognitive Screening Test Predicts Postoperative Complications in Older Orthopedic Surgical Patients

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Abstract

Background—The American College of Surgeons and the American Geriatrics Society have suggested that preoperative cognitive screening should be performed in older surgical patients. We hypothesized that unrecognized cognitive impairment in patients without a history of dementia is a risk factor for development of postoperative complications.

Methods—We enrolled 211 patients ≥ 65 years of age without a diagnosis of dementia that were scheduled for an elective hip or knee replacement. Patients were cognitively screened preoperatively using the MiniCog and demographic, medical, functional, and emotional/social data were gathered using standard instruments or review of the medical record. Outcomes included discharge to place other than home (primary outcome), delirium, in-hospital medical complications, hospital length-of-stay, 30-day emergency room visits and mortality. Data were analyzed using univariate and multivariate analyses.

Results—Fifty of 211 (24%) patients screened positive for probable cognitive impairment (MiniCog ≤ 2). On age adjusted multivariate analysis patients with a MiniCog score ≤ 2 were more likely to be discharged to a place other than home (67% vs. 34%; OR = 3.88, 95% CI = 1.58–9.55), develop postoperative delirium (21% vs. 7%; OR = 4.52 95% CI = 1.30–15.68), and have a longer hospital length of stay (HR=0.63 95% CI 0.42–0.95) compared to those with a MiniCog score > 2.

Conclusions—Many older elective orthopedic surgical patients have probable cognitive impairment preoperatively. Such impairment is associated with development of delirium postoperatively, a longer hospital stay, and lower likelihood of going home upon hospital discharge.

Introduction

Approximately 1 of every 3 surgical procedures nationally is performed on a patient ≥ 65 years of age. There is intense interest in identifying predictors of adverse outcomes in this age group, as they have a high complication rate and often do poorly.[1–4] Preoperative assessment of major vital organs has been a routine part of preparation for surgery for decades[5,6] but brain function is typically not formally evaluated.[7] Yet, cognitive impairment is common in older persons, including those living independently. Five percent of Americans aged 70–79 years, 24% of those 80–89, and nearly 40% of those 90 or older are demented.[8] In epidemiologic surveys, the prevalence of impairment is 35–50% in those ≥ 65 and higher still in those ≥ 85 if milder forms of cognitive impairment (e.g. MCI [mild cognitive impairment] or CIND [cognitive impairment, not dementia]) are included, although estimates vary with the age structure of the population and definition and assessment methods used.[9–12] Consequently, it is reasonable to assume that many seniors without a diagnosis of dementia scheduled for elective surgery have cognitive impairment at baseline. In fact, using the MiniCog, a brief, validated, structured cognitive screening tool with high inter-rater reliability and patient acceptance, we demonstrated recently that 25–33% of elective surgical patients ≥ 65 years of age score in a range consistent with probable cognitive impairment preoperatively[13] and, using the same test, others report that 44% of geriatric surgical patients with planned admission to an intensive care unit (ICU) postoperatively are impaired before surgery.[14]

One key question in the geriatric surgical setting is whether baseline cognition predicts medical complications and other adverse outcomes. Previous work demonstrates that a chronic dementing illness or a clouded sensorium (i.e. acute or chronic delirium) before surgery is associated with a greater risk of postoperative cognitive and non-cognitive (medical) morbidity and that a low preoperative MiniCog score predicts adverse outcomes in older surgical patients requiring postoperative care in an ICU.[14–16] However, few persons suffering from dementia or an acute change in cognition have elective surgery and the vast majority of elective procedures performed on older persons (e.g. elective joint replacements, spine surgery) do not typically require admission to an ICU postoperatively. Unresolved, therefore, is whether preoperative cognitive screening, as recommended by the American College of Surgeons and the American Geriatrics Society in jointly published guidelines[17], can help identify those at risk for an adverse outcome when the procedure is common and elective. We hypothesized that even in that situation poor preoperative cognition will be associated with suboptimal surgical outcomes. To test this hypothesis, we cognitively screened older patients without a diagnosis of dementia with the MiniCog prior to scheduled elective lower extremity joint replacement surgery and examined the relationship of a low preoperative MiniCog score to postoperative morbidity and outcomes.

Methods

The Partners Institutional Review Board approved this prospective observational study (clinicaltrials.gov ID: NCT02570451). Between September 30, 2014 and July 27, 2015, study staff members approached patients aged 65 years of age and older scheduled for a primary lower extremity (hip or knee) joint replacement procedure, who presented to the Weiner Center for Preoperative Evaluation at the Brigham and Women's Hospital. We selected this group because lower extremity joint replacements are relatively homogeneous, do not share a risk factor with cognitive impairment (beyond age), and do not affect the central nervous system directly. All eligible patients were identified from the preoperative evaluation center tracking system on the day prior to surgery. Exclusion criteria included concurrent enrollment in another study; a prior diagnosis of dementia noted on the patient chart or reported to the investigator by the patient or a surrogate; planned outpatient surgery; planned postoperative ICU stay; history of stroke or brain tumor; uncorrected vision or hearing impairment (unable to see pictures or read or hear instructions); limited use of the dominant hand (limited ability to draw); and/or inability to speak, read or understand English.

A power calculation of the number of patients required for 80% power to detect a 25% difference in discharge destination at the P = 0.05 level (primary outcome) using a logistic regression model with a baseline incidence of discharge to place other than home being 53% and our expectation of a 20% loss to follow up in this older patient population would require 192 patients. After obtaining written informed consent, 211 patients participated in the study and completed a survey about their perceptions of preoperative cognitive screening and their primary outcome goals for their surgical procedure (Table 1) and were tested on the MiniCog. The MiniCog involves a 3-item recall test for memory and a clock drawing test that serves in part as a distractor; it tests visuospatial representation, recall, and executive function, and takes just minutes to complete.[18,19] The MiniCog is validated in community-based populations; it has minimal education, language, or ethnic bias, high sensitivity and specificity for cognitive impairment, and good inter-rater reliability.[20,21] Investigators were trained to grade the tests by reviewing information easily accessed via the internet (www.alz.org/documents_custom/Mini-Cog.pdf) and education sessions provided by the geriatrician (HJ). The Mini-Cog is graded on a 5-point scale, where 5 is considered a perfect score and score ≤ 2 is considered probably impaired.[18] Accordingly, we used ≤ 2 as the cutoff in the current study. Two investigators scored each test independently. The first scored it during the preoperative evaluation and the second investigator scored it later and was blinded to patient identity. In the event of a disagreement, a third investigator scored the test and served as a tie-breaker. Patients also completed the 1) short form 36 health survey,[22] an index of quality of life across eight domains (physical functioning, limitations due to physical health or emotional problems, energy/fatigue, emotional well-being, social functioning; pain, general health); 2) geriatric depression scale short form;[23] 3) activities of daily living;[24] and 4) instrumental activities of daily living.[25] We also measured grip strength as an index of frailty using a Jamar Dynamometer[26] and obtained baseline data on age, weight, gender, highest level of education, American Society of Anesthesiologists (ASA) functional status, Metabolic Equivalent of Task,[27] and type of surgical procedure from the medical record.

The a priori primary outcome was discharge to place other than home; those living elsewhere prior to surgery were excluded from the discharge location analysis. Secondary outcomes were delirium and complications involving the cardiac (myocardial infarction, congestive heart failure, cardiac arrest, new onset arrhythmia); pulmonary (pneumonia, reintubation); infectious (wound infections); coagulation (pulmonary embolism, deep venous thrombosis); renal (acute renal injury), or cerebrovascular (stroke) systems. Additional secondary outcomes were post anesthesia care unit length of stay, hospital length of stay, 30-day readmission, and 30-day mortality. Delirium was identified both by chart review using published criteria[28] and by direct, independent assessment with the Confusion Assessment Method (CAM).[29] The CAM was administered once per day on postoperative days 1–3, or until discharge if the patient was discharged early, by an investigator trained by the geriatrician (HJ) and blinded to chart review information. We used both methods because they are complimentary and well-established. The Confusion Assessment Method is typically administered once or twice a day but delirium waxes and wanes so this test will miss episodes of delirium if they occur at other times. Conversely, chart review reflects events over an entire day but may miss hypoactive delirium (the most common form) since it may be mistaken for sedation. We gathered most of the other patient information by systematic chart review or examination of discharge diagnoses in the Brigham and Women's Research Patient Data Registry. All data were collected and managed using REDCap (Research Electronic Data Capture), a secure, web-based, electronic data capture tool.

Statistical Analysis

Data were analyzed by several methods. We used Fisher's exact test to examine patient responses to the survey questions by MiniCog score and Krippendroff α (KA) was calculated using "kripp.alpha" function in "irr" package in R software (https://cran.rproject.org/web/packages/irr/irr.pdf) to evaluate the agreement between the 2 initial raters of the Mini-Cog. The confidence intervals of KA were calculated using a bootstrapping method by random sampling the data points with replacement.

We used logistic regression to estimate the odds ratios (ORs) for dichotomous outcomes and a Cox's proportional hazard model to estimate the hazard ratio of length of hospital stay (time to discharge) by MiniCog score. We first performed age-adjusted univariate analyses between covariates (MiniCog score, gender, weight, education level, ASA, and METS) that, based on a priori background knowledge, could modify the outcomes. Subsequently, all the covariates were entered into a backwards stepwise algorithm, retaining variables with $P < 0.1$ in the multivariate models. Age and MiniCog score were forced into the multivariate model. For the primary and secondary outcomes, the significance threshold was set at $P < 0.05$. The Hosmer-Lemeshow goodness of fit test was performed to evaluate model-fitting of the logistic multivariable models. The proportional hazards assumption was tested using scaled Schoenfeld residual. All analyses were performed with statistical software R version 3.1.2 (R Foundation, Vienna, Austria).

Results

During the study period, our preoperative center evaluated 368 patients 65 years of age or older scheduled for elective total knee or total hip replacement surgery. Of these, 43 were ineligible, 14 refused to front desk staff and were not approached by study personnel, and 30 were missed because the study staff was occupied with a concurrent subject. Study personnel approached 281 eligible patients; 70 declined to participate and 211 patients were enrolled (Fig. 1). Among those enrolled, 8 did not have their surgical procedure and were eliminated from outcome analysis.

Overall, 5 of 211 (24%) patients scored ≤ 2 on the preoperative MiniCog, suggesting probable cognitive impairment. Inter-rater reliability in MiniCog scoring was similar to that found in our prior experience with a Krippendroff α of 0.906 (95% CI = 0.857 - 0.950). Characteristics associated with a MiniCog ≤ 2 included advanced age ($P < 0.001$) and less education ($P = 0.02$); low metabolic equivalents of task ($P < 0.001$), instrumental activities of daily living ($P = 0.03$), and basic activities of daily living ($P = 0.02$); physical function limitations on the short form 36 health survey ($P = 0.015$) and having a knee rather than a hip replacement procedure ($P = 0.03$)(Table 1). Patients with a MiniCog score ≤ 2 were also less likely to live in their own home ($P = 0.004$) and more likely to be accompanied by someone to the preoperative evaluation appointment ($P = 0.02$)(Table 2). Ninety-four percent of subjects supported the idea of performing a short memory test (Table 2). Pain and use of pain medications were common but did not vary by MiniCog score. Thus, based on pain scores reported on the short form 36, there was no difference in preoperative pain between patients with a MiniCog ≤ 2 vs. ≥ 3 (51 [95% CI 45–56] vs. 50 [95% CI 47–53], respectively; P = 0.88). Likewise, 84% of patients were taking pain medication (opioids, NSAIDS, acetaminophen, gabapentin) at the time of the preadmission testing visit but there was no in the type of pain medications used between those with a MiniCog ≤ 2 vs. ≥ 3 (P = 0.999). Accordingly, it is unlikely pain or the medications used to treat it biased the MiniCog results.

Eighty-three patients (42%; Table 3A) living at home prior to surgery were discharged to a place other than home after surgery (primary outcome measure). This outcome was more likely if they had a preoperative MiniCog score ≤ 2 (67% vs. 34%; OR = 2.97 [95% CI = 1.43 to 6.18]; P = 0.004) in the age-adjusted univariate analysis and remained a predictor of discharge location after multivariate adjustment (OR = 3.88 [95% CI = 1.58 to 9.55]; P = 0.003). The average hospital length of stay was 2.6 ± 0.9 days, with a low preoperative MiniCog score predicting longer hospital stay by both univariate (P = 0.018) and multivariate analysis (hazard ratio (HR) = 0.63 [95% CI 0.42–0.95]; P = 0.026)(Table 3B).

Four patients were discharged from the hospital < 24 h after surgery and prior to delirium screening by CAM. Of the remainder, 14 (6.9%) developed CAM+ delirium postoperatively and 21 (10%) were delirium positive by comprehensive chart review. Of the 14 patients positive by CAM, 11 were also positive by chart review. A preoperative MiniCog score ≤ 2 was associated with development of postoperative delirium diagnosed by the Confusion Assessment Method on both age-adjusted univariate (P = 0.003) and multivariate analysis (18% vs. 4%; OR = 4.52 [95% CI 1.3–15.68]; P = 0.017)(Table 4A). A preoperative MiniCog score ≤ 2 was likewise associated with postoperative delirium identified by chart review on both age-adjusted univariate (P = 0.021) and multivariate analysis (21% vs. 7%; OR = 3.41 [95% CI 1.26–9.23]; P = 0.016)(Table 4B). A post-hoc age adjusted analysis revealed that patients with delirium stayed in the hospital 1.12 days longer than those without delirium (95% CI 0.67–1.58; P < 0.001).

Seventeen patients (8.1%) had postoperative cardiac complications, with the majority (N = 15) being onset of new arrhythmias, mainly atrial fibrillation. A low preoperative MiniCog score was associated with cardiac events on age-adjusted univariate (OR = 3.14 [95% CI 1.07–9.18]; P 0.037) but not multivariate analysis (17% vs. 6%; OR = 2.87 [95% CI 0.89–9.23]; P =0.077). Other adverse events identified by chart review or discharge diagnosis codes, including pneumonia, reintubation, pulmonary embolism, deep venous thrombosis, stroke, coma, wound infection, sepsis, renal failure, urinary tract infection, reoperation, and unanticipated ICU admission, occurred too infrequently to be analyzed as independent outcomes. The only predictor of 30-day emergency room visits was metabolic equivalents of task (P = 0.017 and 0.013 by univariate and multivariate analysis, respectively) and 30-day mortality was too rare (N = 2) to be analyzed statistically.

Discussion

These data confirm that poor preoperative cognition as assessed by MiniCog screening is both prevalent among geriatric patients scheduled for elective major joint replacement surgery and predictive of adverse outcomes including postoperative delirium, a longer hospital stay, and greater likelihood of being discharged to a place other than home. Importantly, this was true despite the fact that we excluded patients with a known diagnosis of dementia. In contrast, age, ASA functional status, grip strength, preoperative geriatric depression scale scores, and functional state (Short form 36 health survey, Instrumental Activities of Daily Living and Activities of Daily Living) were not associated with the pre-specified outcomes and/or complications by multivariable modeling. Metabolic equivalents of task was the exception, as it predicted delirium diagnosed by chart review (but not Confusion Assessment Method) and the likelihood of being discharged to a place other than home. Taken together, these data show a remarkably high percentage of seniors electing to undergo a total hip or knee replacement procedure have probable, but previously undetected, cognitive impairment at baseline and that preoperative cognitive screening with a simple, brief test can help identify those at risk of postoperative cognitive and medical complications.

That about 1 in 4 geriatric patients scheduled for elective major joint replacement surgery have probable cognitive impairment preoperatively is not surprising given the prevalence of dementia and milder forms of cognitive impairment in community samples.[9–11] Much of this is undetected as, by definition, MCI can be present with no functional deficit and only a minority of demented people have a clinical cognitive evaluation that leads to a diagnosis.[30] Our results compare well with our prior data on geriatric patients scheduled for a variety of elective non-cardiac, non-neurosurgical procedures[13] and with results of studies in hospitalized patients or other surgical populations.[14,31–33] For instance, depending upon age and type of cognitive testing, the prevalence of cognitive impairment in patients ≥ 65 years presenting to an emergency department, an ambulatory urogynecology clinic, or having surgery with planned admission to the ICU ranges from 5% to 63%.[14,31,33] Nor it is surprising that people with cognitive impairment are more likely to develop delirium. Poor cognitive status, typically defined as dementia in population studies, is a well-known risk factor for in-hospital delirium and also appears to be an independent predictor of morbidity and mortality in geriatric patients having major elective operations.[14,34] The problem, however, is that in both primary care and hospital settings cognitive impairment, and even dementia, often go unnoticed without structured screening because routine clinical interactions are insensitive.[19,35,36] Accordingly, as we demonstrate, a formal, yet simple and brief, cognitive screening procedure can be useful both to identify probable cognitive impairment before surgery and, in conjunction with other information gathered routinely preoperatively, to forecast which patients are most likely to have undesirable postoperative outcomes. Moreover, most subjects endorsed use of a brief memory test preoperatively.

There are numerous abridged cognitive screening tests but few have been used in the preoperative setting. We chose the MiniCog because it is brief, freely available, requires no specialized personnel or technology, has minimal education and cultural/language bias, and is validated against standardized cognitive measures in community samples.[37–42] Designed for primary care, the MiniCog has been used in surgical settings, including by us,[13,14] and has high inter-rater reliability and is easy to administer. The MiniCog involves a 3-item recall test for memory and a clock drawing test that serves as a distractor. It tests visuospatial representation, recall, and executive function and detects dementia with a sensitivity and specificity of 0.91 and 0.86, respectively.[14,18,19,21] We used ≤ 2 as the cutoff for probable cognitive impairment because it identifies with reasonable sensitivity and specificity the level of impairment found in individuals who might present to a memory clinic for evaluation of MCI or dementia,[18] but others have used a higher cutoff and found a correspondingly higher prevalence of probable cognitive impairment preoperatively.[14] Category fluency has also been used as a cognitive screening test in this setting with similar results in terms of prevalence of probable cognitive impairment preoperatively and association with delirium postoperatively but selection bias is possible since about half of eligible patients were not screened.[43] It is important to emphasize in this context that no single cognitive test, administered at a single time, can diagnose MCI or dementia. Therefore, by itself, a low preoperative MiniCog score is not enough to diagnose or label a patient as having a memory disorder. However, as we demonstrate, what it can do is help identify a subpopulation of geriatric surgical patients at risk for postoperative delirium and poor outcomes and, as such, potentially guide and enhance the care of these patients.

This study has multiple limitations. First, the stress of being in the preoperative evaluation center could confound performance of seniors on the cognitive screening test, leading to a high false-positive rate for cognitive impairment and, potentially, hesitation among patients about undergoing elective surgery for fear of having cognitive impairment afterward. Few experiences, however, are as stressful as surgery and hospitalization, As such, testing in a busy preoperative clinic may reveal more about an individual’s likely response to surgery and hospitalization than if testing was done the quieter, artificial environment of a neuropsychology laboratory. Second, other brief cognitive screening instruments may work as well or better than the MiniCog in the presurgical setting and non-cognitive screening measures might be equally useful. Indeed, frailty, walking speed, functional dependency, and self-reported diminished mobility or history of falls have all been linked to postoperative complications and mortality in geriatric patients.[44–48] Third, we assessed patients for delirium only once per day, typically around noon, but clinical delirium waxes and wanes throughout the day. Thus, we may have underestimated the incidence of delirium. Likewise, because we used grip strength as the only marker of frailty, we may have underestimated the prevalence of this syndrome in our population and made it difficult to detect the relationship between frailty and adverse postoperative outcomes observed by others.[49] Also, because we cannot entirely exclude confounding by co-variates (e.g. age, co-morbidity) and the significance threshold for the primary and secondary outcomes was set at $P < 0.05$, the results should be considered preliminary and in need of confirmation in larger studies.[50] Lastly, our study was limited to orthopedic patients having elective major joint replacement procedures, so the results may not generalize to all geriatric surgery patients. However, studies involving general surgical patients suggest the link between poor cognition and medical-surgical morbidity is not unique to older orthopedic patients.[14,51,52]

Based on limited evidence, the American College of Surgeons and the American Geriatrics Society recently published joint guidelines that recommend preoperative cognitive assessment of older surgical patients with a screening tool such as the MiniCog.[17] However, cognitive screening requires time and can trouble older adults,[53,54] so it is not a trivial matter to adopt it in a preoperative clinic and results must be interpreted cautiously. Yet, because data from this and other studies show that preoperative cognitive screening is practical and that poor performance is associated with adverse postoperative events (delirium, surgical complications), cognitive screening may be a valuable adjunct to traditional preoperative risk assessment practices for this demographic. There are as yet no data to show targeting poor cognitive performers for special attention before, during, and after surgery improves surgical outcomes but recent evidence that prehabilitation, specialized units, and comprehensive geriatric care may enhance outcomes of older surgical patients provides reason for optimism that outcomes can be improved.[55–57] Preoperative cognitive risk stratification may help identify those at greatest risk for adverse surgical outcomes so interventions designed to mitigate complications can be targeted to those most likely to benefit.

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Summary Statement

Preoperative cognitive screening of older orthopedic surgical patients demonstrates that 24% have probable cognitive impairment at the time of the preoperative evaluation and that this impairment is associated with a lower chance of being discharged to home, postoperative delirium, and a longer hospital stay.

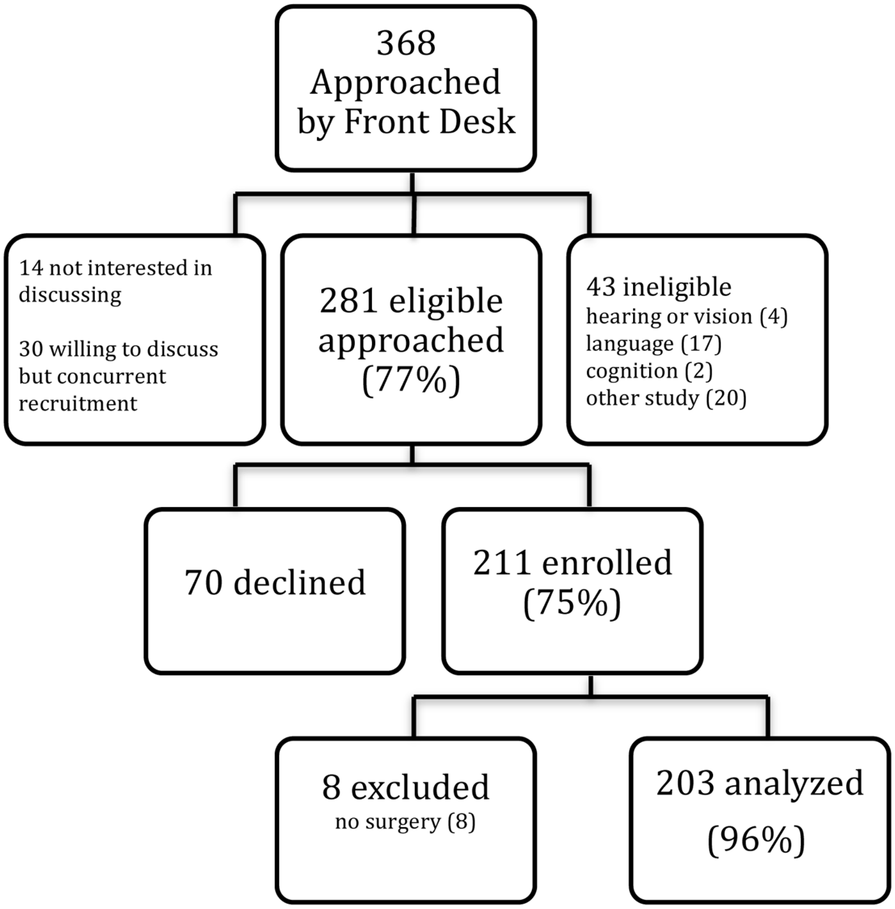

Figure 1.
Flow diagram on recruitment and retention.

Table 1

Baseline Patient Characteristics and Mini-Cog Score

Baseline Characteristic	Total Group (N = 211)	MiniCog ≤ 2 (N = 50)	MiniCog ≥ 3 (N = 161)	P value
Age, years, mean ± SD	72 ± 6	76 ± 6	72 ± 5	< 0.001
ASA Physical Status Score ± SD	3 ± 1	3 ± 1	3 ± 1	0.167
Female, N (%)	127 (60%)	29 (58%)	98 (61%)	0.72
Body mass index, mean ± SD	30 ± 6	31 ± 7	30 ± 6	0.30
College Graduate, N (%)	123 (58%)	22 (44%)	101 (63%)	0.02
Metabolic Equivalent of Task, mean ± SD	4 ± 2	4 ± 1	5 ± 2	< 0.001
Geriatric Depression Scale ≥ 5	16 (8%)	5 (10%)	11 (7%)	0.54
Instrumental Activities of Daily Living	29 ± 3	28 ± 4	29 ± 3	0.03
Activities of Daily Living	29 ± 1.6	29 ± 2.1	29 ± 1	0.02
Grip Strength (mmHg)	58 ± 24	55 ± 24	60 ± 24	0.22
Short form 36 health survey	521 ± 128	499 ± 129	528 ± 127	0.16
Physical function	55 ± 25	52 ± 25	56 ± 25	0.437
Role Limitations due to Physical Health	42 ± 38	30 ± 31	45 ± 38	0.015
Role Limitations due to Emotional Problems	85 ± 32	85 ± 33	85 ± 32	0.995
Energy/Fatigue	58 ± 23	53 ± 25	60 ± 23	0.07
Emotional Well-Being	83 ± 17	82 ± 20	83 ± 17	0.752
Social Functioning	82 ± 21	79 ± 23	84 ± 21	0.189
Pain	50 ± 21	51 ± 20	50 ± 22	0.883
General Health	64 ± 12	65 ± 11	64 ± 13	0.695
Type of Surgery, N (%)				0.03
Knee replacement	123 (58%)	36 (29%)	87 (70%)	
Hip replacement	88 (42%)	14 (16%)	74 (84%)	

Table 2

Patient Responses to Survey Questions and Mini-Cog Score

Question	Total Group % Yes	MiniCog ≤ 2 % Yes	MiniCog ≥ 3 % Yes	P value
Do you believe that a short memory test should be performed before having a surgical procedure? (N=167)	157 (94%)	35 (88%)	122 (96%)	0.152
Which of the following outcomes is most important to you? (Choose two)				
Correction of disease process	142 (67%)	28 (56%)	114 (71%)	0.059
No pain	120 (57%)	30 (60%)	90 (56%)	0.628
No nausea or vomiting	37 (18%)	9 (18%)	28 (17%)	1
No memory of the surgery	18 (9%)	3 (6%)	15 (9%)	0.573
Discharge to home	67 (32%)	17 (34%)	50 (31%)	0.729
Where do you currently live? (N=209)				
In my own home	196 (94%)	41 (82%)	155 (97%)	0.004
In a care facility	3 (1%)	2 (4%)	1 (1%)	
In someone else's home	10 (5%)	6 (12%)	4 (3%)	
Do you live with anyone?	150 (71%)	31 (62%)	119 (74%)	0.111
Did anyone accompany you today to your preoperative appointment?	109 (52%)	33 (66%)	76 (47%)	0.024
I feel stressed today during my preoperative visit (% agree or strongly agree) (N=210)	70 (59%)	20 (67%)	50 (56%)	0.221
Have you had a fall in the last 6 months? (N=192)	30 (16%)	8 (17%)	22 (15%)	0.921

Table 3A &B

Age adjusted univariate and multivariate predictors of discharge to place other than home and hospital length of stay.

A. Discharge to Place Other than Home

		Age adjusted univariate model		Multivariate (GOF test p=0.37)*	
Reference Variable	**Contrast Variable**	**Odds ratio (95% CI)**	**P-value**	**Odds ratio (95% CI)**	**P-value**
Mini-Cog Score (≥ 3)	≤ 2	2.97 (1.43 to 6.18)	0.004	3.88 (1.58 to 9.55)	0.003
Gender (male)	Female	4.32 (2.23 to 8.38)	<0.001	3.52 (1.58 to 7.84)	0.002
Type of surgery (Knee)	Hip	1.3 (0.72 to 2.35)	0.38	-	-
Body mass index	Continuous	1.09 (1.03 to 1.14)	0.001	-	-
Highest level of education (No College Grad)	College graduate	0.5 (0.28 to 0.91)	0.024	-	-
Grip Strength	Continuous	0.96 (0.95 to 0.98)	<0.001	-	-
ASA Physical Status (≤ 2)	≥ 3	3 (1.57 to 5.72)	0.001	2.93 (1.34 to 6.4)	0.007
Metabolic Equivalent of Task	Continuous	0.47 (0.36 to 0.63)	<0.001	0.53 (0.39 to 0.73)	<0.001
Geriatric Depression Scale (≤ 4)	≥ 5	5.74 (1.72 to 19.18)	0.005	-	-
Short form 36 health survey	Continuous	0.99 (0.99 to 1)	<0.001	-	-
Physical Function	Continuous	0.99 (0.98 to 0.99)	0.002		
Instrumental Activities of Daily Living	Continuous	0.73 (0.63 to 0.86)	<0.001	-	-
Activities of Daily Living	Continuous	0.5 (0.37 to 0.68)	<0.001	-	-

B. Hospital LOS

		Age adjusted univariate model		Multivariate (PH assumption p=0.09) **	
Reference Variable	**Contrast Variable**	**Hazard Ratio (95% CI)**	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Mini-Cog Score (≥ 3)	≤ 2	0.65 (0.45 to 0.93)	0.018	0.63 (0.42 to 0.95)	0.026
Gender (male)	Female	0.71 (0.54 to 0.95)	0.019	-	-
Type of surgery (Knee)	Hip	0.98 (0.74 to 1.3)	0.869	-	-
Body mass index	Continuous	0.97 (0.95 to 1)	0.019	-	-
Highest level of education (No College Grad)	College graduate	1.4 (1.05 to 1.86)	0.022	-	-
Grip Strength	Continuous	1.01 (1 to 1.01)	0.008	-	-
ASA Physical Status (≤ 2)	≥ 3	0.07 (−0.18 to 0.33)	0.569	-	-
Metabolic Equivalent of Task	Continuous	1.28 (1.18 to 1.39)	<0.001	1.21 (1.1 to 1.32)	<0.001

B. **Hospital LOS**

		Age adjusted univariate model		Multivariate (PH assumption p=0.09) **	
Reference Variable	**Contrast Variable**	**Hazard Ratio (95% CI)**	**P-value**	**Hazard Ratio (95% CI)**	**P-value**
Geriatric Depression Scale (≤ 4)	≥ 5	0.62 (0.37 to 1.04)	0.072	-	-
Short form 36 health survey	Continuous	1 (1 to 1)	0.028	-	-
Physical Function	Continuous	1 (1 to 1)	<0.001	1 (1 to 1)	0.001
Instrumental Activities of Daily Living	Continuous	1.06 (1.01 to 1.11)	0.017	-	-
Activities of Daily Living	Continuous	1.17 (1.05 to 1.3)	0.004	-	-

* Hosmer and Lemeshow goodness of fit test with g=10.

** The global chi-squared test using scaled Schoenfeld residuals demonstrated that the proportional hazard assumption was held (p=0.09)

Table 4A &B

Age adjusted univariate and multivariate predictors of delirium by CAM and Chart Review on POD 1, 2, or 3.

A.		Delirium by CAM			
		Age adjusted univariate model		**Multivariate (GOF test p=0.29)***	
Reference Variable	**Contrast Variable**	**Odds ratio (95% CI)**	**P-value**	**Odds ratio (95% CI)**	**P-value**
Mini-Cog Score (≥ 3)	≤ 2	6.28 (1.89 to 20.86)	0.003	4.52 (1.3 to 15.68)	0.017
Gender (male)	Female	4.09 (0.89 to 18.83)	0.07	-	-
Type of surgery (Knee)	Hip	0.56 (0.17 to 1.85)	0.343	-	-
Body mass index	Continuous	1.07 (0.98 to 1.16)	0.116	-	-
Highest level of education (No College Grad)	College graduate	0.36 (0.12 to 1.13)	0.081	-	-
Grip Strength	Continuous	0.97 (0.94 to 1)	0.036	-	-
ASA Physical Status (≤ 2)	≥ 3	1.55 (0.46 to 5.2)	0.474	-	-
Metabolic Equivalent of Task	Continuous	0.37 (0.2 to 0.69)	0.002	0.39 (0.21 to 0.75)	0.005
Geriatric Depression Scale (≤ 4)	≥ 5	6.31 (1.69 to 23.62)	0.006	-	-
Short form 36 health survey	Continuous	0.99 (0.99 to 1)	0.01	-	-
Physical Function	Continuous	0.99 (0.97 to 1.01)	0.214		
Instrumental Activities of Daily Living	Continuous	0.81 (0.71 to 0.92)	0.001	-	-
Activities of Daily Living	Continuous	0.73 (0.57 to 0.95)	0.018	-	-

B.		Delirium by Chart Review			
		Age adjusted univariate model		**Multivariate (GOF test p=0.89)***	
Reference Variable	**Contrast Variable**	**Odds ratio (95% CI)**	**P-value**	**Odds ratio (95% CI)**	**P-value**
Mini-Cog Score (≥ 3)	≤ 2	3.17 (1.19 to 8.45)	0.021	3.41 (1.26 to 9.23)	0.016
Gender (male)	Female	3.2 (1.03 to 9.94)	0.044	3.47 (1.1 to 11.01)	0.034
Type of surgery (Knee)	Hip	0.53 (0.2 to 1.44)	0.215	-	-
Body mass index	Continuous	1.07 (0.99 to 1.15)	0.087	-	-
Highest level of education (No College Grad)	College graduate	0.42 (0.16 to 1.07)	0.07	-	-
Grip Strength	Continuous	0.98 (0.96 to 1)	0.071	-	-
ASA Physical Status (≤ 2)	≥ 3	0.7 (0.27 to 1.78)	0.455	-	-
Metabolic Equivalent of Task	Continuous	0.47 (0.29 to 0.75)	0.002	-	-

B. **Delirium by Chart Review**

		Age adjusted univariate model		Multivariate (GOF test p=0.89)*	
Reference Variable	**Contrast Variable**	**Odds ratio (95% CI)**	**P-value**	**Odds ratio (95% CI)**	**P-value**
Geriatric Depression Scale (≤ 4)	≥ 5	3.73 (1.05 to 13.23)	0.041	-	-
Short form 36 health survey	Continuous	1 (0.99 to 1)	0.034	-	-
Physical Function	Continuous	1 (0.99 to 1.01)	0.755	-	-
Instrumental Activities of Daily Living	Continuous	0.89 (0.8 to 0.99)	0.039	-	-
Activities of Daily Living	Continuous	0.83 (0.66 to 1.04)	0.101	-	-

* Hosmer and Lemeshow goodness of fit test with g=10