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

Deborah J. Culley, M.D., Devon Flaherty, M.D., M.P.H., Margaret C. Fahey, M.A., James L. Rudolph, M.D., Houman Javedan, M.D., Chuan-Chin Huang, Ph.D., John Wright, M.D., Angela M. Bader, M.D., M.P.H., Bradley T. Hyman, M.D., Ph.D., Deborah Blacker, M.D., Sc.D., Gregory Crosby, M.D.

CME This article has been selected for the ANESTHESIOLOGY CME Program. Learning objectives and disclosure and ordering information can be found in the CME section at the front of this issue.

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 yr of age or older without a diagnosis of dementia who were scheduled for an elective hip or knee replacement. Patients were cognitively screened preoperatively using the Mini-Cog 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 (Mini-Cog less than or equal to 2). On age-adjusted multivariate analysis, patients with a Mini-Cog score less than or equal to 2 were more likely to be discharged to a place other than home (67% *vs.* 34%; odds ratio = 3.88, 95% CI = 1.58 to 9.55), develop postoperative delirium (21% *vs.* 7%; odds ratio = 4.52, 95% CI = 1.30 to 15.68), and have a longer hospital length of stay (hazard ratio = 0.63, 95% CI = 0.42 to 0.95) compared to those with a Mini-Cog score greater than 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. (ANESTHESIOLOGY 2017; 127:765-74)

APPROXIMATELY one of every three surgical procedures nationally is performed on a patient 65 yr of age or older. There is intense interest in identifying predictors of adverse outcomes in this age group, given that 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 to 79 yr, 24% of those aged 80 to 89, and nearly 40% of those 90 or older are affected with dementia.[8] In epidemiologic surveys, the prevalence of impairment is 35 to 50% in those 65 yr of age or older and higher still in those 85 yr of age or older if milder forms of cognitive impairment (*e.g.*, MCI [mild cognitive impairment] or 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

What We Already Know about This Topic

- A substantial (one-fourth to nearly half) portion of elective surgical patients 65 yr or older without dementia have cognitive impairment at baseline before surgery
- It is unknown whether preoperative cognitive screening can identify patients at risk for an adverse postoperative outcome after common and elective surgical procedures

What This Article Tells Us That Is New

- In a prospective clinical investigation of patients 65 yr or older without dementia having elective hip or knee replacement, screened preoperatively with the Mini-Cog, 24% were found to have probable cognitive impairment
- Patients with probable preoperative cognitive impairment, compared to those patients without, were more likely to be discharged to a place other than home, develop postoperative delirium, and have a longer hospital length of stay
- Preoperative cognitive screening of older surgical patients may be valuable for risk assessment and risk stratification in older surgical patients

---

<doi;10.1097/ALN.0000000000001859>

that many seniors without a diagnosis of dementia scheduled for elective surgery have cognitive impairment at baseline. In fact, using the Mini-Cog, a brief, validated, structured cognitive screening tool with high interrater reliability and patient acceptance, we demonstrated recently that 25 to 33% of elective surgical patients 65 yr of age or older 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 noncognitive (medical) morbidity and that a low preoperative Mini-Cog 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 Mini-Cog prior to scheduled elective lower extremity joint replacement surgery and examined the relationship of a low preoperative Mini-Cog score to postoperative morbidity and outcomes.

Materials and Methods

The Partners Institutional Review Board (Boston, Massachusetts) approved this prospective observational study (clinicaltrials.gov No. NCT02570451). Between September 30, 2014, and July 27, 2015, study staff members approached patients 65 yr 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 (Boston, Massachusetts). 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 the English language.

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 Mini-Cog. The Mini-Cog involves a three-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 Mini-Cog is validated in community-based populations; it has minimal education, language, or ethnic bias, high sensitivity and specificity for cognitive impairment, and good interrater reliability.[20,21] Investigators were trained to grade the tests by reviewing information easily accessed *via* the Internet (https://www.alz.org/documents_custom/minicog.pdf; accessed August 18, 2017.) and education sessions provided by the geriatrician (H.J.). The Mini-Cog is graded on a 5-point scale, where 5 is considered a perfect score and a score of 2 or less is considered probably impaired.[18] Accordingly, we used a score of 2 or less 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] (JLW Instruments, USA) 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); immune (wound infections); circulatory (pulmonary embolism, deep venous thrombosis); renal (acute renal injury), or cerebrovascular (stroke) systems. Additional secondary outcomes were postanesthesia care unit length of stay, hospital length of stay,

Table 1. Baseline Patient Characteristics and Mini-Cog Score

Baseline Characteristic	Total Group (N = 211)	Mini-Cog ≤ 2 (N = 50)	Mini-Cog ≥ 3 (N = 161)	P Value
Age, yr, 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%)	

ASA = American Society of Anesthesiologists.

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 to 3, or until discharge if the patient was discharged early, by an investigator trained by the geriatrician (H.J.) and blinded to chart review information. We used both methods because they are complementary and well-established. The Confusion Assessment Method typically is 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) because 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. Study data were collected and managed using Research Electronic Data Capture (REDCap) tools hosted at Partners Healthcare.[30] REDCap is a secure, web-based application designed to support data capture for research studies, providing (1) an intuitive interface for validated data entry; (2) audit trails for tracking data manipulation and export procedures; (3) automated export procedures for seamless data downloads to common statistical packages; and (4) procedures for importing data from external sources.

Statistical Analysis

Data were analyzed by several methods. We used Fisher exact test to examine patient responses to the survey questions by Mini-Cog score and Krippendroff α (KA) was calculated using the "kripp.alpha" function in "irr" package in R software (https://cran.rproject.org/web/packages/irr/irr.pdf; accessed September 5, 2017) to evaluate the agreement between the two initial raters of the Mini-Cog. The CIs 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 Mini-Cog score. We first performed age-adjusted univariate analyses between covariates (Mini-Cog score, gender, weight, education level, ASA, and metabolic equivalents of task) 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 Mini-Cog score were forced into the multivariate model. For the primary and secondary outcomes, the significance threshold was set at $P < 0.05$. The Hosmer-Leesha 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 yr 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, eight did not have their surgical procedure and were eliminated from outcome analysis.

Overall, 50 of 211 (24%) patients scored 2 or lower on the preoperative Mini-Cog, suggesting probable cognitive impairment. Interrater reliability in Mini-Cog scoring was similar to that found in our prior experience with a Krippendroff α of 0.906 (95% CI = 0.857 to 0.950). Characteristics associated with a Mini-Cog equal to or less than 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 Mini-Cog score less than or equal to 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 Mini-Cog score. Thus, based on pain scores reported on the short form 36, there was no difference in preoperative pain between patients with a Mini-Cog score less than or qual to 2 *versus* those with a score greater than or equal to 3 (51 [95% CI 45 to 56] *vs.* 50 [95% CI 47 to 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 were no differences in the type of pain medications used between those with a Mini-Cog
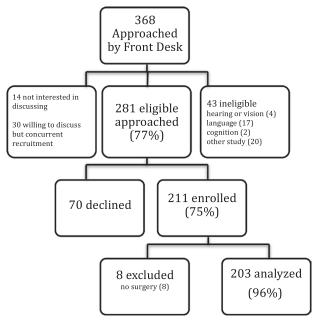
score less than or qual to 2 *versus* those with a score greater than or equal to 3 ($P = 0.999$). Accordingly, it is unlikely pain or the medications used to treat it biased the Mini-Cog results.

Eighty-eight 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 Mini-Cog score less than or equal to 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 Mini-Cog score predicting longer hospital stay by both univariate ($P = 0.018$) and multivariate analysis (hazard ratio = 0.63 [95% CI 0.42 to 0.95]; $P = 0.026$) (table 3B).

Four patients were discharged from the hospital less than 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 Mini-Cog score less than or equal to 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 to 15.68]; $P = 0.017$) (table 4A). A preoperative MiniCog score less than or equal to 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 to 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 to 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 Mini-Cog score was associated with cardiac events on age-adjusted univariate (OR = 3.14 [95% CI 1.07 to 9.18]; $P = 0.037$) but not multivariate analysis (17% *vs.* 6%; OR = 2.87 [95% CI 0.89 to 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 Mini-Cog screening is both prevalent among geriatric patients scheduled for elective major joint replacement surgery and predictive of adverse outcomes including postoperative

Fig. 1. Flow diagram on recruitment and retention.

368 Approached by Front Desk

14 not interested in discussing

30 willing to discuss but concurrent recruitment

281 eligible approached (77%)

43 ineligible
hearing or vision (4)
language (17)
cognition (2)
other study (20)

70 declined

211 enrolled (75%)

8 excluded
no surgery (8)

203 analyzed (96%)

Table 2. Patient Responses to Survey Questions and Mini-Cog Score

Question	Total Group % Yes	Mini-Cog ≤ 2 % Yes	Mini-Cog ≥ 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%)	1.0
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

delirium, a longer hospital stay, and greater likelihood of being discharged to a place other than home. Importantly, this was true even though 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 prespecified outcomes and/or complications by multivariable modeling. Metabolic equivalents of task was the exception; 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 that 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 one in four 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 because, by definition, MCI can be present with no functional deficit and only a minority of people with dementia have a clinical cognitive evaluation that leads to a diagnosis.[31] Our results compare well with our prior data on geriatric patients scheduled for a variety of elective noncardiac, non-neurosurgical procedures[13] and with results of studies in hospitalized patients or other surgical populations.[14,32–34] For instance, depending upon age and type of cognitive testing, the prevalence of cognitive impairment in patients 65 yr of age or older presenting to an emergency department, an ambulatory urogynecology

clinic, or having surgery with planned admission to the ICU ranges from 5 to 63%.[14,32,34] Nor is it 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.[14,35] 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.[19,36,37] 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 Mini-Cog 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.[38–43] Designed for primary care, the Mini-Cog has been used in surgical settings, including by us,[13,14] and has high interrater reliability and is easy to administer. The Mini-Cog involves a three-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 or less as the cutoff for probable cognitive impairment because it identifies with reasonable sensitivity and specificity the level

Table 3A and 3B. 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

Reference Variable	Contrast Variable	Age-adjusted Univariate Model		Multivariate (GOF test P = 0.37)*	
		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 graduation)	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 Length of Stay

Reference Variable	Contrast Variable	Age-adjusted Univariate Model		Multivariate (PH assumption P = 0.09) **	
		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 graduation)	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
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-square test using scaled Schoenfeld residuals demonstrated that the proportional hazard assumption was held (P = 0.09)

ASA = American Society of Anesthesiologists; GOF = goodness of fit; PH = proportional hazards.

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 also has 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 because about half of eligible patients were not screened.[44] 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 Mini-Cog score is not enough to diagnose or label a patient as having a memory disorder. As we demonstrate, however, 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 the 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

Table 4A and 4B. Age-adjusted Univariate and Multivariate Predictors of Delirium by Confusion Assessment Method and Chart Review on Postoperative Delirium 1, 2, or 3

		A. Delirium by Confusion Assessment Method			
		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 graduation)	College graduate	0.36 (0.12 to 1.13)	0.081	-	-
Grip strength	Continuous	0.97 (0.94 to 1.0)	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)	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 graduation)	College graduate	0.42 (0.16 to 1.07)	0.07	-	-
Grip strength	Continuous	0.98 (0.96 to 1.0)	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	-	-
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)	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.

ASA = American Society of Anesthesiologists; GOF = goodness of fit.

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 were done in the quieter, artificial environment of a neuropsychology laboratory. Second, other brief cognitive screening instruments may work as well or better than the Mini-Cog in the presurgical setting, and noncognitive 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.[45–49] 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.[48] Also, because we cannot entirely exclude confounding by covariates (*e.g.*, age, comorbidity) 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.[51] 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. Studies involving general surgical patients, however, suggest the link between poor cognition and medical-surgical morbidity is not unique to older orthopedic patients.[14,52,53]

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 Mini-Cog.[17] Cognitive screening requires time, however, and can trouble older adults,[54,55] 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.[56–58] 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.

Research Support

Competing Interests

Dr. Culley serves as director of the American Board of Anesthesiology, chair of the American Board of Medical Specialties (Chicago, Illinois) Committee on Continuous Certification, Accreditation Council for Graduate Medical Education, Anesthesiology Residency Review Committee, *ad-hoc* member (Chicago, Illinois), executive editor of ANESTHESIOLOGY, American Society of Anesthesiologists committee member; receives grant funding from CRICO (Boston, Massachusetts), NIA; has lectured at the Department of Anesthesiology, The State University of New York, Department of Anesthesiology, Maine Medical Center, Washington State Society of Anesthesiology, Virginia Mason Medical Center, University of Florida (Jacksonville), Mayo Department of Anesthesiology, and the University of Alabama. Dr. Crosby receives grant funding from CRICO; serves as editor of *Anesthesia and Analgesia*, as an American Society of Anesthesiologists committee chair and member, and on the Scientific Advisory Board of The Medicines Company; has lectured at New York Postgraduate Assembly, California Society of Anesthesiologists, American Society of Anesthesiologists, and International Anesthesia Research Society. All other authors declare no competing interests.

Correspondence

Address correspondence to Dr. Culley: Department of Anesthesiology, Perioperative and Pain Medicine, Brigham and Women's Hospital, 75 Francis St., Boston, Massachusetts. 02115. dculley@bwh.harvard.edu. This article may be accessed for personal use at no charge through the Journal Web site, www.anesthesiology.org.

References

1. Finlayson E, Wang L, Landefeld CS, Dudley RA: Major abdominal surgery in nursing home residents: A national study. Ann Surg 2011; 254:921–6
2. Finlayson E, Zhao S, Boscardin WJ, Fries BE, Landefeld CS, Dudley RA: Functional status after colon cancer surgery in elderly nursing home residents. J Am Geriatr Soc 2012; 60:967–73
3. Gajdos C, Kile D, Hawn MT, Finlayson E, Henderson WG, Robinson TN: Advancing age and 30-day adverse outcomes after nonemergent general surgeries. J Am Geriatr Soc 2013; 61:1608–14
4. Gleason LJ, Schmitt EM, Kosar CM, Tabloski P, Saczynski JS, Robinson T, Cooper Z, Rogers SO, Jones RN, Marcantonio ER, Inouye SK: Effect of delirium and other major complications on outcomes after elective surgery in older adults. JAMA Surg 2015; 150(12): 1134–40
5. Ficarra BJ: Preoperative biochemical evaluation of the surgical patient., Am J Surg 1949; 78:504–6
6. Barbour CM: Preoperative evaluation. ANESTHESIOLOGY 1958; 19:275–8
7. Crosby G, Culley DJ, Hyman BT: Preoperative cognitive assessment of the elderly surgical patient: A call for action. ANESTHESIOLOGY 2011; 114:1265–8
8. Plassman BL, Langa KM, Fisher GG, Heeringa SG, Weir DR, Ofstedal MB, Burke JR, Hurd MD, Potter GG, Rodgers WL, Steffens DC, Willis RJ, Wallace RB: Prevalence of dementia in the United States: The aging, demographics, and memory study. Neuroepidemiology 2007; 29:125–32
9. Petersen RC: Clinical practice. Mild cognitive impairment. N Engl J Med 2011; 364:2227–34
10. Plassman BL, Langa KM, Fisher GG, Heeringa SG, Weir DR, Ofstedal MB, Burke JR, Hurd MD, Potter GG, Rodgers WL, Steffens DC, McArdle JJ, Willis RJ, Wallace RB: Prevalence of cognitive impairment without dementia in the United States. Ann Intern Med 2008; 148:427–34
11. Plassman BL, Langa KM, McCammon RJ, Fisher GG, Potter GG, Burke JR, Steffens DC, Foster NL, Giordani B, Unverzagt FW, Welsh-Bohmer KA, Heeringa SG, Weir DR, Wallace RB: Incidence of dementia and cognitive impairment, not dementia in the United States. Ann Neurol 2011; 70:418–26
12. Ward A, Arrighi HM, Michels S, Cedarbaum JM: Mild cognitive impairment: Disparity of incidence and prevalence estimates. Alzheimers Dement 2012; 8:14–21
13. Culley DJ, Flaherty D, Reddy S, Fahey MC, Rudolph J, Huang CC, Liu X, Xie Z, Bader AM, Hyman BT, Blacker D, Crosby G: Preoperative cognitive stratification of older elective surgical patients: A cross-sectional study. Anesth Analg 2016; 123:186–92
14. Robinson TN, Wu DS, Pointer LF, Dunn CL, Moss M: Preoperative cognitive dysfunction is related to adverse postoperative outcomes in the elderly. J Am Coll Surg 2012; 215:12–7; discussion 17–8
15. Silbert B, Evered L, Scott DA, McMahon S, Choong P, Ames D, Maruff P, Jamrozik K: Preexisting cognitive impairment is associated with postoperative cognitive dysfunction after hip joint replacement surgery. ANESTHESIOLOGY 2015; 122:1224–34
16. 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 2015; 150:30–6
17. Chow WB, Rosenthal RA, Merkow RP, Ko CY, Esnaola NF; American College of Surgeons National Surgical Quality

Improvement Program; American Geriatrics Society: 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; 215:453–66

18. Borson S, Scanlan JM, Chen P, Ganguli M: The Mini-Cog as a screen for dementia: Validation in a population-based sample. J Am Geriatr Soc 2003; 51:1451–4

19. Borson S, Scanlan JM, Watanabe J, Tu SP, Lessig M: Improving identification of cognitive impairment in primary care. Int J Geriatr Psychiatry 2006; 21:349–55

20. Tsoi KKF, Chan JYC, Hirai HW, Wong SYS, Kwok TCY: Cognitive tests to detect dementia: A systematic review and meta-analysis. JAMA Intern Med 2015; 175:1450–8

21. McCarten JR, Anderson P, Kuskowski MA, McPherson SE, Borson S: Screening for cognitive impairment in an elderly veteran population: Acceptability and results using different versions of the Mini-Cog. J Am Geriatr Soc 2011; 59:309–13

22. Geeske Peeters GMEE, Rainbird S, Lorimer M, Dobson AJ, Mishra GD, Graves SE: Improvements in physical function and pain sustained for up to 10 years after knee or hip arthroplasty irrespective of mental health status before surgery. Acta Orthop 2016; 88:158–65

23. Snowden MB, Atkins DC, Steinman LE, Bell JF, Bryant LL, Copeland C, Fitzpatrick AL: Longitudinal association of dementia and depression. Am J Geriatr Psychiatry 2015; 23:897–905

24. Luttenberger K, Reppermund S, Schmiedeberg-Sohn A, Book S, Graessel E: Validation of the Erlangen Test of Activities of Daily Living in Persons with Mild Dementia or Mild Cognitive Impairment (ETAM). BMC Geriatr 2016; 16:111

25. Lawton MP, Brody EM: Assessment of older people: Self-maintaining and instrumental activities of daily living. Gerontologist 1969; 9:179–86

26. Kim H, Higgins PA, Canaday DH, Burant CJ, Hornick TR: Frailty assessment in the geriatric outpatient clinic. Geriatr Gerontol Int 2014; 14:78–83

27. Hlatky MA, Boineau RE, Higginbotham MB, Lee KL, Mark DB, Califf RM, Cobb FR, Pryor DB: A brief self-administered questionnaire to determine functional capacity (the Duke Activity Status Index). Am J Cardiol 1989; 64:651–4

28. Kuhn E, Du X, McGrath K, Coveney S, O'Regan N, Richardson S, Teodorczuk A, Allan L, Wilson D, Inouye SK, MacLullich AM, Meagher D, Brayne C, Timmons S, Davis D: Validation of a consensus method for identifying delirium from hospital records. PLoS One 2014; 9:e111823

29. Inouye SK, van Dyck CH, Alessi CA, Balkin S, Siegal AP, Horwitz RI: Clarifying confusion: The confusion assessment method. A new method for detection of delirium. Ann Intern Med 1990; 113:941–8

30. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG: Research electronic data capture (REDCap): A metadata-driven methodology and workflow process for providing translational research informatics support. J Biomed Inform 2009; 42:377–81

31. Kotagal V, Langa KM, Plassman BL, Fisher GG, Giordani BJ, Wallace RB, Burke JR, Steffens DC, Kabeto M, Albin RL, Foster NL: Factors associated with cognitive evaluations in the United States. Neurology 2015; 84:64–71

32. Carpenter CR, Bassett ER, Fischer GM, Shirshekan J, Galvin JE, Morris JC: Four sensitive screening tools to detect cognitive dysfunction in geriatric emergency department patients: Brief Alzheimer's Screen, Short Blessed Test, Ottawa 3DY, and the caregiver-completed AD8. Acad Emerg Med 2011; 18:374–84

33. Evered LA, Silbert BS, Scott DA, Maruff P, Ames D, Choong PF: Preexisting cognitive impairment and mild cognitive impairment in subjects presenting for total hip joint replacement. ANESTHESIOLOGY 2011; 114:1297–304

34. Trowbridge ER, Kim D, Barletta K, Fitz V, Larkin S, Hullfish KL: Prevalence of positive screening test for cognitive impairment among elderly urogynecologic patients. Am J Obstet Gynecol 2016; 215:663.e1–663.e6

35. Monk TG, Weldon BC, Garvan CW, Dede DE, van der Aa MT, Heilman KM, Gravenstein JS: Predictors of cognitive dysfunction after major noncardiac surgery. ANESTHESIOLOGY 2008; 108:18–30

36. Callahan CM, Hendrie HC, Tierney WM: Documentation and evaluation of cognitive impairment in elderly primary care patients. Ann Intern Med 1995; 122:422–9

37. Chodosh J, Petitti DB, Elliott M, Hays RD, Crooks VC, Reuben DB, Galen Buckwalter J, Wenger N: Physician recognition of cognitive impairment: Evaluating the need for improvement. J Am Geriatr Soc 2004; 52:1051–9

38. Borson S, Scanlan J, Brush M, Vitaliano P, Dokmak A: The Mini-Cog: A cognitive 'vital signs' measure for dementia screening in multi-lingual elderly. Int J Geriatr Psychiatry 2000; 15:1021–7

39. Borson S, Scanlan JM, Watanabe J, Tu SP, Lessig M: Improving identification of cognitive impairment in primary care. Int J Geriatr Psychiatry 2006; 21:349–55

40. Chester JG, Grande LJ, Milberg WP, McGlinchey RE, Lipsitz LA, Rudolph JL: Cognitive screening in community-dwelling elders: Performance on the clock-in-the-box. Am J Med 2011; 124:662–9

41. Borson S, Scanlan J, Hummel J, Gibbs K, Lessig M, Zuhr E: Implementing routine cognitive screening of older adults in primary care: Process and impact on physician behavior. J Gen Intern Med 2007; 22:811–7

42. Borson S, Frank L, Bayley PJ, Boustani M, Dean M, Lin PJ, McCarten JR, Morris JC, Salmon DP, Schmitt FA, Stefanacci RG, Mendiondo MS, Peschin S, Hall EJ, Fillit H, Ashford JW: Improving dementia care: The role of screening and detection of cognitive impairment. Alzheimers Dement 2013; 9:151–9

43. Harrington MB, Kraft M, Grande LJ, Rudolph JL: Independent association between preoperative cognitive status and discharge location after cardiac surgery. Am J Crit Care 2011; 20:129–37

44. Long LS, Wolpaw JT, Leung JM: Sensitivity and specificity of the animal fluency test for predicting postoperative delirium. Can J Anaesth 2015; 62:603–8

45. Robinson TN, Wu DS, Sauaia A, Dunn CL, Stevens-Lapsley JE, Moss M, Stiegmann GV, Gajdos C, Cleveland JC Jr, Inouye SK: Slower walking speed forecasts increased postoperative morbidity and 1-year mortality across surgical specialties. Ann Surg 2013; 258:582–8; discussion 588–90

46. Robinson TN, Wu DS, Pointer L, Dunn CL, Cleveland JC Jr, Moss M: Simple frailty score predicts postoperative complications across surgical specialties. Am J Surg 2013; 206:544–50

47. Jones TS, Dunn CL, Wu DS, Cleveland JC Jr, Kile D, Robinson TN: Relationship between asking an older adult about falls and surgical outcomes. JAMA Surg 2013; 148:1132–8

48. Scarborough JE, Bennett KM, Englum BR, Pappas TN, Lagoo-Deenadayalan SA: The impact of functional dependency on outcomes after complex general and vascular surgery. Ann Surg 2015; 261:432–7

49. Kim S, Marsh AP, Rustowicz L, Roach C, Leng XI, Kritchevsky SB, Rejeski WJ, Groban L: Self-reported mobility in older patients predicts early postoperative outcomes after elective noncardiac surgery. ANESTHESIOLOGY 2016; 124:815–25

50. Brown CH IV, Max L, LaFlam A, Kirk L, Gross A, Arora R, Neufeld K, Hogue CW, Walston J, Pustavoitau A: The association between preoperative frailty and postoperative delirium after cardiac surgery. Anesth Analg 2016; 123:430–5

51. Rothman KJ: No adjustments are needed for multiple comparisons. Epidemiology 1990; 1:43–6

52. Millar K, Asbury AJ, Murray GD: Pre-existing cognitive impairment as a factor influencing outcome after cardiac surgery. Br J Anaesth 2001; 86:63–7

53. Smith PJ, Attix DK, Weldon BC, Greene NH, Monk TG: Executive function and depression as independent risk factors for postoperative delirium. ANESTHESIOLOGY 2009; 110:781–7

54. Boustani M, Perkins AJ, Fox C, Unverzagt F, Austrom MG, Fultz B, Hui S, Callahan CM, Hendrie HC: Who refuses the diagnostic assessment for dementia in primary care? Int J Geriatr Psychiatry 2006; 21:556–63

55. Brayne C, Fox C, Boustani M: Dementia screening in primary care: Is it time? JAMA 2007; 298:2409–11

56. Cheema FN, Abraham NS, Berger DH, Albo D, Taffet GE, Naik AD: Novel approaches to perioperative assessment and intervention may improve long-term outcomes after colorectal cancer resection in older adults. Ann Surg 2011; 253:867–74

57. Gillis C, Li C, Lee L, Awasthi R, Augustin B, Gamsa A, Liberman AS, Stein B, Charlebois P, Feldman LS, Carli F: Prehabilitation *versus* rehabilitation: A randomized control trial in patients undergoing colorectal resection for cancer. ANESTHESIOLOGY 2014; 121:937–47

58. Boddaert J, Cohen-Bittan J, Khiami F, Le Manach Y, Raux M, Beinis JY, Verny M, Riou B: Postoperative admission to a dedicated geriatric unit decreases mortality in elderly patients with hip fracture. PLoS One 2014; 9:e83795

ANESTHESIOLOGY REFLECTIONS FROM THE WOOD LIBRARY-MUSEUM

Presidential Perforations? James T. Gwathmey, M.D., Modifies Yankauer Masks

Better known today for his namesake suction wand, Sidney Yankauer, M.D. (1872 to 1932), practiced at New York's Mount Sinai Hospital as an otorhinolaryngologist and pioneer bronchoscopist. The invention that he popularized around 1904, his Yankauer mask (*left*), reigned as America's favorite open-drop ether mask for half a century. Roughly 8 yr after the introduction of Yankauer's mask, James T. Gwathmey, M.D. (1862 to 1944; president of the New York Society of Anesthetists, 1912), modified that mask (*right*) and featured it in his 1914 textbook *Anesthesia* as the "Yankauer-Gwathmey Drop and Vapor Mask." In characterizing the latter "vapor" capacity, he described "a close-fitting mask, the base of which is a hollow tube with perforations inside so that, as the vapor is pumped…or passed from an oxygen or air tank through the apparatus, the patient inhales a certain known percentage of the anesthetic and gets only this percentage, regardless of the depth or rate of respiration." (Copyright © the American Society of Anesthesiologists' Wood Library-Museum of Anesthesiology.)

George S. Bause, M.D., M.P.H., Honorary Curator and Laureate of the History of Anesthesia, Wood Library-Museum of Anesthesiology, Schaumburg, Illinois, and Clinical Associate Professor, Case Western Reserve University, Cleveland, Ohio. UJYC@aol.com.