The American Journal of Surgery 220 (2020) 1064–1070

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Prospective evaluation of preoperative cognitive impairment and postoperative morbidity in geriatric patients undergoing emergency general surgery

Kamil Hanna [a], Muhammad Khan [b], Michael Ditillo [a], Mohammad Hamidi [a], Andrew Tang [a], Muhammad Zeeshan [a], Abdul Tawab Saljuqi [a], Bellal Joseph [a], *

[a] *Division of Trauma, Critical Care, Emergency Surgery, and Burns, Department of Surgery, College of Medicine, University of Arizona, Tucson, AZ, USA*
[b] *Department of Surgery, Westchester Medical Center, Valhalla, NY, USA*

ARTICLE INFO

Article history:
Received 5 May 2019
Received in revised form
14 March 2020
Accepted 3 April 2020

Oral presentation at the 2018 American College of Surgeons Clinical Congress, October 2018, Boston, Massachusetts.

Keywords:
Geriatrics
Emergency general surgery
Cognitive impairment
MOCA
EGSFI

ABSTRACT

Background: Cognitive impairment (CI) is common in geriatric patients. We aimed to evaluate the prevalence and impact of CI on outcomes in geriatric patients undergoing emergency general surgery (EGS).
Methods: We performed a (2017–2018) prospective analysis of patients (age ≥65y) who underwent EGS. Cognition was assessed using the Montreal Cognitive Assessment (MoCA). Patients were stratified into: CI (MoCA score<26) and no-CI (MoCA≥26). Outcomes were the prevalence of CI, in-hospital complications, discharged to rehab/skilled nursing facility (SNF), and mortality.
Results: A total of 142 patients were enrolled. Overall prevalence of CI was 20%. Patients with CI had higher rates of complications (OR 1.6 [1.4–1.9]; p = 0.01), and discharge to rehab/SNF (OR 2.2 [2.0–2.5]; p = 0.03). There was no difference in mortality (OR 1.1 [0.6–1.8]; p = 0.24) between the 2 groups.
Conclusion: One in five geriatric EGS patients has CI. It is associated with higher complications and adverse discharge. Cognitive assessment should be included in preoperative risk stratification.

Introduction

The elderly are the fastest-growing segment of the US population.[1] According to projections, the number of people above the age of 65 is expected to grow to 98 million constituting 24% of the population by 2060.[2] The current demographic changes are a major public health concern and have multiple ramifications for clinicians across the spectrum of care especially in emergency general surgery (EGS).

While advancements in the management of age-related chronic medical conditions have led to an improved overall perioperative risk profile, the management of elderly EGS patients still constitutes a challenge to surgeons.[3] Risk stratification in elderly patients undergoing EGS is a challenging endeavor. There are many reasons why elderly patients require keen preoperative evaluation. Geriatric patients present with their own set of age-related pre-existing medical conditions many of which can complicate the patient's post-operative course leading to eventual decompensation and possibly death. Cognitive impairment is one such pre-existing condition that has a high incidence and prevalence in this age group.[4] An established risk factor for post-operative neuropsychiatric alterations such as delirium, confusion, and anxiety,[5] it is highly relevant in the setting of surgery. However, the impact of cognitive impairment on major outcomes following emergency general surgery is relatively less explored. This study aims to evaluate the prevalence of preoperative cognitive impairment and ascertain its impact on postoperative outcomes in geriatric patients undergoing EGS. We hypothesized that the presence of preoperative cognitive impairment in associated with a higher morbidity and mortality.

---

* Corresponding author. FACS, University of Arizona, Department of Surgery, Division of Trauma, Critical Care, And Emergency Surgery, 1501 N. Campbell Ave, Room 5411, P.O. Box 245063, Tucson, AZ, 85724, USA.

E-mail addresses: kamilhanna@surgery.arizona.edu (K. Hanna), mnumankhan21@gmail.com (M. Khan), michael.ditillo@ahn.org (M. Ditillo), hamidi@surgery.arizona.edu (M. Hamidi), atang@surgery.arizona.edu (A. Tang), mzeeshan@surgery.arizona.edu (M. Zeeshan), tsaljuqi@surgery.arizona.edu (A.T. Saljuqi), bjoseph@surgery.arizona.edu (B. Joseph).

https://doi.org/10.1016/j.amjsurg.2020.04.004
0002-9610/

Methods

After obtaining approval from the University of Arizona Institutional Review Board, we performed a 2-year (2017–2018) prospective cohort study of all patients who presented to our center and underwent an EGS procedure as defined by the American Association for the Surgery of Trauma (AAST).[6] All eligible patients were approached for the consenting process and those who agreed to participate in the study were included in the analysis.

Study population: Inclusion & exclusion criteria

We approached all geriatric (≥65 years) EGS patients admitted to our center for at least 1 day. We excluded patients who were dead on arrival, transferred from other institutions, unwilling to consent, or unable to complete the survey due to an altered mental status and/or unavailability of family historians.

Study protocol

Patients were screened during the morning sign-outs. All eligible EGS patients were identified and approached by the investigators. The study protocol along with the benefits and risks were explained to every eligible patient. Following written informed consent, we administered surveys that measured cognitive impairment and frailty at the time of admission. Data points regarding demographics and the hospital course were collected through a review of electronic medical records.

Measurements & datapoints

Cognitive evaluation

Patients were approached by a single investigator following a hospital admission and before undergoing the EGS procedure. After obtaining informed consent, baseline cognitive function was assessed using the Montreal Cognitive Assessment (MoCA) tool systematically. MoCA is a prospectively validated neuropsychiatric tool to screen patients who present with cognitive complaints and usually perform in the normal range on the Mini-Mental Status Exam (MMSE).[7–9] The current study used the final revised version of the MoCA composed of one page 10-min-30-point cognitive screening tests that asses eight cognitive domains using rapid, sensitive, and easy-to-administer tasks. Fig. 1. MoCA has more emphasis on tasks of frontal executive functioning and attention than the MMSE, which may make it more sensitive in detecting mild cognitive impairment (MCI) and dementia.[10] Scores on the MoCA range from 0 to 30, with a score of 26 and higher generally considered cognitively intact and a score below 26 is considered cognitively impaired. Our center provides care to a sizable population of Hispanic patients from both southern Arizona and Mexico. Spanish speaking patients were not excluded from the study. For these patients, we utilized the Spanish language version of the MoCA test. This version of the MoCA was validated in Spanish for the age group of patients we recruited in our study.[11] When the Spanish version of the MoCA was used we utilized the validated cutoffs derived by Delgado et al. to identify patients who have CI (MoCA<21).[11] The investigator that administered the MoCA test first read the instructions available on the MoCA website. Following familiarization with the test, the investigator underwent training in the implementation and use of the questionnaire. This was followed by several practice sessions for performing the MoCA in a simulated clinical situation supervised by a clinician experienced is using the test.

Frailty

Frailty was measured on admission using the validated Emergency General Surgery Frailty Index (EGSFI) questionnaire which is derived from the Rockwood frailty survey.[12] The EGSFI follows the deficit accumulation model of frailty and covers a patient's overall health including comorbidities, activities of daily living, social activity, nutritional status, and general health attitude.[12] Most of its 15 variables are dichotomized, whereas others have multiple categories. Each variable is given a score and individual scores are then added up and divided by the maximum score to calculate the EGSFI. The EGSFI score ranges from 0 to 1 with higher scores indicating frail status. Patients' frailty status was determined based on their EGSFI: non-frail (EGSFI <0.25), and frail (EGSFI ≥ 0.25).

Demographics and clinical characteristics

Data were collected by trained researchers systematically for each subject including demographics (age, gender, and race), emergency department vital signs (systolic blood pressure, heart rate, Glasgow Coma Scale, and temperature), MoCA score, leukocytosis (white blood cell count ≥11,000 per mm^3), albumin level, and comorbidities. We also abstracted data on ASA (American Society for Anesthesiology) class, diagnosis, presence of postoperative complications (respiratory, cardiovascular, infectious, hematological, renal), discharge disposition, in-hospital mortality, ICU admission, ICU length of stay, hospital length of stay, and 30-day readmission.

Patient stratification

Following MoCA administration, the patients were stratified into two groups based on their MoCA scores. Patients scoring <26 were classified as cognitively impaired (CI) while those scoring ≥26 were classified as cognitively intact (no-CI) when the English assessment tool was used. Patients scoring <21 were classified as cognitively impaired (CI) while those scoring ≥21 were classified as cognitively intact (no-CI) when the Spanish assessment tool was used.

Outcome measures

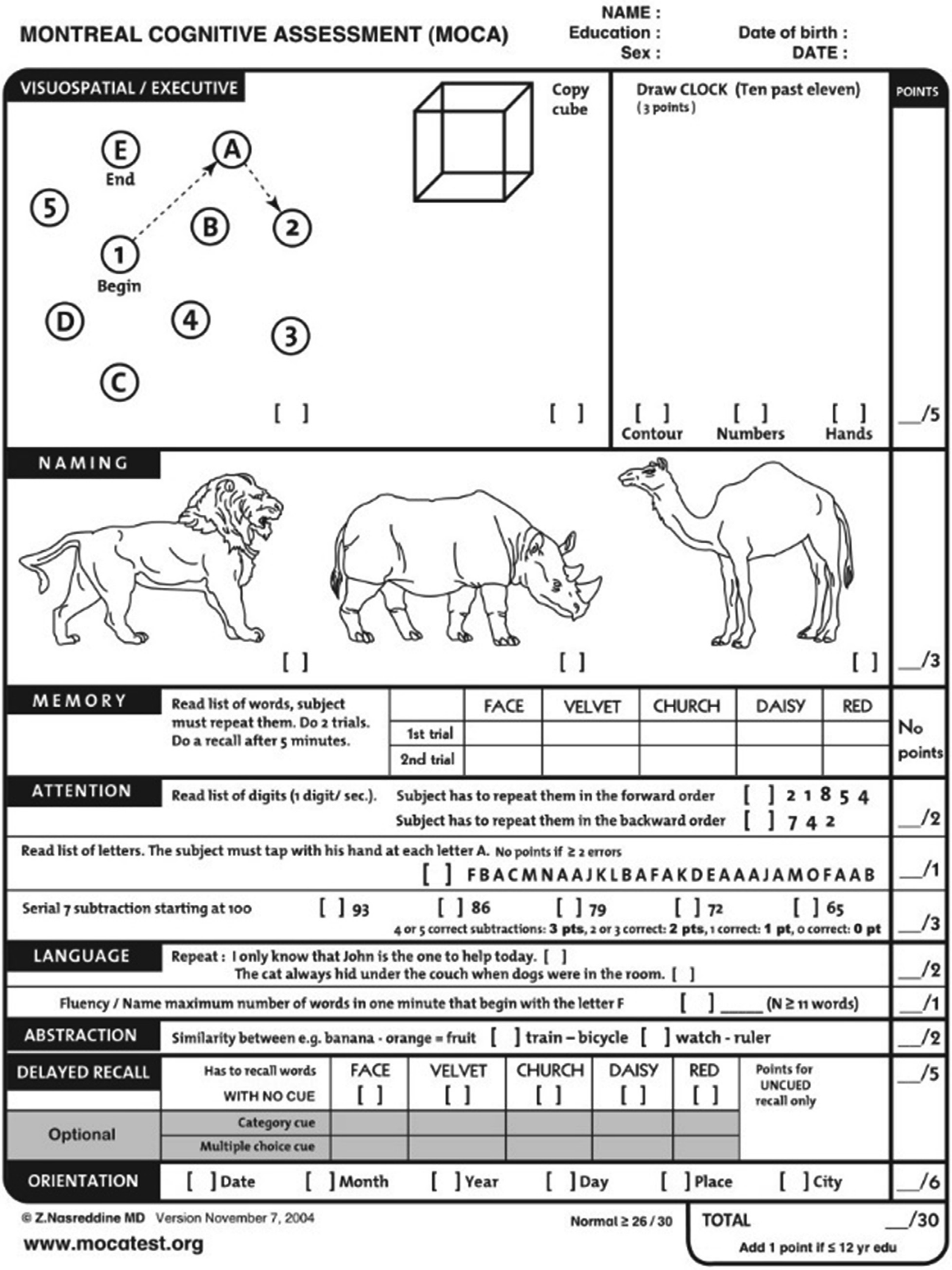
Our primary outcome measure was the prevalence of cognitive impairment. Our secondary outcome measures were in-hospital complications, adverse discharge disposition (discharge to rehab or skilled nursing facility), 30-day mortality, and 30-day readmission rate.

Statistical analysis

We performed descriptive statistics. Continuous parametric data were reported as mean ± standard deviation. Continuous nonparametric data as median with interquartile range. Categorical data were reported using proportions and percentages. To analyze the differences between the two groups on a univariate level, we used a chi-square test for categorical variables, the Mann-Whitney *U* test for continuous nonparametric data, and the independent Student's t-test for continuous parametric data. A multivariable logistic regression model was then built to ascertain the impact of cognitive impairment on the secondary outcomes adjusting for variables significant on the univariate level and confounding variables (comorbidities, ASA-class, pre-operative labs, and vital signs, type of operative intervention, frailty status). P values < 0.05 were considered statistically significant. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, version 23; SPSS, Inc, Armonk, NY).

Results

A total of 161 elderly EGS patients were approached for



MONTREAL COGNITIVE ASSESSMENT (MOCA)

NAME :
Education :
Sex :
Date of birth :
DATE :

		POINTS
VISUOSPATIAL / EXECUTIVE [ ] Copy cube [ ]	Draw CLOCK (Ten past eleven) (3 points) [ ] Contour [ ] Numbers [ ] Hands	__/5
NAMING [ ] [ ] [ ]		__/3

MEMORY Read list of words, subject must repeat them. Do 2 trials. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED	
1st trial						No points
2nd trial						

ATTENTION Read list of digits (1 digit/ sec.). Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2 __/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] FBACMNAAJKLBAFAKDEAAAJAMOFAAB __/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt** __/3

LANGUAGE Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ] __/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] ____ (N ≥ 11 words) __/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler __/2

DELAYED RECALL	Has to recall words WITH NO CUE	FACE [ ]	VELVET [ ]	CHURCH [ ]	DAISY [ ]	RED [ ]	Points for UNCUED recall only	__/5
Optional	Category cue							
	Multiple choice cue							

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City __/6

© Z.Nasreddine MD Version November 7, 2004
www.mocatest.org

Normal ≥ 26 / 30 **TOTAL** __/30
Add 1 point if ≤ 12 yr edu

Fig. 1. Montreal cognitive assessment tool.

enrollment out of which 142 consented and were included in the study Fig. 2. Following cognitive assessment using MoCA, 113 (80%) were found to be cognitively intact and 29 (20%) were found to be cognitively impaired. The mean age was 74 ± 8 years, 58% were male, and 83% were white. The most common comorbidity was hypertension (33%) followed by chronic obstructive pulmonary disorder (22%). The median MoCA score was 28 [20–30], and 35% of the sample had an ASA class >3. In terms of admission parameters, the majority of patients were hemodynamically stable on admission with a mean systolic blood pressure of 136 ± 28 mm of Hg and a mean heart rate of 87 ± 15 beats per minute. Moreover, 44% of the patients were febrile on admission and 57% had leukocytosis. Based on the EGSFI, 40% of the sample were frail. The most common diagnosis was cholecystitis (18%) followed by appendicitis (11%). Overall, 11% were admitted to the ICU, with a median ICU LOS of 1 [1–3] days and a hospital LOS of 5 [2–10] days. Table 1.

There were no differences in age ($p = 0.55$), gender ($p = 0.34$), emergency department systolic blood pressure ($p = 0.11$), emergency department heart rate ($p = 0.21$), American Society of Anesthesiology (ASA) class>3 ($p = 0.55$) between the two groups. Furthermore, baseline comorbidities, laboratory parameters, and presenting diagnosis also did not differ between patients who were cognitively impaired versus those who were cognitively intact ($p > 0.05$). In comparison to cognitively intact patients, those who were cognitively impaired had a higher rate of complications (38% vs. 19%; $p < 0.001$). In particular, patients who were cognitively impaired had a higher rate of respiratory complications (14% vs. 4%; $p = 0.01$), and infectious complications (21% vs. 11%; $p = 0.01$). However, there was no difference between the two groups with regards to cardiovascular (3% vs. 2%; $p = 0.65$), hematological (3% vs. 0.9%; $p = 0.67$), or renal (3% vs. 2%; $p = 0.87$) complications. Table 2. Furthermore, patients with cognitive impairment were more likely to have an adverse discharge disposition (45% vs. 17%; $p < 0.001$) and had higher rates of mortality (17% vs. 7%; $p < 0.001$), and 30-day readmission (10% vs. 4%; $p < 0.001$) in comparison to patients who were cognitively intact. Table 3. On regression analysis after adjusting for demographic characteristics, comorbidities, vital parameters on admission, pre-operative lab tests, ASA class, type of operative intervention, and EGSFI, patients who had cognitive impairment had a higher adjusted odds of complications (OR 1.6 [1.4–1.9]; $p = 0.01$), adverse discharge disposition (OR: 2.2 [2.0–2.5]; $p = 0.03$), and 30-day readmission (OR 1.3 [1.1–1.7]; $p = 0.01$) however there was no difference in the adjusted odds ratio of mortality between the two groups (OR 1.1 [0.6–1.8]; $p = 0.24$) Table 4. Fig. 3.

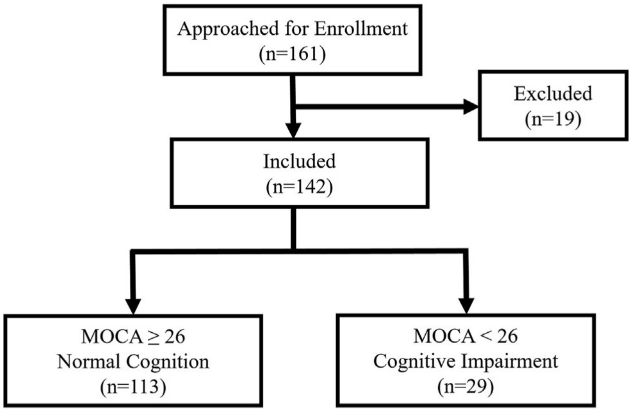


Fig. 2. Patient flow diagram.

Discussion

The results of our study indicate that around one in five elderly EGS patients is found to be cognitively impaired at the time of presentation. CI is therefore not uncommon comorbidity and must not be overlooked in the setting of EGS. This has wide implications on practice especially in the multidisciplinary care of these patients who are predisposed to develop a myriad of complications in the postoperative period. It is therefore important to ensure the availability of specialists, adequate staffing, performing an early comprehensive geriatric assessment, along with timely post-operative medication adjustment.[13]

Table 1
Demographics of the study population.

Variable	No-CI (n = 113)	CI (n = 29)	*P-value*
Age, years mean ± SD	74.2 ± 8.1	73.5 ± 7.8	0.55
Male, n (%)	67 (59)	21 (72)	0.34
Whites, n (%)	97 (86)	21 (72)	0.02
Weight Kg, median [IQR]	32 [15–62]	54 [22–73]	<0.01
Vital parameters			
ED SBP, mmHg, mean ± SD	137 ± 27	131 ± 31	0.11
ED HR, BPM, mean ± SD	88 ± 14	84 ± 18	0.21
ED GCS, median [IQR]	15 [14–15]	14 [14–15]	0.43
ED T > 38°, n (%)	51 (45)	12 (41)	0.72
Comorbidities			
CAD, n (%)	14 (12)	8 (28)	0.04
CKD, n (%)	17 (15)	6 (21)	0.45
CLD, n (%)	8 (7)	3 (10)	0.52
COPD, n (%)	28 (25)	3 (10)	0.08
HTN, n (%)	34 (30)	13 (45)	0.12
CVA, n (%)	11 (10)	3 (10)	0.94
Laboratory Parameters			
WBC >11,000 per mm^3, n (%)	62 (55)	19 (65)	0.13
Albumin >3.5 g/dL, n (%)	93 (82)	17 (59)	0.01
ASA Class > 3, n (%)	40 (35)	11 (38)	0.55
MoCA, median [IQR]	29 [26–30]	23 [19–24]	<0.01
EGFSI, mean ± SD	0.18 ± 0.11	0.24 ± 0.12	0.04
Frail, n (%)	42 (37)	15 (52)	0.13
Diagnosis			
Cholecystitis, n (%)	19 (17)	6 (21)	0.62
Appendicitis, n (%)	10 (9)	5 (17)	0.19
SBO, n (%)	9 (8)	3 (10)	0.68
Strangulated inguinal hernia, n (%)	9 (8)	4 (14)	0.33
Colonic diverticulitis, n (%)	8 (7)	4 (14)	0.24
Other, n (%)	58 (51)	7 (24)	0.01
ICU admission, n (%)	10 (9)	5 (17)	0.20
ICU LOS, days, median [IQR]	1 [1–3]	1 [1–2]	0.04
Hospital LOS, days, median [IQR]	4 [2–7]	6 [4–9]	0.02

CI = cognitive impairment; SD = standard deviation; IQR = interquartile range; ED = emergency department; SBP = systolic blood pressure; HR = heart rate; bpm = beats per minute; GCS = Glasgow Coma Scale; T = temperature; CAD = coronary artery disease; CKD = chronic kidney disease; CLD = chronic liver disease; COPD = chronic obstructive pulmonary disease; HTN = hypertension; CVA = cerebrovascular accident; WBC = white blood cell count; ASA = American Society of Anesthesiologists; MoCA=Montreal cognitive assessment tool; EGFSI = emergency general surgery frailty index; SBO = small bowel obstruction; ICU = intensive care unit; LOS = length of stay.

Table 2
Post-operative complications.

Complication	No-CI (n = 113)	CI (n = 29)	*P-value*
Any complication, n (%)	21 (19)	11 (38)	<0.001
Respiratory, n (%)	5 (4)	4 (14)	0.01
Cardiovascular, n (%)	2 (2)	1 (3)	0.65
Infectious, n (%)	12 (11)	6 (21)	0.01
Hematological, n (%)	1 (0.9)	1 (3)	0.67
Renal, n (%)	2 (2)	1 (3)	0.87

CI = cognitive impairment.

Table 3
Secondary outcomes.

Outcome	No-CI (n = 113)	CI (n = 29)	*P-value*
Adverse discharge disposition, n (%)	19 (17)	13 (45)	<0.001
Mortality, n (%)	8 (7)	5 (17)	<0.001
30-day Readmission, n (%)	5 (4)	3 (10)	<0.001

CI = cognitive impairment.

Patients with CI are predisposed to multiple post-operative neuropsychiatric sequelae that can persist for prolonged periods such as confusion, and delirium which can complicate the in-hospital course leading to a protracted length of stay, risk of falls, and non-compliance with medical advice.[14] Being aware of the burden of CI and its in-hospital consequences may allow for early screening and assessment along with applying prophylactic measures.[15–18] Understanding the prevalence of CI may as well allow us to re-evaluate the patients' decision-making capacity especially when surgery and other interventions are to be performed.[19,20] Identification of patients at risk will guide post-operative care in many ways. Examples include documentation of baseline cognitive status,[21] medication adjustment,[22] multicomponent non-pharmacologic interventions to prevent delirium,[23] optimal pain control,[24] geriatric assessment,[25] thorough post-operative instruction delivery, and implementing the teach-back method for self-wound care. Finally, pre-operative cognitive assessment is an integral part of the system-wide changes needed for the adaptation of the healthcare system to the needs of surgical geriatric patients in all centers.[26] Such healthcare infrastructural changes constitute the theoretical basis of geriatric centers of excellence. The American College of Surgeons has initiated the geriatric surgery verification program after years of planning and research.[27] Currently, it is being piloted at multiple hospitals across the nation and is expected to redefine the standard of care and improve healthcare quality. Hospitals will be verified if they meet a number of standards related to geriatric care. A preoperative screening cognitive assessment was validated as a quality indicator for older adult surgical patients.[28] Additionally, the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP®)/American Geriatrics Society (AGS) Best Practice Guidelines: recommend preoperative cognitive evaluation for patients without a known history of cognitive impairment or dementia.[29,30]

MoCA is not routinely used in acute care surgery however Hewitt et al. conducted a prospective observational study of elderly EGS patients from 3 hospitals in Wales and Scotland using the same cognitive assessment tool.[31] The rate of cognitive impairment was reported to be 66.9% which is three-fold the rate found in this study. Multiple reasons could explain this discrepancy, the sample of patients differed in many ways. Hewitt et al. studied an older cohort of geriatric EGS patients from a different population from both rural and urban sources. Furthermore, the patients also had a more diverse group of conditions including neurosurgical and vascular conditions. The difference in the prevalence of vascular dementia could explain the differences in cognitive impairment between the two studies.

The results also suggest that CI is an independent predictor of postoperative complications in patients with the same demographics, comorbidities, and ASA operative risk. This is attributed primarily to respiratory and infectious complications. Pulmonary complications are the most common cause of morbidity and mortality in the postoperative period.[32] Inadequate ventilation in the immediate post-operative period can lead to atelectasis, bronchiolar mucous plugging, the collapse of the alveoli, and hypoxia. The cascade of events can eventually progress to fever, and pneumonitis.[33] Patients with CI are less likely to be compliant with medical advice especially regarding prophylactic measures for postoperative respiratory complications such as usage of incentive spirometry, early ambulation, deep breathing and coughing exercises. According to Martin et al. among the factors influencing non-adherence is the patient's ability to remember the recommendations made to them during post-operative visits whether in-hospital or following discharge.[34] Retention of information regarding post-operative instructions is likely to be significantly lower in patients with pre-operative cognitive impairment. Aykut et al. in a prospective cohort study reported that the prevalence of mild CI assessed using the same tool is 52%.[35] Furthermore, significant differences were found in patients with mild CI as they had high rates of atelectasis (84%), prolonged ventilation (24%), and deterioration in the postoperative spirometry tests.[36] The differences were as well attributed to the observed post-operative noncompliance with respiratory exercises, ineffective cough, and difficulty in the use of inhalers. The rate of pneumonia was reported to be 8% which is comparable to the rate of overall infection complications found in this study.

Furthermore, patients with CI were found to have higher crude rates of adverse discharge disposition (skilled nursing facilities), mortality and 30-day readmission. Not surprisingly, these patients are less likely to be functionally independent and may not be able to adhere to post-operative wound care practices and medication regimens. Discharge to SNF is by its very nature determined by criteria such as poor mobility, CI, frailty, and poor in-home support.[37] Many factors played a role in determining whether patients should be discharged to rehab or skilled nursing facility. This is why around one in six patients with no pre-operative CI had an adverse discharge disposition. However, patients with CI had a significantly higher rate of adverse discharge disposition. In this way, patients with pre-operative CI are more likely to meet criteria that necessitate a discharge to a facility and CI contributes to loss of functional independence in this age group and this increases the likelihood of institutionalization. Baseline CI is likely to be exacerbated in the post-operative period due to post-operative cognitive dysfunction (POCD).[38,39] Newman et al. conducted a systematic review of POCD.[40] The evidence suggests that older participants are more likely to show POCD. For the same reasons, patients with CI are more likely to be re-hospitalized as well. Anderson et al. investigated the effect of CI on short-term readmission.[41] The adjusted odds of readmission increased 13% with each point increase in the

Table 4
Multivariable logistic regression analysis.

Outcome	aOR	95% CI	*P-value*
Complications	1.6	1.4–1.9	0.01
Adverse discharge disposition	2.2	2.0–2.5	0.03
30-day readmission	1.3	1.1–1.7	0.01
Mortality	1.1	0.6–1.8	0.24

CI = confidence interval; aOR = Adjusted Odds Ratio.

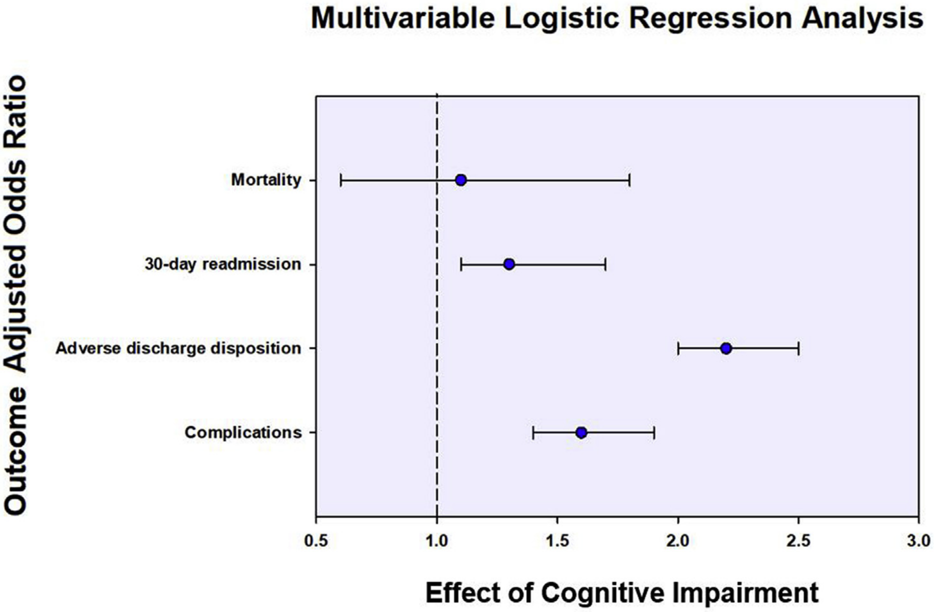


Fig. 3. Multivariable logistic regression analysis.

CI. Patients who independently managed their medications and were receiving more than seven medications were shown to be at greatest risk. A similar analysis was conducted by Huynh et al. demonstrating that one in five are likely to be readmitted.[42] Moreover, adding the MoCA score to an existing prediction model of 30-day readmission significantly improved its predictive power and accuracy. Rigorous multidisciplinary follow-up is needed in patients with cognitive impairment following EGS to assess their post-discharge course, track functional independence, and prevent readmission. Extra care must be exercised on the transition of the care plan with communication with primary care clinicians and family members.

Interestingly, CI was no longer a predictor of mortality after adjusting for measurable confounding factors. While cognitive dysfunction leads to complications in the post-operative course and readmissions, its association with mortality was confounded by other factors adjusted for in the model. Mortality is dependent on more comprehensive measures that capture the vulnerability in this age group such as frailty.[40] EGSFI was adjusted for in the model along with baseline demographic factors and comorbidities. Frailty is a multidimensional phenotype that measures the state of depleted physiological reserves in these patients and includes a mental dimension and cognitive dysfunction.[41] Cano et al. examined the association between frailty and cognitive impairment as predictors of mortality.[42] It was reported that as the Mini-Mental Status Exam score declined over time. The percent of frail individuals increased linearly highlighting the association between frailty and cognitive impairment. Further sensitivity analysis conducted in the study has shown that frailty and cognitive impairment were independent risk factors for mortality when included individually in the model after controlling for all measurable covariates.[42] However, when both CI and frailty were added to the model, the adjusted hazard ratio for CI was no longer statistically significant which is in line with the results reported in this study.

Our study had multiple limitations. We did not reassess the patients' cognitive status in the post-operative period to ascertain the prevalence of post-operative cognitive dysfunction which can exacerbate in-hospital and long-term outcomes and is more likely to occur in patients with preoperative cognitive dysfunction. This would have been needed if we sought to determine the impact of surgery on baseline cognitive status. We restricted patient assessment to the pre-operative period when the process of risk stratification and evaluation of surgical risk typically occurs. Such objective data is advantageous when available in the pre-operative period and factors in the risk-benefit considerations of the operative intervention and can anticipate post-operative complications and guide post-operative care. The tool utilized assesses the patient's cognitive status on admission but does not take into consideration the duration of the impairment. Even when patients with altered mental status were excluded the mental status on admission is likely to be inadequately assessed in the elderly due to their underlying condition and associated symptoms such as pain, fever, nausea, and confusion leading to an overall lower score. However, all patients in the study were able to successfully complete the assessment and were cooperative with the assessor this may help reduce such bias. Patients who can complete the survey were only included in the study. Even though around 25% of patients with cognitive impairment scored $\leq$18 and are likely to have moderate-severe dysfunction, the utility of the tool is primarily to discriminate between normal cognition and mild cognitive impairment. This eliminates patients on the severe end of the spectrum and the findings of the study are not generalizable to these patients as well. The association between cognitive impairment and outcomes can be mediated by other non-measurable confounding variables as well. A thorough cognitive evaluation requires additional standardized performance-based tests and neuropsychological measures. However, such additional testing is not feasible within the time constraints of emergency surgery. We utilized the MoCA test for screening purposes rather than diagnostic purposes and its advantages include its brevity, simplicity, validity, and reliability as a screening test for CI. The MoCA results could have been influenced when administered in the pre-operative setting. However, when studying an emergency surgery cohort, the pre-operative period is the only time available to screen for cognitive impairment, unlike elective surgery settings.

Future research studies should look into the causal factors contributing to the association between CI and adverse outcomes in elderly EGS patients. Furthermore, future directions should address patients on the severe end of the spectrum who are expected to have worse outcomes and would benefit from early risk stratification.

Conclusion

Cognitive impairment is a significant comorbidity in elderly patients undergoing EGS. One in every five geriatric patients undergoing EGS is found to have cognitive impairment on admission. Screening for and diagnosing cognitive impairment is crucial considering its apparent association with higher complications and adverse discharge disposition. Cognitive assessment should be included in preoperative risk stratification and physician-patient discussions.

Funding

The authors have no financial or proprietary interest in the subject matter or materials discussed in the manuscript.

Declaration of competing interest

There are no identifiable conflicts of interest to report.

References

1. *American Community Survey 2011-2015*. United States Census Bureau; 2015.
2. Colby SL, Ortman JM. *Projections of the Size and Composition of the US Population: 2014 to 2060: Population Estimates and Projections*. 2017.
3. Desserud KF, Veen T, Soreide K. Emergency general surgery in the geriatric patient. *Br J Surg*. 2016 Jan;103(2):e52–e61. PubMed PMID: 26620724. Epub 2015/12/02. eng.
4. Jokar TO, Ibraheem K, Rhee P, et al. Emergency general surgery specific frailty index: a validation study. *Journal of Trauma and Acute Care Surgery*. 2016;81(2): 254–260.
5. Plassman BL, Langa KM, Fisher GG, et al. Prevalence of cognitive impairment without dementia in the United States. *Ann Intern Med*. 2008;148(6):427–434.
6. Rundshagen I. Postoperative cognitive dysfunction. *Deutsches Arzteblatt Int*. 2014 Feb 21;111(8):119–125. PubMed PMID: 24622758. Pubmed Central PMCID: PMC3959222. Epub 2014/03/14. eng.
7. Shafi S, Aboutanos MB, Agarwal Jr S, et al. Emergency general surgery: definition and estimated burden of disease. *J Trauma Acute Care Surg*. 2013;74(4): 1092–1097.
8. Nasreddine ZS, Phillips NA, Bédirian V, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. *J Am Geriatr Soc*. 2005;53(4):695–699.
9. Smith T, Gildeh N, Holmes C. The Montreal Cognitive Assessment: validity and utility in a memory clinic setting. *Canadian J Psychiatr Revue Canad de Psychiatr*. 2007 May;52(5):329–332. PubMed PMID: 17542384. Epub 2007/06/05. eng.
10. Luis CA, Keegan AP, Mullan M. Cross validation of the Montreal Cognitive Assessment in community dwelling older adults residing in the Southeastern US. *Int J Geriatr Psychiatr: J Psychiatr late life Allied Sci*. 2009;24(2):197–201.
11. Delgado C, Araneda A, Behrens MI. Validation of the Spanish-language version of the montreal cognitive assessment test in adults older than 60 years. *Neurologia*. 2019;34(6):376–385.
12. Wong GKC, Lam SW, Wong A, et al. Comparison of montreal cognitive assessment and mini-mental state examination in evaluating cognitive domain deficit following aneurysmal subarachnoid haemorrhage. *PloS One*. 2013;8(4), e59946.
13. Xue DD, Cheng Y, Wu M, Zhang Y. Comprehensive geriatric assessment prediction of postoperative complications in gastrointestinal cancer patients: a meta-analysis. *Clin Interv Aging*. 2018;13:723–736. PubMed PMID: 29731614. Pubmed Central PMCID: PMC5927346. Epub 2018/05/08. eng.
14. Sieber FE. Postoperative delirium in the elderly surgical patient. *Anesthesiol Clin*. 2009;27(3):451–464.
15. Fong TG, Tulebaev SR, Inouye SK. Delirium in elderly adults: diagnosis, prevention and treatment. *Nat Rev Neurol*. 2009;5(4):210.
16. Kalisvaart KJ, De Jonghe JFM, Bogaards MJ, et al. Haloperidol prophylaxis for elderly hip-surgery patients at risk for delirium: a randomized placebo-controlled study. *J Am Geriatr Soc*. 2005;53(10):1658–1666.
17. Teslyar P, Stock VM, Wilk CM, et al. Prophylaxis with antipsychotic medication reduces the risk of post-operative delirium in elderly patients: a meta-analysis. *Focus*. 2013;11(4):544–551.
18. Kat MG, Vreeswijk R, De Jonghe JFM, et al. Long-term cognitive outcome of delirium in elderly hip surgery patients. *Dement Geriatr Cognit Disord*. 2008;26(1):1–8.
19. Kim SYH, Karlawish JHT, Caine ED. Current state of research on decision-making competence of cognitively impaired elderly persons. *Am J Geriatr Psychiatr*. 2002;10(2):151–165.
20. Fitten LJ, Lusky R, Hamann C. Assessing treatment decision-making capacity in elderly nursing home residents. *J Am Geriatr Soc*. 1990;38(10):1097–1104.
21. Schenning KJ, Berger M. *Postoperative Neurocognitive Disorders in the Geriatric Patient*. Essentials of Neurosurgical Anesthesia & Critical Care: Springer; 2020: 105–107.
22. Dworsky JQ, Childers CP, Gornbein J, et al. Hospital experience predicts outcomes after high-risk geriatric surgery. *Surgery*. 2020;167(2):468–474.
23. Hornor MA, McDonald JD, Anaya DA, Rosenthal RA. *Care of the Geriatric Surgery Patient: The Surgeon's Perspective*. Geriatric Anesthesiology: Springer; 2018: 85–97.
24. Nano M, Solej M. *Principles of Geriatric Surgery*. Surgical Management of Elderly Patients: Springer; 2018:31–46.
25. Southerland LT, Gure TR, Ruter DI, et al. Early geriatric consultation increases adherence to TQIP geriatric trauma management Guidelines. *J Surg Res*. 2017;216:56–64.
26. Hanna K, Ditillo M, Joseph B. The role of frailty and prehabilitation in surgery. *Curr Opin Crit Care*. 2019;25(6):717–722.
27. Surgeons ACo. Introducing the ACS geriatric surgery verification program [cited 2019 3/11/2020]; Available from: https://www.facs.org/quality-programs/geriatric-surgery; 2019.
28. McGory ML, Kao KK, Shekelle PG, et al. Developing quality indicators for elderly surgical patients. *Ann Surg*. 2009;250(2):338–347.
29. Chow WB, Rosenthal RA, Merkow RP, et al. Optimal preoperative assessment of the geriatric surgical patient: a best practices guideline from the American College of Surgeons national surgical quality improvement program and the American geriatrics society. *J Am Coll Surg*. 2012;215(4):453–466.
30. Mohanty S, Rosenthal RA, Russell MM, et al. Optimal perioperative management of the geriatric patient: a best practices guideline from the American College of Surgeons NSQIP and the American Geriatrics Society. *J Am Coll Surg*. 2016;222(5):930–947.
31. Hewitt J, Williams M, Pearce L, et al. The prevalence of cognitive impairment in emergency general surgery. *Int J Surg*. 2014;12(10):1031–1035.
32. Kelkar KV. Post-operative pulmonary complications after non-cardiothoracic surgery. *Indian J Anaesth*. 2015;59(9):599.
33. Martin LR, Feig C, Maksoudian CR, et al. A perspective on nonadherence to drug therapy: psychological barriers and strategies to overcome nonadherence. *Patient Prefer Adherence*. 2018;12:1527.
34. Aykut K, Albayrak G, Guzeloglu M, et al. Preoperative mild cognitive dysfunction predicts pulmonary complications after coronary artery bypass graft surgery. *J Cardiothorac Vasc Anesth*. 2013;27(6):1267–1270.
35. Sun Y, Gao W, Zheng H, et al. Pulmonary lobectomies for patients with cognitive impairment: the importance of postoperative respiratory care. *Ann Transl Med*. 2015;3(14).
36. Allen LA, Hernandez AF, Peterson ED, et al. Discharge to a skilled nursing facility and subsequent clinical outcomes among older patients hospitalized for heart failure. *Circulation: Heart Fail*. 2011;4(3):293–300.
37. Moller JT, Cluitmans P, Rasmussen LS, et al. Long-term postoperative cognitive dysfunction in the elderly: ISPOCD1 study. *Lancet*. 1998;351(9106):857–861.
38. Moncada LV, Andersen RE, Franckowiak SC, Christmas C. The impact of cognitive impairment on short-term outcomes of hip fracture patients. *Arch Gerontol Geriatr*. 2006;43(1):45–52.
39. Huynh Q, Negishi K, De Pasquale CG, et al. Validation of predictive score of 30-day hospital readmission or death in patients with heart failure. *Am J Cardiol*. 2018;121(3):322–329.
40. Joseph B, Pandit V, Zangbar B, et al. Superiority of frailty over age in predicting outcomes among geriatric trauma patients: a prospective analysis. *JAMA surgery*. 2014;149(8):766–772.
41. Clegg A, Young J, Iliffe S, et al. Frailty in elderly people. *Lancet*. 2013;381(9868): 752–762.
42. Cano C, Samper-Ternent R, Al Snih S, et al. Frailty and cognitive impairment as predictors of mortality in older Mexican Americans. *J Nutr Health Aging*. 2012;16(2):142–147.