Cognitive impairment is associated with mortality in older adults in the emergency surgical setting: findings from the Older Persons Surgical Outcomes Collaboration (OPSOC)

A Prospective Cohort Study

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Word count: 3851

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Keywords: mortality, cognitive impairment, older adults, emergency surgical admissions, dementia, delirium

Abstract

Background: Cognitive impairment is prevalent in older surgical patients, yet the condition is greatly under-recognized, and outcomes associated with it are poorly understood.

Methods: This is a prospective multi-center cohort study of unselected consecutive older adults admitted to five emergency general surgical units across the United Kingdom participating in the Older Persons Surgical Outcomes Collaboration (www.OPSOC.eu), between 2013-2014. The effect of moderate cognitive impairment defined as ≤17, bottom quartile of Montreal Cognitive Assessment (MoCA) was examined using multivariate logistic regression models. Primary outcome measure was the relationship between a low MoCA score (≤17) and mortality at 30- and 90-days. Secondary outcome measures included the association between having a low MoCA and hospital length of stay.

Results: A total of 539 older patients admitted consecutively to five surgical units during the 2013 & 2014 study periods were included. The median age (IQR) was 76 (70-82) years, the emergency operation rate was 13%(n=72). The prevalence of cognitive impairment using the traditional MoCA cut off score of ≤26 was 84.4%, whilst using the recently suggested cut-off score of ≤23 the prevalence was 61.0%. Multivariable analyses showed patients with a low MoCA score (≤17) had three-fold increase in 30-day mortality (adjusted OR=3.10 (95% CI:1.19-8.11; *p*=0.021) and an increased length of hospital stay (10 or more days; 1.80(1.10-2.94; *p*=0.02) and 14 or more days; 2.06 (1.17-3.61; *p*=0.012)).

Conclusion: We recommend a routine cognitive assessment in emergency surgical setting whenever feasible to help identify patients at risk of poor outcomes.

Introduction

Cognitive impairment is reported in over 65% of older adults (65 years and over) presenting with emergency general surgical conditions.[1,2] Earlier evidence from elective surgery suggests that cognitive impairment is associated with an increased risk of post-operative complications and poorer outcomes when compared with patients with normal cognition.[3] With the older adult population continuing to increase in significant numbers and subsequently placing increasing demands on the emergency surgeon, establishing the relationship of cognitive impairment with patient outcomes could lead to improved recognition, understanding and early intervention in this vulnerable older adult surgical population.[4]

Cognitive impairment can be long-standing (dementia) or acute (delirium) and both frequently co-exist in acutely unwell older people. Dementia is defined as chronic cognitive impairment involving at least two domains of intellectual capacity; memory, language, visuospatial, executive functioning and calculation, which negatively impacts functioning.[4-7] Meanwhile, delirium is characterized by fluctuating disturbances of consciousness, disorientation and perceptual abnormalities, with impaired thinking and speech, which usually resolves after several days.[4] There are a multitude of pre-disposing factors for delirium including: polypharmacy, sepsis, surgical intervention and dementia.[4]

The screening tool of choice for detecting mild cognitive impairment is the Montreal Cognitive Assessment (MoCA).[1,12,13] This is a validated and easy-to-use questionnaire consisting of visual, memory/ recall questions, scored out of 30.[14] The creators of the cognitive assessment provide guidance on the interpretation of MoCA scores; with scores of 18-25 indicating mild, 10-17 indicating moderate and scores of less than 10, indicating severe cognitive impairment.[14] When compared to the Mini Mental State Examination (MMSE) the sensitivity of the MoCA was 90% versus 18% in the detection of mild cognitive impairment.[12,14-17]

An earlier work using MoCA in a single center vascular surgical setting reported the prevalence of cognitive impairment to be as high as almost 70%[17], however, this has yet to be confirmed in a multicenter study of acute general surgical patients. Moreover, it was also observed that a low MoCA was associated with poor outcomes such as an increased length of hospital stay.[17] Nevertheless, there remains a gap in the literature examining the association between a low MoCA and outcomes such as mortality and hospital re-admission in a multi-center cohort of older adults admitted to the emergency general surgical setting.

Methods

Study Design

As part of the Older Persons Surgical Collaboration (OPSOC) http://www.opsoc.eu, a prospective study was conducted across five hospitals in the United Kingdom (UK) between 2013-2014. Data were collected within the acute general surgical admissions setting for patients ≥65 years consecutively admitted to the participating units throughout May-June (two months) of both years, as described in an earlier OPSOC study by Hewitt and colleagues.[1] Patients were excluded if they presented with vascular, orthopedic, urological, gynecological or neurological conditions because these patients are admitted to specialist surgical departments within the National Health Service (NHS). In the UK, most emergency general surgical admissions relate to gastrointestinal disturbances i.e. appendicitis, diverticulitis, bowel obstruction/ perforation or pancreato-biliary disease, but may also include surgical conditions such as abscesses.[1]

Outcomes

Primary outcome measure was the relationship between MoCA score and mortality at 30- and 90-days. Secondary outcome measures included the association between having impaired cognition a (low MoCA score) and 30-day readmission and hospital length of stay.

Data Collection

Data were recorded and stored in conjunction with local data management and safety standard operating procedures. Anonymized data were collated centrally at the chief investigator's institution. All patients were service users of the state funded point-of-access care provided by the NHS in the UK, and only routinely available audited data were collected. As such, the collection of the data used in this study was deemed a service evaluation audit which did not require ethical approval, only approval from individual organizations participating in the service evaluation was required and granted. All patients were identified prospectively, and baseline demographic data collected at admission. As a surrogate marker of co-morbidity and disease severity, we recorded the presence of anemia (<129g/L), hypoalbuminemia (albumin <35g/L) and polypharmacy (≥5 medications on admission) as categorical data.

All data collectors were appropriately trained in the cognitive assessments used. In both the 2013 and 2014 data collection periods (N=539), all older adults admitted to the emergency general surgical setting had a MoCA test before any surgical intervention or within 24 hours of their admission. MoCA is a 30-point score (range 0-30) which is used as a screening tool to detect cognitive impairment.[14] Scores were dichotomized into being in the bottom 25% vs. the other 75% to reflect the actual MoCA scores of the bottom quartile of older emergency surgical patients across the UK. When using data collected from 2013 and 2014, the bottom 25% MoCA was ≤17. Developers of MoCA have recommended the interpretation of MoCA scores between 10-17 to indicate moderate cognitive impairment.[14] We used the MoCA test in English, original version 7.1.

During the 2014 data collection period (N=354), both MoCA and Confusion Assessment Method (CAM) data were collected from all older patients admitted to the emergency general surgical setting before any surgical intervention or within 24 hours of their admission. CAM is a validated method of allowing non-psychiatric clinicians to detect delirium through identifying three out of four described features, demonstrating an overall sensitivity of 94% and specificity of 89%.[18,19] CAM data was only collected during the 2014 collection period due to delirium becoming a new service evaluation focus of OPSOC. In the 2014 sample, the bottom 25% MoCA was ≤18. With one-point difference, it is unlikely to have any major clinically significant differences in outcomes between two cut-off points but using specific cut off points for sub-group analysis provides statistical robustness as well as confirm the association between bottom quartile of MoCA and outcome in the sub-cohort.

Follow-up data were obtained from electronic patient records. A continuous value was recorded, for length of hospital stay (LOS), with days rounded up to the nearest whole day integer. The LOS was arbitrarily re-categorized for ease of interpretation for clinicians, into three dichotomized variables <7 and ≥7-days, <10 days and ≥10-days and <14 days and ≥14-day, which corresponded approximately with the 60th, 75th and 85th centile values of the continuous values. Furthermore, data regarding patient readmission at 30-days, and mortality at 30- and 90-days were collected as dichotomized variables.

Statistical Analysis

All analyses were performed using Statistical Package for Social Science (SPSS), version 24.0. Descriptive statistics were compared between patients in the bottom 25%

MoCA score (≤17) vs. the other 75% MoCA score (≥18) using ANOVA and Chi-squared test for continuous and categorical data.

In our primary analysis, we examined the association between having moderate cognitive impairment (bottom 25% MoCA score of ≤17) with study outcomes, using the following models; unadjusted (model A), and adjusted for receiving an emergency operation and characteristics; age, sex, low hemoglobin, hypoalbuminemia, polypharmacy (≥5 medications on admission) (model B).[1] In our secondary analysis, which only included patients with both CAM and MoCA data (N=354), we recalculated the bottom quartile MoCA cut-off score for sensitivity analysis purposes (bottom 25% MoCA score of ≤18). Models used in our secondary analysis included; adjusted for delirium assessed using CAM (model A) and adjusted for receiving an emergency operation and characteristics; age, sex, low hemoglobin, hypoalbuminemia, polypharmacy (≥5 medications on admission) (model B).

In order to assess the sensitivity of our approach of using bottom quartile MoCA cut-off score in predicting our primary outcome of 30-day mortality, using our full cohort, we also calculated cut-off points for the middle 50% and upper 25% of MoCA scores, which were ≤22/30 and ≤25/30 respectively. We then examined the association between the middle 50% and upper 25% of MoCA scores, adjusted for receiving an emergency operation and characteristics; age, sex, low hemoglobin, hypoalbuminemia, polypharmacy (≥5 medications on admission) with 30-day mortality.

To identify the relationship between delirium and mild to moderate cognitive impairment, we compared the rates of patients with delirium assessed using CAM and a MoCA score of ≤18/30, using only patients with both CAM and MoCA data i.e. 2014 cohort. Descriptive statistics were compared between patients excluded due to MoCA test not being completed vs. patients included in our study with completed MoCA data, using ANOVA and Chi-squared test for continuous and categorical data.

Results

A total of 660 patients were enrolled into 2013 and 2014 data collection cycles. Of them, 121 patients were excluded due to incomplete data (see Figure 1 for exclusion). Thus 539 patients were included in the current study. The median age (IQR) was 76 (70-82) years. There were 283 (52.5%) women in our sample. The median (IQR) MoCA score was 22.0 (17-25). When using the traditional cut-off score, 455 (84.4%) had a MoCA score ≤26, whilst using the recently proposed cut-off score of ≤23 the prevalence was 329 (61.0%). When using the bottom quartile MoCA cut-off score to ≤17, 379 (73.7%) patients scored ≥18, with 142 (26.3%) patients scoring ≤17 indicating about a quarter of the older unselected emergency general surgical patients had cognitive impairment comparable to people living with Alzheimer's disease.[12]

The characteristics of the sample by MoCA categories (≤17 and ≥18) are presented in Table 1. Of the 142 patients with a score of ≤17, 80 (56.3%) were female and 62 (43.7%) male, with a similar likelihood of being in the lowest quartile of the study population between two sexes (p=0.29). Polypharmacy was prevalent (65.1%). Nearly half of all patients had low serum albumin levels (35g/L) (44.0%) and anemia (46.0%) in low MoCA group. Characteristic comparisons between groups showed increasing age, polypharmacy, low hemoglobin levels and delirium were all significantly associated with having a low MoCA score. Figure 2 shows the relationship between delirium assessed using CAM and moderate cognitive impairment (bottom 25% MoCA score of ≤18), using only those with both CAM and MoCA data i.e. 2014 cohort. A low MoCA score was not associated with low serum albumin levels or receiving surgical intervention.

We have also presented the characteristics of the 95 patients excluded from our study due to MoCA testing not being conducted for reasons such as severe disability, being too unwell or known advanced dementia[1] (Supplementary Table 1). Patients without a completed MoCA test were predominantly male (56.8%), had low serum albumin levels (35g/L) (77.9%) and were anemic (80.0%). We observed no statistical association between not having a completed MoCA and 30-day mortality, whilst we did observe an association between the excluded patients and higher 90-day mortality, when compared with patients included in our study.

For our primary analysis, the bottom 25% MoCA group (≤17) in univariate analyses was associated with 30-day mortality (3.27 (1.30-8.21); *p*=0.012), increased hospital length of stay; ≥7-days (1.57 (1.04-2.36); *p*=0.032), ≥10-days (1.69 (1.10-2.61); *p*=0.018), ≥14-days (1.78 (1.08-2.95); *p*=0.024). In fully adjusted logistic regression models, being in the bottom 25% MoCA group was associated with 30-day mortality (3.10 (1.19-8.11); *p*=0.021), increased hospital length of stay; ≥10-days (1.80 (1.10-2.94); *p*=0.020) and ≥14-days (2.06 (1.17-3.61); *p*=0.012). We found no association between being in the bottom 25% MoCA group and 90-days mortality, 30-day readmission and a hospital length of stay of ≥7 days (Table 2).

Patients with missing delirium data (185 patients) assessed using CAM were further excluded from our secondary analysis. Therefore, subgroup analysis was undertaken in 354 patients (see Figure 1) and additional adjustment was made for presence of delirium in model A (Table 3). In our sub-group analysis, being in the bottom 25% of MoCA (≤18) was associated with 30-day mortality (3.61 (1.31-9.95); *p*=0.013), increased odds of hospital length of stay outcomes; ≥7-days (1.94 (1.15-3.26); *p*=0.012), ≥10-days (1.87 (1.08-3.25); *p*=0.025), in univariate analysis. In fully adjusted logistic regression models, being in the bottom 25% of MoCA score was associated with 30-day mortality (3.42 (1.19-9.81);

p=0.022), increased hospital length of stay; ≥7-days (1.91 (1.07-3.41); *p*=0.029) and ≥10-days (1.96 (1.02-3.77); *p*=0.044). 24.8% of patients with dementia also had delirium, with 11.1% of this group dying at 30-days. No association was observed for other outcomes in sub-group analyses.

Using the full cohort, in our sensitivity analysis, MoCA scores of the middle 50% (≤22/30) and upper 25% (≤25/30) were not found to be associated with our primary outcome of 30-day morality (2.81 (0.90-8.81); p=0.08) (4.84 (0.67-37.44); p=0.13) (Table 4).

Discussion

This is the first study to report the association between cognitive impairment, assessed using MoCA score in older adults aged ≥65 years and patient related outcomes on admission to the emergency general surgical setting. Mild to moderate cognitive impairment assessed on admission using MoCA, was associated with increased odds of 30-day mortality and increased hospital length of stay. When adjusting additionally for delirium in a sub-group of patients with available CAM data, we observed that having a low MoCA score remained associated with a three-fold increase in odds of 30-day mortality and increased odds of prolonged length of hospital stay.

In a 2014 single center study of elective and emergency aortic and lower limb vascular surgical patients of ≥60 years of age, in which the MoCA was assessed pre-operatively, it was reported that nearly 70% of the patients had cognitive impairment when using the cut-off score of 24/30.[17] Within our UK multicenter cohort of older patients (aged ≥65 years), we were able to confirm the high prevalence of cognitive impairment in the emergency general surgery setting. This may reflect the World Health Organization's estimation that there are approximately 9.9 million new cases of dementia each year and this may be increasing.[20] It has been reported that dementia is often undiagnosed, with one study finding that 88% of the patients detected to have dementia being previously unaware of their condition.[2,17,21] To the best of our knowledge, it is not a routine practice to complete a cognitive assessment on admission to the general surgical wards.[1]

Indeed, the consistent finding of high prevalence of cognitive impairment among older acute surgical patient population has several important implications for acute care surgeons. Firstly, pre-operative assessment of cognitive function will allow acute care surgeons to more accurately assess peri-operative risk as dementia is an independent risk factor associated with increased post-operative complications such as sepsis, delirium and re-operation.[3] Secondly, within UK courts, the Montgomery ruling of 2015 elucidated the importance of explaining different treatment options to patients, which requires patients to have capacity to evaluate the risks and benefits of different proposed options by their surgeon.[22] Similarly in the United States, approximately half of the states adopt reasonable-patient standards based upon the Janine Harnish vs. Children's Hospital Medical Center case, which views the informed consent process from the patient’s perspective.[23]

Capacity is a requirement for informed consent, and high rates of patients with mild-moderate cognitive impairments and more severe dementias may lack capacity.[24-26] In the wake of the Montgomery ruling, the Royal College of Surgeons in 2016 warned NHS trusts that they are at great risk of a substantial increase of litigation pay-outs if appropriate changes to gaining informed consent before an operation are not made.[26] Meanwhile, in the United States, the recognition of the inadequacy of current informed consent practice has led to states such as Washington, promoting the use of decision aids and supporting concomitant training for health professionals to engage more effectively in shared decision making.[27] With that in mind, the high prevalence in conjunction with the high proportion of undiagnosed dementia may suggest that using the MoCA on admission in older patients (aged ≥65) is useful in identifying patients whom are unable to give informed consent in the emergency surgical setting. It is worth noting that whilst cognitive assessment on admission may identify older adults who may lack capacity, cognitive assessment alone is not sufficient to establish capacity as other factors such as medical illiteracy also have an important role.

Furthermore, unlike elective care, the 2016 National Emergency Laparotomy Audit (NELA) report highlighted that there is often limited time to investigate and prepare patients before emergency surgery and therefore the use of the MoCA score on admission will allow surgeons to promptly identify patients in need of additional support from other health care professionals, including input from care of the elderly services.[28] The NELA has already identified that the highest mortality rates post-emergency laparoscopy occur in older adults aged >65 year, and therefore cognitive assessment on admission may allow identification of older adults at a greater risk of poor outcomes.[28] Current guidance recommends that a cut-off score of ≤18 is usually considered the borderline between mild cognitive impairment and Alzheimer's disease, but there is overlap in the scores, since Alzheimer's disease is defined by the presence of cognitive impairment in conjunction with the loss of autonomy.[14] In a study conducted by the creators of the cognitive assessment, Nasreddine and colleagues reported that the mean MoCA score of patients with mild Alzheimer's disease was 16.2.[12,14] Furthermore, Hoops and colleagues report that a MoCA of 17-18 out of maximum of 30 was the optimal diagnostic cut-off point for the detection of dementia in a cohort of patients with no cognitive impairment, mild cognitive impairment and Parkinson's disease dementia.[29] Within our study, we observed that a MoCA of both ≤17/30 and ≤18/30, representing the bottom quartile of MoCA in whole cohort and the sub-cohort, respectively, were independent predictors of mortality at 30-days. This suggests that our study may be describing 30-day mortality in patients with cognitive impairment that is comparable to those with the early stages of dementia. Future research is required to identify the optimal MoCA cut-off score to predict 30-day mortality in older adult admitted to the emergency general surgical setting and whether this finding can be extended to other emergency surgical departments.

Dementia is recognized as a main risk factor for the development of delirium, with delirium and dementia often co-existing in acutely unwell older patients.[7,30] In our Figure 2, we have displayed the relationship between delirium and low MoCA (≤18) in this cohort, which shows all patients with delirium, apart from one, also had a low MoCA score (≤18). Earlier studies[3,31] have shown that delirium superimposed upon dementia is associated with mortality and therefore it may be the case that 30-day mortality is co-driven by delirium rather than dementia alone. This is further supported by the failure to detect an association with mortality at 90 days, because the acute effects of delirium will have diminished by that time point. Subsequently, in a sub-cohort with available data on both MoCA and delirium (N=354), we adjusted additionally for delirium using CAM, with the intention of establishing whether our previous findings displayed in Table 2 were in actuality being driven by delirium. We recalculated the MoCA cut-off score to reflect the bottom quartile (≤18) of the sample population and adjusted additionally for presence or absence of delirium. In the multi-variate analysis, despite adjusting for delirium, we observed that having a low MoCA was an independent predictor associated with a three-fold increased risk of 30-day mortality. Whilst the two patients with delirium that died at 30-days also had a MoCA score ≤18, there were a further 16 patients with a MoCA score of ≤18 that died at 30-days who did not have delirium. This may suggest that although delirium assessed using CAM has been shown to predict morality in older surgical patients, MoCA assessed on admission may in fact be a more sensitive predictive tool. Nevertheless, it is important to note that MoCA is unable to distinguish acute from chronic cognitive impairments – rather it serves to detect the presence of a cognitive deficit.

Our findings are in agreement with previous studies which reported the association between dementia/delirium and an increased length of hospital stay in both medical and surgical units.[17, 31-35] Prolonged hospital stay is not only costly but also results in a reduced availability of surgical ward beds.[33,34] This is problematic because dementia is on the rise globally and a lack of available beds due to prolonged hospital stay and under resourcing of social care has an impact on elective bed utilization and acute surgical admissions.[32-35] Furthermore, patients with dementia/delirium have additional care needs which require a greater number of staff with specific training.[36] A low MoCA score is associated with an increased hospital length of stay, and offers a potential predictive tool in identifying patients at risk of a prolonged hospital stay at the point of health care.

The high prevalence of cognitive impairment detected in the emergency general surgical setting in conjunction with the associated poor outcomes identified in our study raise additional important issues. Firstly, undiagnosed cognitive impairment may lead to a delay in patients seeking medical care and a prolongation of length of stay in operative patients receiving surgery due to missing the opportunity to address early clinical symptoms of complications. This may be a contributing factor which leads to the increased odds of mortality at 30-days in this study. Routine MoCA testing of older adults admitted to the emergency general surgical setting offers surgeons the opportunity to identify this vulnerable group at the point-of-contact, thereby allowing emergency surgeons to more accurately tailor patient centered care. Cognitive assessment on admission will also allow surgeons to make pre-emptive adjustments, including early comprehensive geriatric assessment and multi-disciplinary discharge planning. Additionally, a low MoCA score may be taken into account along with other predictors of poor surgical outcome to help decide whether the benefits of operative management outweigh the risks, and in cases where the risks are judged to be inappropriately high, patient/family counselling can be considered.

This was a pragmatic exploratory analysis using non-randomized patients from a multi-site service evaluation, so the results need to be interpreted with caution. Data were not collected on co-morbidities and therefore we cannot be certain that the association between having a low MoCA score and 30-day mortality and increased length of hospital stay are not being driven by comorbidities. However, we were able to adjust for polypharmacy, low hemoglobin and albumin which are all highly related to co-morbid burden and these serve as surrogate markers of severity of existing chronic and acute co-morbid burden, thus perhaps a better measure of co-morbidities compared to simple yes/no which merely states presence of a diagnosis rather than the severity of the condition. Additionally, we did not have any records of which patients were previously diagnosed with dementia and therefore we are unable to assess the extent to which dementia was under diagnosed. We did not collect data on admission or discharge diagnosis, nor the type of emergency procedure carried out. The strengths of our study include large sample size, consecutive unselected data collection during study periods and multicenter nature of the study which covered different regions of UK.

Conclusion

Moderate cognitive impairment in older adults admitted to the emergency general surgical setting, assessed using MoCA on admission, is prevalent and is associated with increased odds of 30-day mortality and an increased length of hospital stay. These observations are relevant to emergency surgeons as they provide the potential of identifying older patients at risk of poor outcomes so that appropriate adjustments can be pre-emptively made. Pre-emptive adjustments include early geriatric involvement and patient/family counselling. We recommend that emergency surgeons routinely complete MoCA tests on admission as it will allow surgeons to more accurately tailor patient centered care postoperatively whilst also assessing competence and the ability to consent to invasive procedures.

Funding statement

This study represents independent research part funded by the National Institute for Health Research (NIHR) Biomedical Research Centre at South London and Maudsley NHS Foundation Trust and King's College London (BRC). ADA was sponsored by Medical Research Scotland (MRS) for a summer research scholarship (Vac-1058-2017). MRS has no role in study design and interpretation of the study results.

Acknowledgements

Cardiff and Vale University Health Board: Maeve Middleton, Silas Fuller, Siti Abdul Jabar, Stephanie Thomas, Mathew Williams, Amy Black, Svetlana Kulikouskaya, Caroline Best, Andrew Forrester, Joseph Ereaut, James Moore, Dominic Hampson, Stephanie Owen, Shaanjan Islam, Nicolas Gill, Stephan Merrix, Jack Topham, Pip Killingworth, Syed Rahman and Nurulaida Mohd Darus

North Bristol NHS Trust: Madeline Tarant, Emily Benson, Tom Wright, Sarah Blake, Calum Honeyman, Simon Huf, Anni Dong, Indira Garaeva, Manuk Wijeyaratne, Michael Campbell and Eng Hean Teh

Royal Alexandra Hospital, Paisley: Mahua Chakrabati, Adam Tay and Nurwasimah Haj Asnan

NHS Grampian: Caroline McCormack, Tay Hui Sian, Matthew Greig

Central Manchester University Hospitals: Jen Law and Elizabeth Norr

Contributors

ADA, PKM and JH conceived the study. JH is the PI of OPSOC. BC was the study statistician. ADA performed literature search, statistical analysis and drafted the manuscript. All authors contributed to the writing of the paper. PKM is the guarantor.

Conflict of Interest

None.

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Table 1. Patient characteristics by patients with bottom 25% MoCA score (≤17) vs. other 75% MoCA score (≥18) in 539 patients.

Variable	**MoCA score (≤17) (n=142)**	**MoCA score (≥18) (n=397)**	***p-value***
Age	79.44 (7.34)	75.61 (7.63)	**<0.001**
Sex			0.29
Male	43.7% (62)	48.9% (194)	
Female	56.3% (80)	51.1% 203)	
Polypharmacy (≥5)			**0.010**
Yes	73.9% (105)	62.0% (246)	
No	26.1% (37)	38.0% (151)	
Hemoglobin <129 (g/L)			**0.002**
Yes	57.0% (81)	42.1% (167)	
No	43.0% (61)	57.9% (230)	
Albumin <35 (g/L)			0.63
Yes	42.3% (60)	44.6% (177)	
No	57.7% (82)	55.4% (220)	
Receiving an emergency operation			0.99
Yes	13.4% (19)	13.4% (53)	
No	86.6% (123)	86.6% (344)	
Death 30 days after admission			**0.008**
Dead	7.0% (10)	2.3% (9)	
Alive	93.0% (132)	97.7% (388)	
Death 90 days after admission			0.16
Dead	9.9% (14)	6.3% (25)	
Alive	90.1% (128)	372 (94)	
Length of hospital stay			
7 or more days	45.1% (64)	36.3% (144)	**0.031**
10 or more days	32.4% (46)	23.2% (92)	**0.017**
14 or more days	21.1% (30)	13.6% (54)	**0.023**
Readmitted within 30 days			0.78
Yes	19.7% (28)	18.6% (74)	
No	80.3% (114)	81.4% (323)	
Delirium			**<0.001**
Yes	17.6% (25)	0.3% (1)	
No	45.8% (65)	66.2% (263)	

Values presented are mean (SD) for continuous data and percentage (actual number) for categorical data. *p*-values were generated using a one-way ANOVA test for continuous variables and a Chi square test for categorical variables.

Table 2. Results of logistic regression analysis (N=539) examining the association between having moderate cognitive impairment (bottom 25% MoCA score of $\leq$17) (reference category = other 75% MoCA score) and 30-day mortality, 90-day mortality, 30-day readmission and length of stay (LOS).

	Model A		Model B	
Outcomes	OR (95%CI)	*p*	OR (95%CI)	*p*
30-day Mortality	3.27 (1.30-8.21)	**0.012**	3.10 (1.19-8.11)	**0.021**
90-day Mortality	1.63 (0.82-3.23)	0.16	1.60 (0.78-3.28)	0.20
30-day Readmission	1.07 (0.66-1.74)	0.78	1.00 (0.61-1.66)	0.99
LOS				
7-days or more	1.57 (1.04-2.36)	**0.032**	1.52 (0.97-2.38)	0.07
10-days or more	1.69 (1.10-2.61)	**0.018**	1.80 (1.10-2.94)	**0.020**
14-days or more	1.78 (1.08-2.95)	**0.024**	2.06 (1.17-3.61)	**0.012**

Model A: Unadjusted

Model B: Adjusted for receiving an emergency operation, age, sex, polypharmacy, low hemoglobin, low albumin

*Including patients from 2013 and 2014 cohort. Delirium assessed using CAM was not included in this analysis.

Table 3. Results of logistic regression sub-analysis (N=354), including only patients which had both CAM and MoCA assessment, examining the association between having mild-moderate cognitive impairment (bottom 25% MoCA score of ≤18) (reference category = other 75% MoCA score) and 30-day mortality, 90-day mortality, 30-day readmission and length of stay (LOS).

	Model A		Model B	
Outcomes	OR (95%CI)	*p*	OR (95%CI)	*p*
30-day Mortality	3.61 (1.31-9.95)	**0.013**	3.42 (1.19-9.81)	**0.022**
90-day Mortality	1.89 (0.81-4.39)	0.14	1.80 (0.74-4.34)	0.19
30-day Readmission	1.02 (0.55-1.90)	0.95	0.85 (0.44-1.63)	0.62
LOS				
7-days or more	1.94 (1.15-3.26)	**0.012**	1.91 (1.07-3.41)	**0.029**
10-days or more	1.87 (1.08-3.25)	**0.025**	1.96 (1.02-3.77)	**0.044**
14-days or more	1.82 (0.95-3.49)	0.07	2.01 (0.95-4.26)	0.07

Model A: Adjusted for delirium (CAM)

Model B: Adjusted for delirium (CAM), receiving an emergency operation, age, sex, polypharmacy, low hemoglobin, low albumin

*Including only patients from the 2014 cohort.

Table 4. Results of logistic regression analysis (N=539) examining the association between having different MoCA cut-off scores (bottom 25%, middle 50%, upper 25%) with 30-day mortality.

	30-day mortality	
MoCA score cut-off	OR (95%CI)	*p*
Bottom 25% ≤17/30	3.10 (1.19-8.11)	**0.021**
Middle 50% ≤22/30	2.81 (0.90-8.81)	0.08
Upper 25% ≤25/30	4.84 (0.67-37.44)	0.13

* Each MoCA score cut-off adjusted for; receiving an emergency operation, age, sex, polypharmacy, low hemoglobin, low albumin

*Including patients from 2013 and 2014 cohort. Delirium assessed using CAM was not included in this analysis.

Figure 1. Flow chart describing reasons for exclusion.

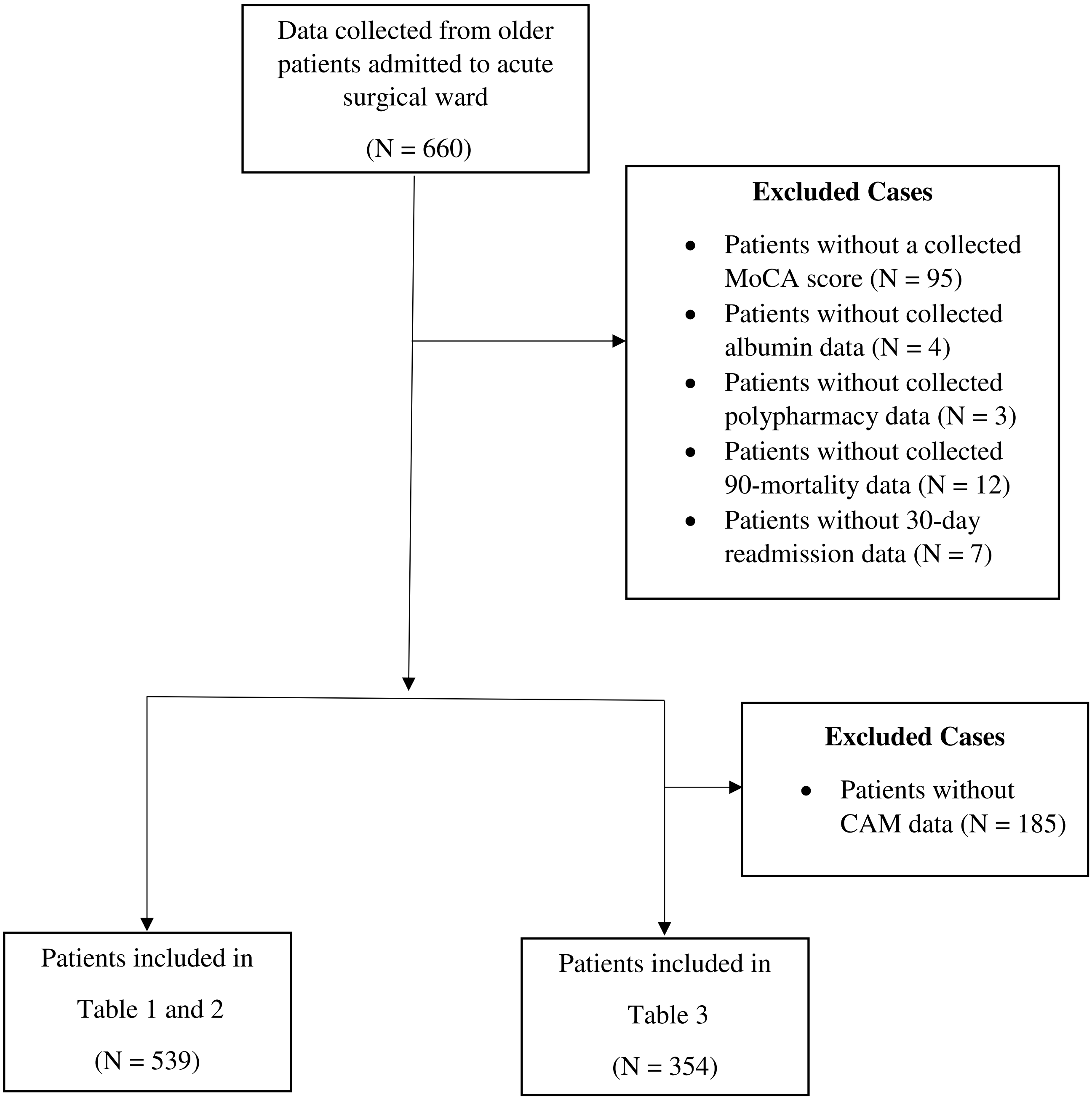
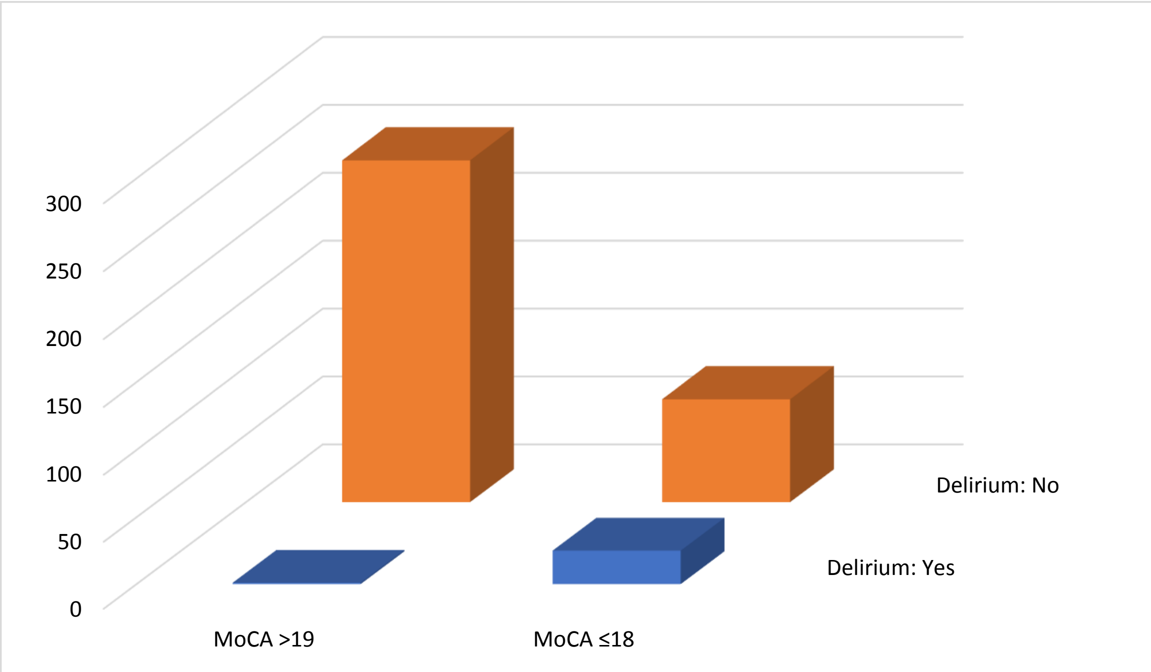


Figure 2. Relationship between delirium assessed using CAM and moderate cognitive impairment (bottom 25% MoCA score = ≤18), using only the 2014 cohort.



Supplementary Table 1. Patient characteristics by patients excluded due to MoCA test not being completed vs. included patients with a completed MoCA test.

Variable	**MoCA test not completed (n=95)**	**MoCA test completed (n=539)**	***p-value***
Age	80.05 (10.07)	76.62 (7.73)	**<0.001**
Sex			0.44
Male	56.8% (54)	47.5% (256)	
Female	43.2% (41)	52.5% (283)	
Polypharmacy (≥5)			0.96
Yes	63.2% (60)	65.1% (351)	
No	36.8% (35)	34.9% (188)	
Hemoglobin <129 (g/L)			**0.043**
Yes	80.0% (76)	46.0% (248)	
No	20% (19)	54.0% (291)	
Albumin <35 (g/L)			**0.001**
Yes	77.9% (74)	44.0% (237)	
No	22.1% (21)	56.0% (302)	
Receiving an emergency operation			0.21
Yes	6.3% (6)	13.4% (72)	
No	93.7% (89)	86.6% (467)	
Death 30 days after admission			0.31
Dead	6.3% (6)	3.5% (19)	
Alive	93.7% (89)	96.5% (520)	
Death 90 days after admission			**0.034**
Dead	13.7% (13)	7.2% (39)	
Alive	86.3% (82)	92.8% (500)	
Length of hospital stay			
7 or more days	8.4% (8)	38.6% (208)	0.92
10 or more days	6.3% (6)	25.6% (138)	0.72
14 or more days	14.7% (14)	15.6% (84)	0.42
Readmitted within 30 days			0.44
Yes	14.7% (14)	18.9% (102)	
No	85.3% (81)	81.1% (437)	
Delirium			
Yes	10.5% (10)	4.8% (26)	**<0.001**
No	34.7% (33)	60.9% (328)	

Values presented are mean (SD) for continuous data and percentage (actual number) for categorical data. *p*-values were generated using a one-way ANOVA test for continuous variables and a Chi square test for categorical variables.