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Preoperative Cognitive Status is Independently Associated with Discharge Location after Cardiac Surgery

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Abstract

Background—Previous work identified impaired preoperative cognitive status in cardiac surgery patients, but measuring cognitive status is time consuming and challenging. Patients with impaired preoperative cognitive status may have longer postoperative length of stay and may require additional care upon discharge.

Objectives—The objective of this study was to determine if a screening measure for cognitive status, the Clock-in-the-Box (CIB), which takes <2 minutes to deliver, was associated with postoperative length of stay and discharge to location other than home.

Methods—In this retrospective study, 181 consecutive participants scheduled for cardiac surgery at a single site were administered the CIB as part of the preoperative evaluation. Postoperative length of stay and discharge location were collected from the medical record. Demographic and operative information was collected from the medical record.

Results—The population studied was older (mean age 68.1 ±10.7 years) and 99% were male. The mean postoperative length of stay was 10.5 (±8.2) days and 19% (n=35) were discharged to a facility. CIB score was not associated with postoperative length of stay. Increasing age, living alone preoperatively, and cardiopulmonary bypass time were associated with discharge to a facility and were used as covariates in adjusted analyses. After adjustment, better preoperative cognitive status reduced the risk of being discharged to a facility (adjusted RR 0.93, 95%CI 0.89, 0.98) after cardiac surgery.

Conclusions—Cognitive screening prior to cardiac surgery can identify patients with impaired cognitive status who are less likely to return home after cardiac surgery.

Keywords

Cognition; Cardiac Surgery; Aged; Dementia; Delirium

Background

Cognitive dysfunction after cardiac surgery has been reported in 25-34% of patients 1 year after surgery and has been found to limit functional recovery and quality of life^{1, 2}. Prior

work has identified poor preoperative cognitive function as a major risk factor for postoperative cognitive dysfunction (POCD)^{3, 4}. As result, there have been recommendations for preoperative cognitive testing on all patients undergoing cardiac surgery.^{5, 6} The neuropsychological tests used in the literature to measure cognitive status prior to cardiac surgery⁷ are lengthy (~1 hour) resulting in decreased utility in a clinical setting. Clock drawing is a brief assessment of cognitive status which has been shown to have high sensitivity (85%) and specificity (85%) for cognitive impairment.⁸ This study examined if preoperative cognitive status, measured with a clock drawing task, was associated with postoperative discharge outcomes.

Impairments in cognitive function were first reported shortly after the invention of cardiac surgery.⁹ Since then there have been a number of longitudinal studies which have measured cognitive function before and after cardiac surgery^{2, 3, 10}. These studies have found that, in general, the cohort's mean performance on tests increases, presumably because of familiarity with the tests¹⁰. However, a significant number of patients develop cognitive decline on neuropsychological testing. The prevalence of POCD is higher in the early postoperative period (3-6 weeks) and declines over the next year.^{2, 3, 10} The cause of POCD is felt to be multifactorial with contribution from patient characteristics, operative manipulation, anesthesia, cardiopulmonary bypass, and perioperative factors.¹¹ Several studies have identified that poor preoperative cognitive function is a risk factor for POCD^{3, 12} and consensus panels have encouraged preoperative cognitive testing on all patients preoperatively.^{5, 6}

Most cardiac surgery is performed to alleviate symptoms of atherosclerosis.¹³ Atherosclerosis is not isolated to the arteries of the heart, but can occur in the kidneys, extremities, and brain. Thus, patients undergoing cardiac surgery may have pre-existing cognitive impairments related to atherosclerosis.^{1, 14-16} In the brain, atherosclerosis may affect executive functioning¹⁷, a collection of higher order cognitive processes including complex attention, abstraction, insight, judgment, inhibition, and organization¹⁸ necessary for independent functioning.^{19, 20} Executive function has been shown to be related to medical adherence²¹, level of care in assisted living and nursing homes²²; ability to carry out instrumental activities of daily living²³ and functional outcome in the rehabilitation setting²⁴. Prior work has demonstrated that cardiac surgery patients have preoperative deficits in cognitive functions, including executive functioning and memory which may place them at risk for POCD.^{1, 4, 14-16} and the associated functional decline.

Cognitive screening in the primary care and surgical setting presents some specific challenges, the most obvious related to time and efficiency. A number of existing, well-validated and reliable neuropsychological measures have excellent sensitivity and specificity in detecting subtle impairment (e.g. Wisconsin Card Sorting Test, Wechsler Memory Scale).^{25, 26} While these measures are often included in a comprehensive neuropsychological evaluation, they are time consuming and require expertise and experience to administer, thereby making them unsuitable as screening measures. Additionally, scoring and interpretation of the neuropsychological tests is not straightforward, because of the multiple cognitive domains and high correlation between tests.²⁷ Surveyed physicians acknowledged the necessity of cognitive screening and identified difficulties of time management and test familiarity, as major barriers to performing routine cognitive screens²⁸. Finally, the results generally do not change management of the patient during the operation (operative) or during the period just before and after the operation (perioperative). As a result, the identification a short, easily-scored measure of cognitive function that afforded opportunity for clinical intervention would be useful.

Clock drawing tasks have been identified as a good screening tool for cognitive impairments including executive dysfunction, and are commonly included in comprehensive assessment of cognitive functioning²⁹⁻³¹. There are a variety of versions of the clock drawing task available, but all require the patient to spontaneously draw an analog clock, place the numbers and set the hands to a specific time^{8, 29-32}. Accurate clock drawing performance relies on working memory, visuospatial abilities, semantic memory, planning, organization and understanding of abstract concepts³²⁻³⁴, and there has been considerable evidence supporting clock drawing as a measure of executive functioning.^{8, 33, 35, 36} The clock drawing task has demonstrated utility in the assessment of neurodegenerative disorders^{8, 37} and has gained popularity as a screening measure for dementia.³⁸ Performance on clock drawing tests is highly correlated with other cognitive measures such as the Blessed Dementia Rating Scale, and block design.⁸

Our version of the clock draw task, the Clock-in-the-Box (CIB), emphasizes working memory and executive function by eliminating verbal cues (increases memory requirement) and requiring the clock to be drawn in a specific location. In a separate validation study, we compared performance of the CIB to a battery of standard neuropsychological tests of memory and executive functioning in diabetes, cardiology, and primary care outpatient clinics. This study demonstrated high inter-rater reliability and CIB score was predictive of performance on measures of shifting attention, learning, and memory recall. (results submitted elsewhere) These results demonstrate that the CIB, like other versions of the clock drawing task, possesses good predictive validity as a screening measure of cognitive status and may be sensitive to cognitive dysfunction in patients with cardiac disease.

The purpose of this study was to determine the association between cognitive status, as measured by performance on the CIB, and hospital discharge outcomes. We conducted this retrospective research study to answer two research questions, a) does preoperative cognitive status, measured with the CIB, affect how long a patient stays in the hospital after cardiac surgery and b) does preoperative cognitive status, measured with the CIB, determine if a patient will be discharged to a location other than home after cardiac surgery? Because patients with impaired preoperative cognitive status would be less able to adapt to the postoperative environment³⁹ and participate in the recovery process⁴⁰, we hypothesized that these patients would require a) longer postoperative hospitalization and b) increased discharge to care environments other than home.

Methods

Design

This is a retrospective study. Information included in this study was gathered as part of the usual system of care and data for this study was abstracted after discharge from the patient's medical record. Within the course of preoperative assessment, participants were screened for cognitive function. Participants with impaired performance were seen by a geriatrician in the perioperative period. The primary outcomes of this study, postoperative length of stay and discharge to home were available after the patient was discharged. The retrospective design allowed a standardized data collection. The study was conducted with human studies committee approval.

Sample

The participants for this study were 181 consecutive patients who underwent non-emergent cardiac surgery (i.e. coronary artery bypass graft with or without valve repair, valve repair or replacement, or thoracic aneurysm repair) at the West Roxbury campus of the Boston VA Healthcare System between May 1, 2006 and December 31, 2006. At our medical center, all

patients undergoing cardiac surgery are admitted prior to surgery (generally 1 day prior) and undergo comprehensive preoperative evaluation for preoperative function, living status, cognitive status, operative risk, and conditions which may predispose to postoperative complications. This evaluation is performed by nurse practitioners on the cardiac surgery service in the patient's room. In our sample, participants were not homeless and none lived in a nursing home preoperatively. Participants who were unable to complete the preoperative assessment due to severity of illness (mechanical ventilation or intra aortic balloon pump) or preoperative delirium were not included in this analysis. All patients underwent general anesthesia in accordance with local protocol. The operative procedure and perioperative care was managed by the attending surgeon and cardiac surgery team. Standard practice at our medical center included the use of cardiopulmonary bypass during cardiac surgery. For patients with impaired preoperative cognitive status, a geriatrician followed the patient in the perioperative period and made recommendations to the surgical team consistent with delirium prevention modules previously described.^{41, 42} The study data and outcomes were collected, retrospectively, after the patient was discharged.

Instruments

As part of the preoperative clinical workup, the CIB was administered and scored by a nurse practitioner on the cardiac surgery service. These clinicians underwent a training protocol for the CIB which included supervised administration and scoring until competence was developed. At the time of preoperative assessment, the participant was given an instruction sheet which directs them to read and follow with four instructions:

“In the blue box on the next page;
draw a picture of a clock;
put in all the numbers;
set the time to ten past eleven;”

After acknowledgement that the directions have been read, the participant is then handed the response sheet, which has a colored box in each of the quadrants (yellow, red, green and blue). The blue box is oriented in the right, lower quadrant. The participant is not allowed to refer to the directions and no additional hints or clues are provided. The CIB is scored on eight criteria including: located in the correct box, object resembles a clock, number inclusion, number order, number spacing, correct time, circle of appropriate size, and hand origin and length. One point is given for each correct criteria resulting in a continuous variable (range 0 to 8 points; lower scores indicate lower cognitive status). Figure 1 depicts sample clock drawings for CIB scores of 2, 4, 6, and 8. For patients with a CIB score ≤ 4 , a postoperative delirium consult was placed. The CIB response forms were collected for the duration of the study period.

After completion of the study, a neuropsychologist, experienced in the scoring of cognitive tests, reviewed all CIB tests as a reference standard. This neuropsychologist was independent of the CIB administration, clinical CIB score, and clinical care. Between the clinically administered CIB score and the neuropsychologist's CIB score, there was a high coefficient of correlation ($r = 0.89$), agreement (93%), weighted kappa ($\kappa = 0.72$, $p < .0001$).

Outcomes

The primary outcome measures for this study were postoperative length of stay and discharge to a location other than home. Postoperative length of stay was calculated by subtracting the date of discharge from the operative date. Postoperative length of stay was selected, as opposed to total length of stay, because our center is a tertiary referral center and some participants had lengthy preoperative hospital stays prior to transfer that were related

to systemic issues (bed availability, etc). The place of discharge (home vs. other facility) was recorded from the medical record.

Other Study Variables

Demographic information related to participants age, years of education, gender, and preoperative living situation (alone vs. with someone) were recorded from the medical record. Comorbidity information necessary to complete the Charlson Comorbidity Index was recorded from the admission history and physical. The Charlson Comorbidity Index (range 0-34; 34-worst) is a sum of weighted comorbidity which has been associated with 1-year mortality after hospitalization.⁴³ Surgical data which may reflect the extent and complexity of surgery were recorded from the operative notes. Surgical procedure type was coded as coronary artery bypass graft (CABG), CABG + valve, or other (e.g. atrial septal defect repair). The number of vessels bypassed (for CABG or CABG + valve surgeries), duration of cardiopulmonary bypass in minutes, and the duration of cross clamp in minutes were recorded from the operative report and anesthesia record.

Analysis

Postoperative Length of Stay—The normality of the postoperative length of stay was severely skewed which violated the normality assumption for parametric statistical methods. As a result, we used a non-parametric Kruskal-Wallis ANOVA, which calculated a mean rank sum for each CIB score level (≤ 4 to 8) and compared how the mean postoperative length of stay differs between CIB scores.

Discharge to home—The place of discharge was dichotomized into ‘home’ (for those who returned to their preoperative residence) and ‘not home’ (for those who went to a facility such as a nursing home, sub-acute rehabilitation center, or acute rehabilitation center). All continuous covariates were assessed for normality (parametric distribution) using a histogram, kurtosis, and skew. In the bivariable analysis, the participant and operative characteristics of those who were discharged home were compared to those who were not discharged home using a Student’s t-test for continuous variables, a chi squared test for dichotomous variables, and a Mann-Whitney-U test for non-parametric variables. Those variables with significant association ($p < .05$) in bivariable analysis were selected for entry into a multivariable regression model.

For multivariable modeling, we selected a Poisson regression because a) the CIB score and duration of cardiopulmonary bypass variables were skewed, b) the CIB score represents a non-normal count, and c) the model presents results as a risk ratio. The intraoperative variables duration of cardiopulmonary bypass and cross clamp duration are highly dependent upon one another and would likely introduce collinearity into the model. To address this, we performed a correlation with the discharge to home variable and selected the variable with the strongest correlation coefficient for inclusion in the model. To improve clinical interpretation of the regression output, age was standardized to 5 year increments (rather than 1 year) and duration of cardiopulmonary bypass was standardized to 15 minute increments (rather than 1 minute). Risk ratios represent the risk of not returning home per one unit increase. All statistical analyses were performed using STATA SE version 9.1 (College Station, TX).⁴⁴

Results

During the study period, CIB testing was completed on one hundred eighty-one participants as part of their preoperative workup. The baseline characteristics of the participants are described in Table 1. Participants were older (mean age 68.1 ± 10.7 years), primarily male

(99%), and had a high school education. The mean CIB score was $6.1 (\pm 1.7)$ and 29% ($n=52$) were in the impaired range (CIB score ≤ 5). The duration of bypass, duration of cross clamp, CIB score, and postoperative length of stay were non-parametrically distributed. The mean postoperative length of stay was 10.5 ± 8.2 days and 35 participants (19%) did not return home.

The main outcomes of the study to answer the research questions are displayed in Figure 2. When analyzed with the non-parametric ANOVA, mean postoperative length of stay was not associated with preoperative cognitive status, as measured by the CIB score ($p=.30$). Participants with better preoperative cognitive status were significantly more likely to return home ($p=.04$).

Table 1 describes the bivariable associations with participants who returned to their preoperative residence. Participants who returned to home were significantly younger (66.5 ± 10.3 vs. 74.8 ± 9.7 years, $p<.001$), were less likely to live alone (37% vs. 66%, $p=.002$), and had lower preoperative cognitive status, as measured by the mean CIB score (6.3 ± 1.5 vs. 5.1 ± 2.2 respectively, $p=.001$) than those who did not return home. Both cardiopulmonary bypass time and cross clamp time were significantly longer in those who did not return home. These time variables were highly correlated ($r=0.92$, $p<.001$) with one another and cardiopulmonary bypass time was selected for inclusion in the multivariable modeling, because of a higher correlation coefficient with discharge to home ($r=0.26$, $p<.001$).

The multivariable model adjusted for age (5 year increments), cardiopulmonary bypass time (15 minute increments), and preoperative living situation (Table 3). After these adjustments, every one point improvement in CIB score decreased the risk (adjusted RR 0.93, 95% CI 0.89, 0.98) of being discharged to a location other than the preoperative residence by 7%.

Discussion

In this retrospective data analysis, we used the CIB, a screening measure of cognitive status, to determine if preoperative performance on the CIB was associated with postoperative length of stay and discharge to home after cardiac surgery. CIB score was not significantly related to postoperative length of stay. After surgery, 35 participants (19%) did not return home. Lower preoperative cognitive status, as measured by the CIB, was significantly associated with discharge to a location other than home. Because restoring function is an important goal after cardiac surgery¹³, preoperative cognitive status should be measured in all patients preoperatively.

The documentation of preoperative cognitive impairment, particularly executive function, may be essential for healthcare staff to deliver effective postoperative care and return participants to their home environment.⁸ In the perioperative period, patients with cognitive deficits may experience difficulty fully understanding the nature of the hospitalization/procedure.^{39, 40} Once discharged from the hospital, these patients may have problems maintaining medical compliance and following the instructions and recommendations of health care providers.^{20, 23} The latter is of great concern, particularly for those patients living alone. Additionally, older patients are more likely to be widowed and live alone, creating social isolation and would theoretically be less likely to return home. This is supported by our findings that older patients who lived alone preoperatively were less likely to return home. Finally, the older patient with poor cognitive status may have a difficult time in the hospital.

Cardiac surgery is a complex procedure with numerous opportunities for seemingly small events to have a profound impact on postoperative length of stay. Such events may include

predisposing patient factors (poor social support, depression, anxiety)⁴⁵, operative factors (cardiopulmonary bypass, embolization, oxygenation)^{46, 47}, anesthesia (depth, pain control, medications)⁴⁸, perioperative care (pain control, sleep deprivation, delirium)^{48, 49}, and postoperative complications (atrial fibrillation, stroke, iatrogenic infections)^{46, 50}. These events can influence hospital length of stay at any point during the inpatient stay and may overshadow preoperative cognitive impairment. Thus, our finding that preoperative cognitive status was not associated with postoperative length of stay does not negate the need to measure preoperative cognitive status with a screening instrument.

The integration of a cognitive screening instrument into clinical practice cannot take the place of a formal assessment of cognitive function. When a formal assessment of cognitive function cannot be provided preoperatively, cognitive screening prior to cardiac surgery is still necessary because of the high rate of preexisting impairment^{1, 4, 14-16} and the potential for cognitive deterioration afterward.^{2, 3, 10} The CIB is a useful screening instrument because it requires minimal training and is quick to administer and easy to score. In this study, a significant number of participants screened positive for possible impairment in cognitive status, which was previously undocumented. In fact, this study found that over 30% of participants with CIB score ≤ 5 required transfer to a rehabilitation center or long-term care facility after cardiac surgery. Thus, the CIB could be used as screening tool to recognize cognitive impairment and identify earlier those participants likely to need more complex discharge planning. However, prior to adoption of the CIB into routine clinical use, further assessment in other health systems and other languages, as well as, after other surgeries would be necessary.

There are important limitations to this study. First, the population was largely men (99%) with predominance toward older patients (54% over age 65 years) and our center serves a mostly white population. In the United States, 72% of cardiac surgery patients are men and 55% are age ≥ 65 years.⁵¹ Thus, the findings need to be replicated in more diverse patient populations to determine the generalizability of the findings. Next, the retrospective design of the study does not provide a definitive causative link between cognitive impairment and poor outcomes. This should not challenge the validity or clinical applicability of our findings, because our study was able to screen for cognitive status and discharge location. Additionally, the perioperative care of participants with a CIB score of 4 or below was supplemented by a geriatrician. This additional care may have prevented delirium⁴¹, prevented complications, or preserved function. Alternatively, those participants with a CIB ≤ 4 who were evaluated by the geriatrician, may have undergone closer scrutiny of their functional status. This may have increased the detection of impairments making them less likely to return home. The impact of the geriatrician's input would require additional study to determine if bias existed. This study would have benefited from measurement of preoperative anxiety, depression, and medications which can influence preoperative cognitive status. Further, we were unable to measure all covariates which may influence discharge outcomes, especially anxiety, depression, preoperative function, social supports, and medication use. Along these lines, measurement of severity of illness, with a tool such as the Acute Physiology, Age, and Chronic Health (APACHE) would have provided a stronger estimate of acute illness.⁵² Inclusion of these factors was not possible given the retrospective design, but would be important factors to measure in future prospective studies.

This study used a brief (<2min) preoperative cognitive screening instrument, the Clock-in-the-Box and found that better preoperative cognitive status was significantly associated with discharge to home after cardiac surgery. Cardiac surgery is unlikely to improve cognitive function, because of the procedure is associated with hypotension, an increased inflammatory response, direct neurologic injury through microembolization, anesthesia, and

iatrogenic complications all of which have a deleterious effect on cognitive status.⁴⁷ As a result, clinicians should consider screening cognitive status to identify pre-existing cognitive impairment, inform participants of risks and outcomes, and preemptively plan for discharge.

Summary of Key Points

Because atherosclerosis can also affect cognitive function, screening for preoperative cognitive impairment in patients undergoing cardiac surgery (for atherosclerosis) has been recommended. However, administration of standard screening and assessment instruments in a busy clinical setting is challenging. This study used a brief clock draw task to measure cognitive status and determine if the results impacted postoperative discharge outcomes.

- Patients undergoing cardiac surgery have preoperative cognitive impairment on a screening clock draw task.
- The clock draw task was administered in a hospital by a cardiac surgery nurse practitioner
- Patients with lower preoperative cognitive performance were less likely to return home postoperatively.

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Figure 1. Clock Drawings and Clock-in-the-Box (CIB) Score

Panel A depicts a drawing with a CIB Score = 8. In Panel B, the time is set incorrectly and the clock was drawn in the wrong box (not shown). The clock in Panel C shows disorganization with impaired number spacing, circle size, hand origin, and wrong box (not shown). Panel D received credit for identifying the object as a clock and the correct box (not shown).

Figure 2. Clock-in-the-Box Performance and Postoperative Outcomes

Panel A depicts the mean postoperative length of stay with CIB score. While mean length of stay declines with improving clock score, the trend was not significant ($p=.30$). Panel B depicts the percentage of patients returning home with Clock-in-the-Box performance. Participants with better preoperative Clock-in-the-Box performance were more likely to be discharged home ($p=.04$).

Table 1

Characteristics of participants and comparison of those who returned home

Characteristic	Overall Cohort (n=181)				Returning Home (n=146)				Not Returning Home (n=35)				p-value*
	Mean n	SD (%)	Mean n	SD (%)	Mean n	SD (%)	Mean n	SD (%)					
Participant Information													
Age (years)	68.1	10.7			66.5	10.3	74.8	9.7					<.001
Male	179	99%			144	99%	35	100%					.49
Education (years)	12.5	2.6			12.5	2.6	12.3	2.7					.75
Lived alone preoperatively	77	42%			54	37%	23	66%					.002
Charlson Comorbidity Index	2.3	1.8			2.3	1.8	2.4	1.8					.75
Clock-in-the-Box Score	6.1	1.7			6.3	1.5	5.1	2.2					.001
Operative Information													
Vessels Bypassed (n=153) ‡	2.6	0.9			2.7	0.9	2.4	1.0					.20
Type of Surgery													
CABG ± Valve	153	85%			125	82%	28	18%					.41
Other‡	28	15%			21	75%	7	25%					
Cardiopulmonary Bypass Time (min)	122	51			115	43	149	69					.02
Cross Clamp Time (min)	81	40			76	34	100	53					.02

CABG ± Valve – coronary artery bypass graft with or without valve repair/replacement; SD – standard deviation;

* p-value compares those returning home and those not returning home.

† Clock-in-the-Box is a measure of cognitive status and is scored on a 0 to 8 scale with higher scores representing better cognitive performance.

‡ Twenty eight patients did not have CABG because of valve repair/replacement (n=24) or other surgery (n=4)

Table 2

Risk of discharge to a location other than home

Variable	Adjusted RR [*]	95% CI
Clock-in-the-Box Score (per point)	0.93	0.89, 0.98
Age (per 5 years)	1.06	1.02, 1.10
Lived alone preoperatively	1.4	1.2, 1.6
Cardiopulmonary Bypass Time (per 15 minutes)	1.03	1.01, 1.05

RR – Relative Risk; CI – confidence interval

* Adjusted RR was calculated with a Poisson regression model that included all of the covariates.