Clinical paper

Comparison of three cognitive exams in cardiac arrest survivors☆,☆☆

Allison C. Koller*, Jon C. Rittenberger, Melissa J. Repine, Patrick W. Morgan,
Jeffrey Kristan, Clifton W. Callaway, the Post-Cardiac Arrest Service

University of Pittsburgh School of Medicine, Department of Emergency Medicine, United States

ARTICLE INFO

ABSTRACT

Background: Cognitive deficits may detract from quality of life after cardiac arrest. Their pattern and prevalence are not well documented. We used the Computer Assessment of Mild Cognitive Impairment (CAMCI), the Montreal Cognitive Assessment (MOCA) and the 41 Cent Test (41CT) to assess cognitive impairment in cardiac arrest survivors and examine the exams' diagnostic accuracy. We hypothesized that the scores of these exams would indicate the presence of cognitive impairment in arrest survivors, that the overall scores on the three study assessments would correlate with one another, and that the 41CT, MOCA, and executive function element of the CAMCI would vary independently from other non-executive CAMCI components, reflecting executive function impairment after cardiac arrest.

Methods: Four researchers administered the CAMCI, MOCA, and/or the 41CT to cardiac arrest survivors after discharge from the intensive care unit between 2010 and 2015. Physicians screened patients with the Mini-Mental State Exam to determine when this cognitive testing was feasible, generally when the patient was able to score 20–25 points on the MMSE. We performed pairwise correlations between the different subscales' and tests' scores.

Results: One hundred and fourteen participants completed the CAMCI, of which 38 (33.3%) participants additionally completed the MOCA and 41CT. The median (IQR) percentile score for CAMCI for all 114 participants was 33.5 (18.3, 49.8), which corresponds to moderately low risk of impairment. The median (IQR) for the MOCA was 22.0 (19, 24.8) out of a possible 30, which is considered indicative of abnormal cognitive function, and for the 41CT was 6 (5, 7) out of a possible 7 points when all 38 participants were included. MOCA correlated strongly with the overall CAMCI score (r = 0.71); the CAMCI correlated moderately strongly with the 41CT (r = 0.62) and the MOCA and 41CT were moderately strongly correlated with each other (r = 0.56). When all 114 CAMCI scores were considered, the Executive Accuracy subscale was strongly correlated with the overall CAMCI score (r = 0.81).

Conclusion: The CAMCI detects cognitive impairment after cardiac arrest. The MOCA correlates strongly with the overall CAMCI and the executive function subscale of the CAMCI. The 41CT as appears less effective than the MOCA in detecting cognitive deficits.

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Background

Cardiac arrest affects approximately 350,000 people yearly in the United States, and survival is an estimated 8% [1]. Survivors exhibit cognitive decline or impairment [2,3] that ranges from mild to severe, including memory loss [2–6] decreases in psychomotor function [5,7], executive function [5], and visuospatial function [5]. These impairments affect up to 88% of long-term arrest survivors and can detract from health-related quality of life for many years [8].

Different examinations assessed impairment after cardiac arrest, including the Mini-Mental State Examination (MMSE), Cerebral Performance Categories (CPC), and the Modified Rankin Scale (mRS) [3,9]. However, these exams may be inadequate. The MMSE has shown ceiling effects when used in patients without dementia, limiting its usefulness to detect mild cognitive impairment in non-demented patients [10,11]. The MMSE was insensitive when used in cardiac arrest patient populations [12], and requires that

the patient exhibit large and noticeable deficits to decrease his or her MMSE score [13]. Additionally, in the cardiac arrest patient population, many patients who scored well the MMSE still needed assistance with basic activities of daily living, making it a less-than-ideal examination to use in isolation [14]. The CPC and mRS are five- and six-point scales used to evaluate functional and global status. They do not directly assess cognitive function. Few levels separate survival with good neurological outcome from coma and death; these exams are too coarse to detect more subtle cognitive impairments that can impact the quality of life for post-arrest patients. Moreover, patients with a satisfactory health-related quality of life score have been found to score poorly on the CPC, indicating cognitive impairment despite a high functional status [15]. No exams designed specifically to assess cognitive impairment in cardiac arrest survivors currently exist.

The Post-Cardiac Arrest Service (PCAS) at the University of Pittsburgh routinely administers three cognitive exams to survivors of cardiac arrest before they are discharged from the hospital: the 41 Cent Test (41CT), the Montreal Cognitive Assessment (MOCA), and the Computer Assessment of Mild Cognitive Impairment (CAMCI). We assessed these bedside exams to determine if they were more sensitive than and potentially superior to the MMSE when applied to cardiac arrest survivors. Both exams assess mild cognitive impairment and were shown to be more sensitive than the MMSE [10,16–18]. We have previously reported on the CAMCI in the acute care setting [19]. The MOCA has been utilized for a small number of out-of-hospital cardiac arrest survivors as a very long-term follow-up cognition measure [8]. The 41CT, developed at the University of Pittsburgh, is a simple screening exam involving mental manipulation of coins that can be given orally. However, this test has not been rigorously studied and its sensitivity compared to the other exams is unknown.

The objective of this study was to examine the utility of the CAMCI, MOCA, and 41CT for identifying cognitive impairment in cardiac arrest survivors who were assessed by physicians with the MMSE. We also determined the correlations between the CAMCI, MOCA, and 41CT. We hypothesized that the scores of these exams would indicate cognitive impairment in arrest survivors. We further hypothesized that the overall scores on the three study assessments would correlate with one another; strong associations would provide evidence of convergent validity. Lastly, we hypothesized that the 41CT, MOCA, and executive function subscore of the CAMCI would reflect executive function impairment after cardiac arrest, which has been well documented in cardiac arrest survivors [20].

Methods

The University of Pittsburgh Institutional Review Board approved the study. All subjects were treated by the PCAS at UPMC Presbyterian and Montefiore hospitals and received standardized post-cardiac arrest care including that has been reported previously [21]. Four researchers administered the CAMCI, MOCA, and/or the 41CT to cardiac arrest survivors no sooner than 24 h after discharge from the intensive care unit (ICU) between April 2010 and January 2015. These researchers were employed as specialists with the University of Pittsburgh Department of Emergency Medicine and received training on exam administration. Testing was administered by one researcher, who was present for all three exams and who could not be blinded for results of the other exams in the exam set. A physician must have deemed the patient ready for additional cognitive testing using a "low bar MMSE" before the patient attempted any of the study exams. The low bar MMSE requires that the patient must be awake, alert, and oriented to self, time and place as well as able to understand basic logic. This would equate

to a minimum score of 20–25 out of a possible 30 points on the MMSE.

Researchers began to conduct the CAMCI independently in April 2010. The MOCA and 41CT were administered in October 2012, at which point all participants were given the 41CT, MOCA, and CAMCI in that order during one session. The three-exam session was conducted within 24–72 h after the low bar MMSE was given. Participants completed the study exams once and were allowed to cease participation at any time during the examination period. The researcher interacted with the patient only as necessary; visitors were asked to step out of the room during testing to ensure a quiet environment. Participants were included if they completed the CAMCI with or without the MOCA or 41CT by January 2015.

Study exams

The MMSE was used as a screening tool in this study. It has been described elsewhere [22]. A physician may have administered the MMSE to a post-cardiac arrest patient multiple times until the patient achieved a satisfactory score, defined for this study as greater than or equal to 20 out of 30 points, before enrollment. We chose this score as it would allow patients with mild to no cognitive impairment to be included, as including only patients with an "unimpaired" MMSE score of 27 out of 30 would exclude most, if not all, of our participants. Patients were excluded from this study if they did not achieve the prerequisite MMSE score before hospital discharge.

The 41CT is a novel six-question exam utilizing American coinage to assess cognitive processing ability. The participant manipulates a penny, nickel, dime and quarter mentally and does calculations with the currency. The exam takes approximately five minutes to complete and is scored by the exam proctor, with each question being worth one point. The patient is given the option to use physical coins; the ability to answer the questions without the physical coins is worth one additional point, making the exam worth a total of seven points. The exam can be given using little to no equipment. Using the same cutoff score as the MOCA (86.7%), a passing score would be 6 out of 7 points.

The MOCA (Version 7.2, Alternative) is a 30-point exam that is administered in paper and pencil format that was recommended for use in the cardiac arrest patient population by the European Resuscitation Council [23]. This test has been described elsewhere in the literature [18]. The MOCA takes approximately ten minutes to complete and is scored by the exam proctor; scores greater than or equal to 26 out of 30 (86.7%) points are considered normal. Scores of less than or equal to 25 out of 30 are considered abnormal [18]. The CAMCI utilizes a portable, touch-screen tablet computer with a digitized pen. This exam has been described elsewhere in the literature [24]. The exam determines the patient's risk of mild cognitive impairment and the results are ranked on eleven cognition subscales. The CAMCI was designed to progress at the patient's own pace, and generally requires at least thirty minutes to complete; the exam is automatically scored upon the patient's completion of the exam. Scores are adjusted based on the exam taker's level of education and familiarity with both computer and ATM usage. It does not adjust for age or sex. The risk of mild cognitive impairment is categorized as low, moderate, or high risk and the scores are presented in percentile format [10].

We describe the variation in exam scores using median and interquartile range (IQR). We investigated the Pearson correlation coefficients for overall CAMCI score, the eleven subscales contained in the CAMCI, the MOCA score and the 41CT score. A correlation coefficient greater than or equal to 0.70 or less than or equal to −0.70 was considered very strong, while a correlation between 0.50–0.69 and −0.69 to −0.50 was considered moderately strong. Coefficients between −0.49 to 0.49 were considered not correlated.