Resuscitation 90 (2015) 67–72

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical Paper

Neurocognitive outcomes following successful resuscitation from cardiac arrest☆

Alexa R. Sabedra[a], Jeffrey Kristan[b], Ketki Raina[c], Margo B. Holm[c], Clifton W. Callaway[b], Francis X. Guyette[b], Cameron Dezfulian[d], Ankur A. Doshi[b], Jon C. Rittenberger[b,*], the Post Cardiac Arrest Service

[a] School of Medicine, University of Pittsburgh, United States
[b] Department of Emergency Medicine, University of Pittsburgh, United States
[c] Department of Occupational Therapy, University of Pittsburgh, United States
[d] Department of Critical Care Medicine, University of Pittsburgh, United States

ARTICLE INFO

Article history:
Received 8 July 2014
Received in revised form 20 February 2015
Accepted 23 February 2015

Keywords:
Heart arrest
Patient outcome assessment
Hypothermia
Cognition
Resuscitation
Critical care

ABSTRACT

Introduction: Cardiac arrest commonly results in varying degrees of cognitive injury. Standard outcome measures used in the cardiac arrest cohort do not rigorously evaluate for these injury patterns. We examined the utility of the Computerized Assessment for Mild Cognitive Injury (CAMCI) in cardiac arrest (CA) survivors. We hypothesized that cognitive deficits would be more severe in patients who were comatose on hospital arrival.

Methods: Prospective cohort of CA survivors at a single tertiary care facility where participants received neurocognitive testing using CAMCI. CAMCI results were subdivided into memory, attention, and executive functions. Scores between subjects who were initially comatose and were not comatose following resuscitation were compared using the Mann–Whitney test.

Results: Of 72 subjects included, the majority ($N = 44$) were initially comatose following resuscitation with mean age of 54 (±14) years. The majority experienced a good neurologic outcome based on Cerebral Performance Category ($N = 47$; 66%) and Modified Rankin Scale ($N = 38$; 53%). Time from resuscitation to CAMCI testing was not associated with total CAMCI score in this cohort (Pearson's r^2 value −0.1941, $p = 0.20$). Initially comatose and not comatose subjects did not differ in their CAMCI overall scores ($p = 0.33$), or in any subtest areas. The not comatose cohort had 1 subtest for which there was a Moderate Risk for mild cognitive impairment (Nonverbal Accuracy), and 2 for which there was a Moderately Low Risk (Verbal Accuracy and Executive Accuracy). The Comatose cohort had 4 subtests, which were deemed Moderately Low Risk for cognitive impairment (Verbal Accuracy, Attention Accuracy, Executive Accuracy and Nonverbal Accuracy).

Conclusions: In-hospital CAMCI testing suggests memory, attention and executive impairment are commonly in patients following resuscitation from cardiac arrest. Outcome evaluations should test for deficits in memory, attention, and executive function.

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1. Introduction

Cardiac arrest is common and results in approximately 300,000 deaths per year in the US.[1] In patients successfully resuscitated from cardiac arrest, manifestation of neurological injury due to global brain ischemia and reperfusion ranges from brain death to normal cognition.[2] Protocolized resuscitation strategies (including the use of targeted temperature management) have been shown to improve neurologic outcomes.[3,4] Although impairment has been demonstrated in each of the areas of memory, attention, and executive function, the frequency of these cognitive impairments varies depending on cohort and testing method.[5–8] Most studies use a global outcome measure to determine outcome and cognitive testing is rarely employed as part of this assessment.

Traditional outcome measures used after resuscitation from cardiac arrest are the Cerebral Performance Category (CPC) and the Modified Rankin Scale (mRS). The former is a 5-category scale with

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2015.02.023.

* Corresponding author at: University of Pittsburgh, 3600 Forbes Avenue, Suite 400A, Pittsburgh, PA 15261, United States.
E-mail address: rittjc@upmc.edu (J.C. Rittenberger).

http://dx.doi.org/10.1016/j.resuscitation.2015.02.023
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1 being the best score and 5 indicating death. The latter is a 7-point scale with 0 indicating no symptoms and 6 corresponding with death. Both of these tests, however, have come under criticism for lacking validation in this population, being subjective and too global to detect subtle but clinically important deficits, and not being well suited for the testing of the patient in the hospital instead of at home.[9] For example, the criteria for an mRS score of 3 focuses on the patient's ability to carry out tasks such as cooking, managing finances, and shopping within the hospital setting where such tasks are neither performed nor observed. Additionally, a CPC score of 3 can include everything from an alert, interactive patient to a minimally conscious patient, thus lacking texture. Patients with a CPC of 3 are sometimes discharged to home, or to hospice or long term acute care for the most severely injured.[9] Even patients considered to have a good outcome based on CPC of 1, on deeper inspection may have significant limitations in memory and executive function and commonly have mild cognitive impairment.[10] These impairments are not without significant consequences including lower functioning in society, low quality of life and high caregiver strain.[11] More detailed outcome measures could better identify and differentiate neurocognitive impairments to improve the lexicon for research, allow for the comparison of clinical outcomes and guide appropriate follow up therapy and support.

Recent work in neuropsychological testing has focused on the development and validation of standardized, efficient, and generalizable computer measures. Standard neuropsychological testing can readily detect cognitive impairment. However, it requires several hours to complete and specialized training for the tester. The Computer Assessment of Mild Cognitive Impairment (CAMCI) is a self-administered, computerized neurocognitive test, requiring 25–35 min, that scores itself automatically and does not require specialized supervision.[12] The CAMCI was designed to detect mild cognitive impairment preceding dementia and measures accuracy and reaction time for multiple domains including attention, memory (verbal, visual, working, recognition, prospective, and incidental recall) and executive function. Although, the CAMCI has been shown as a sensitive and specific measure of mild cognitive impairment in the elderly population, it has not been used to assess post cardiac arrest patients.[12] This study examined whether CAMCI testing is feasible in cardiac arrest survivors. Our criterion for utility was whether CAMCI could detect deficits in patients who appeared well with global measures (CPC or mRS), and whether CAMCI could distinguish degrees of brain injury. To test the latter, we hypothesized that CAMCI scores would be lower in patients who were comatose on hospital arrival (moderate brain injury) relative to patients who were awake on arrival (none or minimal brain injury).

2. Methods

This was a prospective convenience sample of subjects who awoke after resuscitation from cardiac arrest between 4/1/2010 and 7/31/2013. Subjects recruited were treated after an in hospital cardiac arrest (IHCA) or out of hospital cardiac arrest (OHCA) in a single tertiary care facility. Inclusion criteria were the successful resuscitation from cardiac arrest, ability to follow commands, and completion of the CAMCI test. Subjects with uncorrectable audio and/or visual impairment, inadequate comprehension of English to understand the instructions, a physical disability that would prohibit the use of a touchscreen, dementia or who were not independently living in the community at baseline (i.e., nursing home or acute care facility residents) were excluded. Demographic information including: age, pre-arrest Charlson comorbidity index, location of arrest, primary rhythm of arrest, use of therapeutic hypothermia (TH), SOFA Cardiac and Pulmonary scores, coronary angiography, and neurologic outcome using Cerebral Performance Category (CPC) and Modified Rankin Scale (mRS) were abstracted from the chart.[13] The Pittsburgh Cardiac Arrest Category (PCAC), a validated illness severity score in this population, was recorded on hospital arrival.[14,15] Comatose (defined as not following commands) subjects were treated with a standardized post-arrest care bundle, including TH and coronary angiography as appropriate.[3,16]

After awakening (defined as following commands), post-cardiac arrest subjects in our facility received neurocognitive testing using the CAMCI. This testing was obtained following discharge from the intensive care unit and prior to hospital discharge. The test was administered on a laptop computer in the subject's hospital room. In order to minimize disruptions and distractions a sign was placed outside the door advising hospital staff and visitors to refrain from entry while testing was in progress, the television was turned off, and present visitors were asked to leave the room or remain silent for the duration of the testing. The test administrator provided the subject with instruction on the use of the device and was present for the duration of the test, however he/she was also quiet while the patient was actively testing. At the start of the assessment, subjects were prompted to provide information about their age, education level, alcohol use, memory decline, anxiety/depression, and driving, computer, and ATM experience. The CAMCI includes eight subtasks that facilitate testing of multiple cognitive domains including: attention, verbal memory, visual memory, working memory, recognition memory, prospective memory, incidental recall, and executive function.[17] It also includes a virtual road trip to the grocery store with stops at a post office and an ATM machine, all of which require the functional use of each of the cognitive domains measured by the CAMCI. At the end of the assessment the CAMCI uses age and education adjusted normative data to calculate a percentile score by averaging the weighted *Z* scores of 12 variables of accuracy, then converting them to a percentile. The "Risk level" for mild cognitive injury is derived from the percentile score (0–9th % = High Risk, 10–20th % = Moderately High Risk, 21–30th % = Moderate Risk, 31–40th % = Moderately Low Risk, 41–100th % = Low Risk). As this is the first use of the CAMCI in this population, we present data from healthy elderly subjects for reference in the results.[18]

Neurologic outcome was assessed using the CPC and mRS. As in our prior work, medical charts at the time of hospital discharge were reviewed using a standard written template to determine the CPC and mRS.[9] A good neurologic outcome was defined as a CPC of <3 and mRS < 3. CAMCI scores and accuracy were compared between subjects who were initially comatose and not comatose following resuscitation using the Mann–Whitney test in the subtest categories of memory (word recognition and recall, functional memory, and recurring pictures), attention (digit span forward), and executive function (digit span reverse, go/no-go decision-making, intersections, and ATM use). Demographic data were compared using a Chi square, *t*-test or Fisher's Exact test. Analyses were completed using Stata 11.2 (College Station, TX).

3. Results

Of the 219 subjects who awoke following resuscitation during this time epoch, 91 were comatose and 128 were awake on initial examination. From this cohort, 44 initially comatose and 28 initially awake subjects were recruited. All subjects were out of the intensive care unity and had a Glasgow Coma Scale of 15 before testing. Of these, 60% were male with a mean age of 54 (SD 14) years (Table 1). The awake cohort had higher Charlson Comorbidity Scores than the comatose cohort. Ventricular fibrillation was the most common primary rhythm of arrest and the majority of subjects experienced OHCA. Of the 44 comatose subjects, 40 received TH. One subject who rapidly awoke (i.e., not initially comatose) also

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