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ScienceDirect

Journal of the Chinese Medical Association xx (2018) 1−6

www.jcma-online.com

Original Article

The prognostic value of gray−white matter ratio on brain computed tomography in adult comatose cardiac arrest survivors

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Received July 5, 2016; accepted March 9, 2018

Abstract

Background: Recent studies suggested that the gray−white matter ratio (GWR) determined from brain computed tomography (CT) scans may be a reliable predictor of poor neurological outcomes. The aim of study was to evaluate the association between the GWR and the outcomes in adult comatose cardiac arrest (CA) survivors in Chinese.

Methods: A total of 58 CA patients who had CT scans within 72 h of resuscitation between January 2011 and December 2015 were included in this single-center retrospective study. Gray and white matter attenuations (Hounsfield units) were measured, and the GWRs were calculated according to previous studies. The study analyzed the prognostic values of the GWRs in predicting poor outcomes (Cerebral Performance Category 3−5).

Results: The attenuation values of gray matter were significantly higher in the good outcome group than in the poor one. All GWRs were significantly higher in the good outcome group ($p < 0.05$). A GWR (basal ganglia) < 1.18 predicted poor outcomes with a sensitivity and specificity of 50.0% and 87.5%, respectively ($p = 0.021$). GWR (cerebrum) showed the best predictive performance when CT was performed within 24−72 h ($p = 0.003$). No significant differences were found between GWR and poor outcomes when CT was performed within the first 24 h.

Conclusion: Low GWRs which were obtained from brain CT scans in comatose CA patients after restoration of spontaneous circulation were associated with poor neurological outcomes. GWR from brain CT can be a useful parameter for prognostic prediction aiding to an optimal clinical decision process in comatose CA survivors.

Keywords: Coma; Heart arrest; Prognosis; Tomography; X-ray computed

1. Introduction

In recent years, advances in emergency medicine care and resuscitation treatment strategies such as therapeutic hypothermia have increased the number of survivors of cardiac arrest (CA) and improved the chances of good neurological outcome for these patients.[1] However, 45−70% of the survivors still suffered from severe neurologic deficits or died due to hypoxic ischemic encephalopathy (HIE).[2] Thus, early methods to accurately predict patient outcomes should be useful in making therapeutic decisions and titrating therapy. Various indicators including neurologic exams, electrophysiologic studies, biochemical markers, and neuroimaging have been used for prognostication in comatose CA survivors.[3] Of note, brain computed tomography (CT) is frequently performed early following restoration of spontaneous circulation (ROSC) to exclude primary brain injury that could result in CA and coma.[2]

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https://doi.org/10.1016/j.jcma.2018.03.003

HIE is known to be associated with cerebral edema, which reduces the attenuation of gray matter (GM) on un-enhanced CT scans and results in a loss of differentiation between gray and white matter (WM).[4] Several previous studies found that gray−white matter ratio (GWR), the ratio of attenuation of GM to attenuation of WM, was significantly lower in CA survivors with poor outcomes than those with good outcomes, and thus that decreased GWR could predict poor neurological outcome in CA patients.[5−10] However, there is currently no consensus on a distinct GWR cut-off value that may predict poor outcomes with high specificity. The present study was designed to evaluate the association between the GWR and the neurological outcomes in adult comatose CA survivors in Chinese.

2. Methods

2.1. Study population

The present retrospective study retrieved 58 patients with CA who had brain CT scans within 72 h of resuscitation in the period from January 2011 through December 2015 at the First Affiliated Hospital of Nanjing Medical University (Nanjing, China). Most patients underwent brain CT to rule out a primary intracranial event such as subarachnoid hemorrhage (SAH). All CT examinations were performed using a GE Optima 520Pro CT scanner (GE Healthcare, Tokyo, Japan) with 5-mm slice thickness. Regions of interests (ROI) were placed independently by two expert investigators. Both readers were blinded to outcome and other patient data and to ROI placement by the other reader. Patients with age <18 years, poor baseline neurology, terminal malignancy were excluded from the study. Moreover, patients whose CT scans indicated parenchymal abnormalities and whose CT images were technically inadequate for the determination of cerebral density or were not available for evaluation were excluded from the analysis. The study protocol was reviewed and approved by the Institutional Review Boards for Human Studies of Nanjing Medical University.

2.2. GWR determination

Two investigators reviewed CT scans for each patient using a picture archiving and communication system and identified comparable brain slices at three levels including the basal ganglia, centrum semiovale, and high convexity as reported in previous studies.[8,9] Circular regions of measurement (10 mm^2) were placed over these ROI bilaterally (Fig. 1), and the average attenuations were recorded in Hounsfield units (HU). Attenuation values at the basal ganglia level were recorded from the caudate nucleus (CN), putamen (PU), corpus callosum (CC), and posterior limb of the internal capsule (PIC). Values from the medial cortex and medial white matter were recorded at the level of the centrum semiovale (MC1 and MWM1, respectively) and high convexity area (MC2 and MWM2, respectively). The average of both sides was recorded as the value for that area. Previous studies used various methods to calculate the GWR, and no set rule exists for calculating GWR currently. Thus, four GWRs used in previous studies were calculated: $GWR_{basal\ ganglia}$ (GWR-BG) = (CN + PU)/(CC + PIC), $GWR_{cerebrum}$ (GWR-CO) = (MC1 + MC2)/(MWM1 + MWM2), $GWR_{average}$ (GWR-AV) = (GWR-BG + GWR-CO)/2, and $GWR_{simplified}$ (GWR-SI) = PU/PIC.[4,9] To assess the consistency of GWR measurements, the test-retest reliability was measured from a randomly selected sample of 10% of the included subjects.

2.3. Outcome measurement

The primary endpoint was clinical outcome at hospital discharge, which was assessed using the Cerebral Performance Categories (CPC) score, according to recommendations for outcome assessment in comatose CA survivors. CPC grades the levels of neuro-functional status after CA (CPC 1, good; CPC 2, moderate disability; CPC 3, severe disability; CPC 4, comatose or vegetative state; CPC 5, death). The clinical outcome at hospital discharge was dichotomized as either good (CPC 1 or 2) or poor (CPC 3−5).

2.4. Statistical analysis

Continuous variables were expressed as the mean ± standard deviation (SD) or median with interquartile ranges (IQR), as appropriate. Comparisons of continuous variables between independent groups were performed using the two sample *t* test or Mann−Whitney *u* test, as appropriate. Categorical variables were given as frequencies and percentages. Comparisons of categorical variables were performed by the chi-square test or Fisher's exact test, as indicated. Receiver-operating characteristic (ROC) curve analysis was drawn to identify the optimal cut-off value (to determine maximal sensitivity and specificity) to determine the performance of GWRs in predicting prognosis. The statistical performance of the outcome prediction models was assessed using the area under the curve (AUC) with 95% confidence interval (CI). All the statistical tests were performed in SPSS version 16.0 (SPSS Inc. Chicago, IL, USA). A two-tailed *p* value of less than 0.05 was considered statistically significant.

3. Results

3.1. Clinical characteristics

Clinical characteristics of the included patients were shown in Table 1. A total of 159 adult CA patients recovered spontaneous circulation after resuscitation. Among them, 58 survivors underwent brain CT scans were included in this study. According to the CPC score at hospital discharge, 16 patients (27.6%) were assigned to the good neurologic outcome group and 42 patients (72.4%) were the poor outcome group. In most of pre-CA baseline variables, there were no significant differences between the two groups. However, the present study showed 17.2% of the included CA patients were SAH origin, which indicated poor outcomes.

Please cite this article in press as: Wang G-N, et al., The prognostic value of gray−white matter ratio on brain computed tomography in adult comatose cardiac arrest survivors, Journal of the Chinese Medical Association (2018), https://doi.org/10.1016/j.jcma.2018.03.003