

LETTER



CAST: a new score for early prediction of neurological outcomes after cardiac arrest before therapeutic hypothermia with high accuracy

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Dear Editor,

We have developed a prognosis scoring system (the post-Cardiac Arrest Syndrome for Therapeutic hypothermia (CAST) score) for predicting the neurologic prognosis in patients with post-cardiac arrest syndrome (PCAS) before the initiation of therapeutic hypothermia (TH). It may be useful for deciding whether TH should be initiated or not and for explaining the patient's prognosis to his/her family.

A multicenter, retrospective, observational study was performed with the ethics board's approval. Data of a total of 151 consecutive adults who underwent TH after cardiac arrest (77 learning cases in two hospitals and 74 validation cases in two other hospitals) were analyzed (Supplementary Table 1). TH was considered for non-traumatic cardiac arrest patients who were in coma (GCS ≤ 8) after the return of spontaneous circulation (ROSC) without a "do not attempt resuscitation" directive. The target temperature was usually 34 °C, but changed to 35 °C/36 °C depending on the hemodynamic status.

We used eight factors significantly correlated ($p < 0.01$) with the Cerebral Performance Categories score at 30 days in the learning set (Supplementary Table 2). The ratio of gray matter attenuation to white matter attenuation was calculated as shown in Supplementary Fig. 1 [1] and, for

convenience, we converted the continuous variables into categorical variables according to clinical judgment (Supplementary Fig. 2). A tentative scoring system was created from the learning data set using the "glmnet" package for logistic regression (<http://www.jstatsoft.org/v33/i01/>). In an internal validation based on the learning set, the predictive accuracies of this scoring system evaluated by a leave-one-out cross-validation (sensitivity, specificity, and percentage of correct classification) were 0.85, 0.84, and 0.85, respectively. In an external validation based on data from the validation cases, these indices were 0.95, 0.90, and 0.93, respectively, and the area under the receiver operator characteristic curve was 0.97 (Fig. 1). Finally, using all of the data, we created a CAST score to predict the prognosis prior to inducing TH (Supplementary Fig. 3). To simplify the calculation, we created application tools for calculation of the CAST score as an iOS application; iPad: <https://geo.itunes.apple.com/jp/app/meidai-score-for-ipad/id1065338535?mt=8>, iPhone: <https://geo.itunes.apple.com/jp/app/meidai-score-for-iphone/id1067612773?mt=8>.

When a cardiac arrest patient shows ROSC, objective information regarding recovery is helpful for the ICU doctors and also the patient's family, because the decision to induce TH in PCAS patients should be made carefully taking into consideration the cost-effectiveness and invasiveness [2, 3]. The CAST score is more suitable for prognosis prediction than other previously reported scores [4], because it was created using data from only PCAS patients treated by TH, and not from

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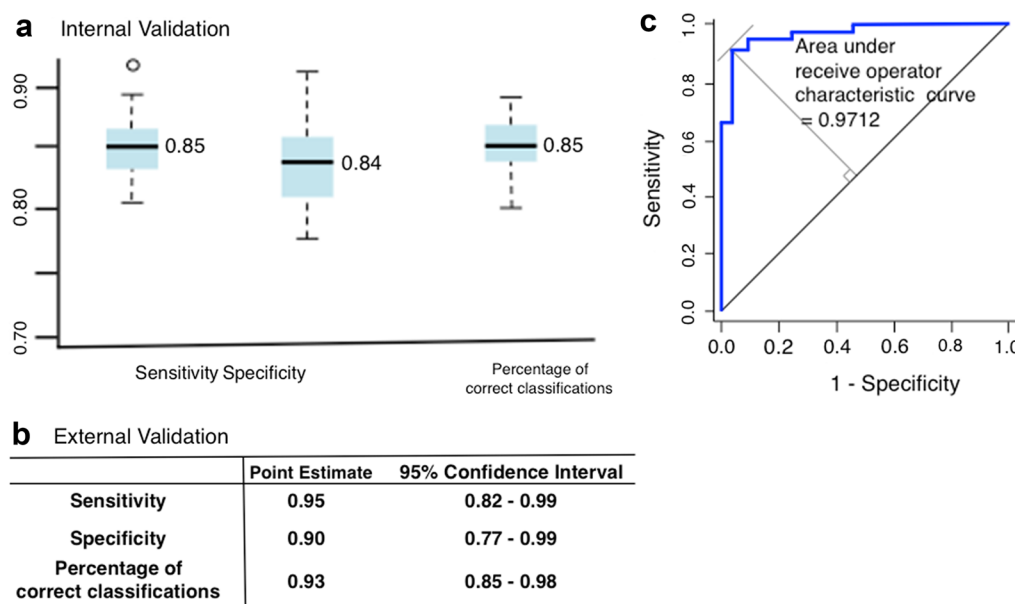


Fig. 1 Sensitivity, specificity, and precision rate of the logistic regression in the internal validation (**a**) and the results of external validation of the tentative scoring system (**b, c**). Specificity measures the proportion of patients with poor outcomes who were correctly identified. For the internal validation, we conducted a ten-fold cross-validation using the learning set. We repeated the cross-validation analysis 50 times with different random sample splits in the learning set to obtain stable estimates of these indices. In the external validation, we estimated each 95 % confidence interval by the exact method based on the beta distribution (we did not employ the normal approximation). With different cutoff values used for the tentative score, we plotted the receive operator characteristic curve and found the area under the curve to be 0.97

all PCAS patients. Of course, predictive scores should be used carefully, since they only show the probability of outcome in a general population, not the precise probability in an individual patient [5]. Although the prediction is not absolute, we suggest that it can serve as a useful guide for the ICU doctors and the patients' families; however, further large prospective validation studies of the CAST score and a study examining the usefulness of this score for predicting the long-term prognosis are required before it can support clinical decision-making.

Electronic supplementary material

The online version of this article (doi:10.1007/s00134-016-4492-3) contains supplementary material, which is available to authorized users.

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Compliance with ethical standards

Conflicts of interest

The authors declare that they have no conflicts of interest.

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