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Prediction of potential for organ donation after circulatory death in neurocritical patients

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KEYWORDS:
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BACKGROUND: The success or failure of donation after circulatory death depends largely on the functional warm ischemia time, which is closely related to the duration between withdrawal of life-sustaining treatment and circulatory arrest. However, a reliable predictive model for the duration is absent. We aimed to compare the performance of the Chinese Donation after Circulatory Death Nomogram (C-DCD-Nomogram) and 3 other tools in a cohort of potential donors.

METHODS: In this prospective, multicenter, observational study, data were obtained from 219 consecutive neurocritical patients in China. The patients were followed until circulatory death after withdrawal of life-sustaining treatment.

RESULTS: The C-DCD-Nomogram performed well in predicting patient death within 30, 60, 120 and 240 minutes after withdrawal of life-sustaining treatment with c-statistics of 0.87, 0.88, 0.86 and 0.95, respectively. The DCD-N score was a poor predictor of death within 30, 60 and 240 minutes, with c-statistics of 0.63, 0.69 and 0.59, respectively, although it was able to predict patient death within 120 minutes, with a c-statistic of 0.73. Neither the University of Wisconsin DCD evaluation tool (UWDCD) nor the United Network for Organ Sharing (UNOS) criteria was able to predict patient death within 30, 60, 120 and 240 minutes after withdrawal of life-sustaining treatment (UWDCD tool: 0.48, 0.45, 0.49 and 0.57; UNOS criteria: 0.50, 0.53, 0.51 and 0.63).

CONCLUSION: The C-DCD-Nomogram is superior to the other 3 tools for predicting death within a limited duration after withdrawal of life-sustaining treatment in Chinese

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neurocritical patients. Thus, it appears to be a reliable tool identifying potential donors after circulatory death.
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Donation after circulatory death (DCD) donors have become a major source of organs for transplantation in European countries, Australia and the USA.[1] In China, a new national deceased organ donation program has been established.[2] DCD donors are the predominant organ source because the concept of brain death is still not widely accepted in China as it is in Western countries. Nevertheless, identification of potential donors is one of the most important challenges in DCD donor schemes.

The vast majority of DCD donors are "controlled" Maastricht Category III donors.[3] Such donors do not fulfill the criteria for certification of brain death but most have irreversible brain injuries (neurocritical patients). Notably, during donation, the period from withdrawal of life-sustaining treatment (WLST) to circulatory arrest is highly variable.[4] The duration and nature have a major impact on whether organ donation is likely to occur and on the quality of the organs recovered.[5] For this reason, accurate prediction of the time to death after WLST is of great interest for DCD.

Two widely used predictive scores, the University of Wisconsin (UW) DCD evaluation tool and the United Network for Organ Sharing (UNOS) criteria, may lack predictive accuracy because they include little information about the neurologic status of the potential donors.[6,7] In 2012, the donation after cardiac death-neurological (DCD-N) score, with 3 neurologic parameters, was developed and reported to have high predictive accuracy.[8] The authors reported a sensitivity of 72%, if the patient had a DCD-N score of ≥3, to predict death within 60 minutes of WLST.

Our group has established and validated a nomogram called the Chinese Donation after Circulatory Death Nomogram (C-DCD-Nomogram) to predict death within 60 minutes after WLST with a c-index of 0.96 (0.93 to 0.98), indicating its potential for clinical use.[9] Nevertheless, similar to the limitations of the DCD-N score, the study did not restrict participants to potential donors, and did not directly compare the performance of the nomogram with other models. For these reasons, we conducted the current prospective, multicenter, observational studies to compare the predictive accuracy of the 4 tools in a cohort of potential DCD donors.

Methods

Design and participants

In this multicenter, observational study, we prospectively obtained data from consecutive neurocritical patients with a likely prognosis of progression to circulatory death after WLST at 4 participating centers in China, including The First Affiliated Hospital of Sun Yat-sen University, The First People's Hospital of Foshan City, The Jiangmen Central Hospital, and The People's Hospital of Dongguan City, between May 2015 and April 2016.

Patients' inclusion criteria were as follows: (1) apnea in deep coma after recent traumatic brain injury or spontaneous intracranial hemorrhage, diagnosed on brain computed tomography (CT) scan; (2) anticipated death attributable directly to severe brain injury; and (3) age range between 15 and 60 years. Patients who met the mandatory criteria of the current brain death criteria in China were excluded.[10] In addition, patients with multiple-organ failure, severe infectious diseases and recurrent or metastatic malignancy were excluded, as these patients were not suitable for organ donation.

The local ethics committee approved the study and written informed consent was obtained from relatives of participants at enrollment.

Data collection

After inclusion, the patients were followed until circulatory death was confirmed. We selected variables for data collection on the basis of findings in 4 previously reported studies.[6–9] Neurologic examination focused on brainstem reflexes, such as pupil size, corneal reflex, cough reflex and motor response to pain. Types of vasopressors administered and oxygen saturation were recorded according to the UWDCD evaluation tool and UNOS criteria.[6,7] We calculated oxygenation index using the formula reported by Rabinstein et al[8]: 100 × (fraction of inspired oxygen × mean airway pressure in cm H_2O) / partial pressure of oxygen in torr, mean airway pressure = half the combination of peak airway pressure in cm H_2O and peak end-expiratory pressure in torr. Brain CT scan images were collected and transferred to the Neurosurgery Department of The First Affiliated Hospital, Sun Yat-sen University, for blind analysis as demonstrated in our previous study.[9] The cisterna ambiens was defined as a sheet-like curved layer of sub-arachnoid space extending from the cisterna quadrigeminalis, bilaterally encircling the mid-brain on each side and connecting with the cisterna interpeduncularis. The status of cisterna ambiens was assessed by width and divided into 3 levels: normal (width >3 mm); narrowed (1 mm $\leq$ width ≤ 3 mm); or absent (width <1 mm). The swirl sign was described as non-contrast CT appearance of low attenuation or radiolucency inside intracranial hyperattenuated hematomas. We assessed the variables at the last examination before WLST, which occurred after discontinuation of sedation and opiate analgesia.

Statistical analysis

To further validate the performance of the C-DCD-Nomogram, model validation was conducted in the prospective validation cohort. Discrimination was assessed using the c-index. Calibration was assessed using a calibration plot.[11]

We calculated the total scores to predict the chance of death within 30, 60, 120 and 240 minutes after WLST according to the C-DCD-Nomogram and the other score charts (UWDCD evaluation tool, UNOS criteria and DCD-N score), respectively.