

Original Research Article

Key points of cooperation for successful implementation of bedside TCD in brain death determination

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ABSTRACT

Background: To clarify the key points of cooperation in bedside TCD examination of potential brain death patients and ensure the successful implementation of bedside TCD.

Methods: From June 2018 to May 2019, the clinical data of potential brain death patients, admitted in ICU of the First Affiliated Hospital of Sun Yat-sen University, were prospectively collected; for patients undergoing bedside TCD examination, through cooperating with TCD examination doctors, the related key points were summarized and analyzed.

Results: Among 127 patients entered the study, including 103 males and 24 females, mean age is (33.2±15.2) years. 112 cases (88.2%) successfully implemented bedside TCD, 15 cases (11.8%) failed to implement bedside TCD. Univariate and multivariate analysis showed that: reasonable blood pressure regulation (systolic pressure: 90-140mmhg) (or = 6.58, 95% CI: 1.72-31.69), effective CCA compression test (rapid and accurate compression) (or = 13.62, 95% CI: 3.04-78.93) and body position adjustment (back and bed surface angle: 30-60°) (or = 11.76, 95% CI: 1.49-76.28) is the key points of cooperation for the successful implementation of bedside TCD in potential brain death patients.

Conclusions: The targeted cooperation can ensure the successful implementation of bedside TCD judgment of brain death, and the results need further external validation.

Keywords: Bedside, Brain death, Cooperation, Intensive care unit, Transcranial doppler

INTRODUCTION

According to Chinese guidelines, transcranial Doppler (TCD) is one of the confirmatory tests for brain death.^{1,2} In ICU, the potential brain death patients need to use ventilator, ECG monitoring, pumping vasoactive drugs, et al. (Figure 1A). It is difficult and risky for those patients to leave ICU for confirmatory tests of brain death.³ Therefore, the bedside TCD examination in ICU is necessary for potential brain death patients, and corresponding cooperative measures are also necessary. At present, there are few reports about the cooperative measures of bedside TCD in ICU.^{4,5} In China, there are few medical centers that can carry out bedside TCD

examination in ICU, and there is no relevant reports. Since 2016, the brain death determination was carried out in our center, authors summarized the key points of cooperation of bedside TCD examination in ICU, and the report as follows.

METHODS

CCA compression test

The methods of common carotid artery (CCA) compression test: the CCA pulsing on the medial side of sternocleidomastoid muscle in the superior sternal fossa, the fingertips of index finger and middle finger were

located on the inside and outside of the anterior wall of CCA, and pressed horizontally downward or downward laterally (Figure 1B). When CCA is compressed, the blood flow of the corresponding extended vessels will reduce for a short time, so as to help vascular recognition and improve the accuracy of TCD examination.⁶

Inclusion criteria

- From June 2018 to May 2019, potential brain death patients admitted to ICU of our hospital;
- Before bedside TCD examination, all patients met the clinical brain death criteria;
- Age >1 year.

Exclusion criteria

- Systolic pressure < 90mmHg;
- The results of TCD examination were influenced by ECMO;
- No blood flow signal was found in TCD examination.

Statistical analysis

SPSS (version 22.0) was used for data analysis. Mean±SD and percentage were used to analyze general data and successful implementation rate of bedside TCD. The bedside TCD success and failure was used as

grouping factors, gender, age, blood pressure during examination, patient position, CCA compression test and decompressive craniectomy were included. Univariate and multivariate analysis were used to screen factors related to successful implementation of bedside TCD.

RESULTS

According to the inclusion and exclusion criteria, 127 patients were enrolled in our study, including 103 males and 24 females, with an average age of 33.2±15.2 years. Primary diagnosis: 71 (55.9%) cases of traumatic brain injury, 41 (32.3%) cases of spontaneous cerebral hemorrhage, 10 (7.9%) cases of hypoxic-ischemic encephalopathy and 5 (3.9%) cases of intracranial tumor .

Among 112 cases (88.2%) successfully implemented bedside TCD, 15 cases (11.8%) failed to implement bedside TCD (Table 1).

Table 1: The implementation rate of bedside TCD in 127 potential brain death patients.

Bedside TCD	No.	Total No.	Percentage
success	112	127	88.2%
failure	15	127	11.8%

Based on the relevant literature, factors influencing TCD examination in ICU bedside were summarized.³⁻⁶

Table 2: Univariate analysis of factors related to successful implementation of bedside TCD.

Factors	Group		OR (95% CI)	p
Age	≤14y	>14y	3.81 (0.35-12.12)	0.02
Gender	Male	Female	1.19 (0.61-3.63)	0.37
Systolic blood pressure	≥90mmHg	<90mmHg	5.42 (1.52-19.67)	0.01
CCA compression test	Effective	Ineffective	5.29 (1.26-18.87)	0.01
Position	30-60° lateral position	Supine position	4.98 (1.73-16.83)	0.01
Decompressive craniectomy	Yes	No	3.91 (0.38-29.36)	0.03

Table 3: Multivariate analysis of factors related to successful implementation of bedside TCD.

Factors	Group		OR (95%CI)	p
Systolic blood pressure	≥90mmHg	<90mmHg	6.58 (1.72-31.69)	0.01
CCA compression test	Effective	Ineffective	13.62 (3.04-78.93)	0.01
Position	30-60° lateral position	Supine position	11.76 (1.49-76.28)	0.01

Univariate analysis showed that: age ≤14 years, systolic blood pressure ≥90 mmHg, effective, effective CCA compression test, 30-60° lateral position and decompressive craniectomy were the factors related to successful implementation of bedside TCDn (Table 2); further multivariate analysis showed that systolic blood pressure ≥90mmHg, effective CCA compression test and 30-60° lateral position are factors related to successful

implementation of bedside TCD (Table 3).

DISCUSSION

In China, the brain death determination guidelines have been promulgated.^{1,2} and applied in clinical practice, such as organ donation after brain death.⁷ Compared with another countries, the biggest feature of China brain

death guidelines is that it requires confirmatory tests compulsorily.^{1,2,8} The confirmatory tests includes three items: cerebral blood flow, EEG(electroencephalogram) and EP(Evoked potential). Compared with bedside EEG and EP, the bedside TCD detection of cerebral blood flow is not affected by the surrounding environment and sedative medicine; therefore, bedside TCD detection of cerebral blood flow is the first choice for potential brain death patients.⁴ There are many monitoring and treatment instruments in ICU, which limited the operation environment of bedside TCD (Figure 1A); meanwhile, the patient is carrying a variety of pipes, such as tracheal intubation, gastric tube, urinary tube and deep vein tube, and nursing cooperation is required during the operation of head up, body position change and CCA compression test; therefore, corresponding cooperation measures are essential for the successful implementation of bedside TCD examination.³

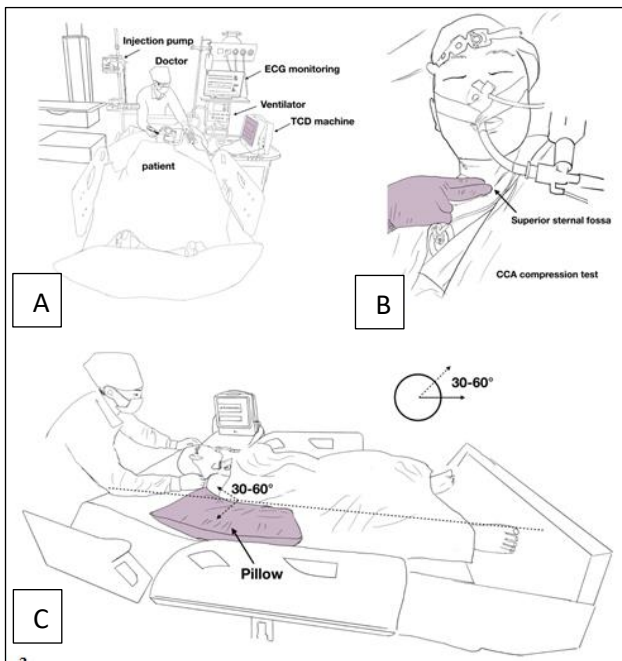


Figure 1: Schematic diagram of bedside TCD examination (A): ICU bedside TCD examination environment (B): CCA compression test (C): 30-60° nursing coordination posture of our centre.

In this study, 107 patients (84.3%) were over 14 years old. Univariate analysis showed the age was correlated with successful implementation of bedside TCD, but multivariate analysis did not show a correlation; the considering reason of this result may be because of small sample size (only 10 cases). Since decompressive craniectomy can improve Doppler ultrasound penetration, which increased the detection rate of cerebral blood flow, so there was no correlation in multivariate analysis. Based on the above, the key points of successful implementation of bedside TCD are systolic pressure ≥ 90 mmHg, effective CCA compression test and 30-60° lateral position.

TCD is a noninvasive and bedside technique for detecting cerebral blood flow. The detectable cerebral blood flow needs to maintain systolic blood pressure ≥ 90 mmHg (adult) or $(80 + \text{age} \times 2, \text{child})$.⁴ Due to the depletion of pituitary hypothalamic related hormones, one or more vasoactive drugs are needed to maintain blood pressure in potential brain death patients.⁹ When the head is raised and the body position is changed, the patient's blood pressure will fluctuate. The reasons are as follows: 1. The pipeline containing vasoactive medicine is compressed or discounted, which caused the medicine unable to enter the blood circulation (the operation time of bedside TCD is 20-30min).¹⁰ 2. The cardiovascular regulatory center of brain stem is damaged, and external stimulation caused blood pressure fluctuation. Therefore, during the process of bedside TCD examination, it is necessary to ensure that the infusion pipeline is unobstructed, in order to avoid the false appearance of cerebral blood flow disappearance caused systolic pressure less than 90mmHg which resulting in wrong TCD interpretation.⁴ In our center, before TCD examination, some vasoactive drugs in the injection pump were rapidly injected, and the systolic pressure was raised to about 120mmHg (avoid more than 140mmHg, since too high systolic pressure would cause false cerebral blood flow which leading to TCD interpretation error) and adjust the pump speed at any time to avoid high or low blood pressure, then ensure that the systolic pressure maintained between 90-140mmHg during bedside TCD examination.^{4,5}

TCD is a blind detection of cerebral blood flow without two-dimensional image. In addition to judging from depth, blood flow velocity and direction of cerebral vessels, TCD also needed to use CCA compression test.^{4,5} TCD determination of brain death is based on the detection of bilateral middle cerebral artery (MCA) and posterior basilar artery (BA).^{1,2} Usually, MCA is detected through temporal window (supine position, in the area of horizontal line between eyebrow arch and ear edge); however, up to 45% of Asians have limited temporal window (bone is thick and Doppler ultrasound can't penetrate), which needs to be detected through eye window (supine position, closed upper eyelid), but eye window examination needs to distinguish MCA on opposite side and siphon of internal carotid artery on the same side. The CCA compression test can reduce the blood flow of the siphon part of the same internal carotid artery by compressing the common carotid artery (CCA) on one side, so as to achieve the purpose of differentiation.⁶ Due to the deep coma state of potential brain death patients, it is impossible to partially rotate the neck to cooperate with CCA compression test. Meanwhile, it is difficult for doctors to perform CCA compression test by themselves since the limitation of surrounding environment (Figure 1A). Therefore, it is important to carry out effective CCA compression test by cooperator. In our center, the cooperator (such as nurse) participating in the bedside TCD examination shall be trained to master the position and technique of CCA compression test. When doctor detected the blood flow

spectrum through the eye window, the CCA shall be positioned with the index finger and the middle finger; after the order, the CCA was compressed rapidly, meanwhile observing the change of blood flow spectrum on TCD display. If the blood flow is significantly reduced, it shows that CCA compression test is effective.

After bilateral MCA detection, BA should also be detected. Traditionally, BA was detected in supine position with head leaning to one side or head raising. However, those patients have had tracheal intubation or short neck, which limited head rotation and caused inadequate exposure of the posterior occipital part.¹⁰ The 90° lateral position can effectively expose the posterior occipital part, but due to the large change of body position, it is easy to cause pipeline traction, pressure, fall off and blood pressure fluctuation of patients, at the same time, special personnel are required to support which increased manpower input.^{11,12} Based on the above, the pillow was used in this study, so patient's back and the bed were in a 30-60° lateral position, which could not only effectively expose the back pillow, but also reduce the interference to the pipeline and the patient's vital signs (Figure 1C).

In addition, during the examination, authors should pay attention to oral secretion and vomitus, avoid polluting the bed unit or inspectors, and avoid falling off of tracheal intubation, gastric tube and deep vein tube.¹¹⁻¹³ At the same time, authors also should pay attention to keeping warm to avoid hypothermia, which will lead to blood circulation instability after examination, resulting in cardiac arrest and failed in organ donation after brain death.^{3,9}

CONCLUSION

In a word, targeted measures are helpful to the successful implementation of bedside TCD in ICU, and provided support for the successful completion of brain death determination.

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