**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.¹ ³ 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.1-6

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

| Factors                      | Group          | OR (95% CI) | p   |
|------------------------------|----------------|-------------|-----|
| Age                          | ≤14y           | 3.81 (0.35-12.12) | 0.02 |
| Gender                       | Male           | 1.19 (0.61-3.63)  | 0.37 |
| Systolic blood pressure      | ≥90mmHg        | 5.42 (1.52-19.67) | 0.01 |
| CCA compression test         | Effective      | 5.29 (1.26-18.87) | 0.01 |
| Position                     | 30-60° lateral position | 4.98 (1.73-16.83) | 0.01 |
| Decompressive craniectomy    | Yes            | 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        | 6.58 (1.72-31.69) | 0.01 |
| CCA compression test         | Effective      | 13.62 (3.04-78.93) | 0.01 |
| Position                     | 30-60° lateral 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. 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. 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.

TCD is a noninvasive and bedside technique for detecting cerebral blood flow. The detectable cerebral blood flow needs to maintain systolic blood pressure ≥90mmHg (adult) or (80 + age × 2, child). 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. 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). 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.

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.

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. Univariater 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 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 ≥90mmHg, effective CCA compression test and 30-60° lateral position.

The TCD compression test is divided into three stages: (1) Compression at the CCA while the patient is supine with a 30-60° head-up position (Figure 1C). If the brain stem is damaged, the cerebral blood flow is debatable and there is a false absence of cerebral blood flow which leads to TCD interpretation error; (2) At the same time, the operator needs to change the head position to 90°; (3) After confirming the direction of embolectomy with the patient in the 30°-60° head-up position, the coordinator should adjust the pump speed to maintain a systolic pressure of 120mmHg and confirm that the TCD examination result is consistent with that of the preform CCA compression test. In cases where the blood flow of the siphon part of the internal carotid artery on one side is debatable, the doctor or nurse should carry out the second stage test.
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.\(^\text{10}\) The 90\(^{\circ}\) 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.\(^\text{11,12}\) Based on the above, the pillow was used in this study, so patient's back and the bed were in a 30-60\(^{\circ}\) 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.\(^\text{11-13}\) 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.\(^\text{3,9}\)

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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