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Effects of Body Position on the Diagnosis of Right-to-Left Shunt and Standard Operations of Transcranial Doppler for Identification of Right-to-Left Shunt

CME Credits

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Patent foramen ovale (PFO) is the most common cause of intracardiac right-to-left shunt (RLS) and is closely associated with paradoxical thrombotic embolism, cryptogenic stroke, transient ischemic attack, and migraine, regardless of early signs. Nonetheless, the role of PFO as a risk factor for stroke or migraine has always been controversial. Therefore, detection of RLS and research into the correlation between RLS and clinical events are necessary.

At present, common methods used in clinical practice for the detection of intracardiac RLS include contrast transesophageal echocardiography, transthoracic echocardiography, and contrast transcranial Doppler (TCD). Among these, transesophageal echocardiography is the gold standard. However, compared with other methods, sensitivity of TCD is higher due to extracardiac shunts. TCD has the additional advantages of low cost, noninvasiveness, and improved tolerability. Moreover, the reduced blood flow velocity within the intracranial artery can be used as a standard for quantification of the Valsalva maneuver (VM), based on real-time monitoring of the intracranial microbubble signal. In addition, the VM can improve the detection rate of RLS by TCD. The use of TCD for the examination of intra- or extracardiac shunts will also increase the sensitivity and specificity of the RLS diagnosis.

Nevertheless, the most appropriate body position for identification of RLS by TCD is still controversial. The supine position was recommended at the Venice Consensus Meeting in 1999 as the standard body position for performing the TCD examination. In recent years, however, studies that have used the classification of shunts and the number of microbubbles as diagnostic standards for quantification have indicated that the supine position is not the optimal body position. In addition, these studies compared the sensitivity (as well as the accuracy) of various body positions, including upright sitting, upright standing, right lateral decubitus, and left lateral decubitus positions. They found that the number of microbubbles was higher during the upright standing position at rest and the positive detection rate of RLS was higher in the upright sitting position under VM condition. In addition, the number of microbubbles and positive rate

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were also higher in the upright sitting position under VM condition.

In both the upright standing and the upright sitting position, position of the right atrium is relatively higher than that of the right ventricle. The microbubbles in the right atrium may easily rise to the location of the PFO, enter the right ventricle through the PFO, and subsequently increase the detection rate of RLS.

Cardiac anatomy of the left lateral decubitus position and that of the upright position are similar. Patients with severe migraine or stroke patients with hemiplegia cannot maintain an upright standing or upright sitting position. Because the left lateral decubitus position is a supine position as well as an upright position, we assumed that the best body position for TCD examination is the left lateral decubitus position. Moreover, the body position for traditional cardiac ultrasound imaging is the left lateral decubitus position, and adopting the same body position for evaluation of an RLS is helpful when comparing between cardiac ultrasound imaging and TCD.

In this study, each patient with migraine was randomly examined in supine, left lateral decubitus, and right lateral decubitus positions. In addition, each body position was examined sequentially under two breathing conditions, i.e., resting and VM. The diagnostic standard for RLS by TCD is detection of microbubbles in any of the body positions under either breathing condition. See Appendix 1 for detailed standard operational procedures for TCD diagnosis.

The results indicated that the left lateral decubitus position, regardless of resting or VM condition, showed the highest positive RLS detection rate. The number of microbubbles and the volume of shunted blood were the highest in the left lateral decubitus position. The lowest failure rate of detection of a positive result was found in the left lateral decubitus position when any two of the body positions showed positive results at rest.

To improve the sensitivity of detecting RLS, a left lateral decubitus position is recommended for examination under both resting and VM conditions. In addition, to avoid a false-negative result, examination in other body positions is also required.

Table 1 Standards for the diagnosis of RLS by TCD.

Definition of RLS	Presence of the microbubble signal indicates RLS (and under most situations, it indicates the presence of a patent foramen ovale)
Quantification of RLS	Level 0: no microbubbles (negative result) Level 1: 1–10 microbubbles Level 2: >10 microbubbles, but not in curtain shape Level 3: in curtain shape, i.e., the microbubbles are presented as in a shower and individual bubbles cannot be identified
Types of RLS	If microbubbles are detected after the Valsalva maneuver, this represents provoked RLS; if microbubbles are detected both at rest and after the Valsalva maneuver, this represents constant RLS

RLS = right-to-left shunt; TCD = transcranial Doppler.

Table 2 Report of the diagnosis of RLS by TCD.

1	Name and model number of the ultrasound instrument.
2	Name of the blood vessel being monitored and its depth.
3	Detection of microbubbles at rest and after Valsalva maneuver. If microbubbles are detected, a detailed description of the time of detection and the number of bubbles shall be provided.
4	The existence of RLS shall be described in the conclusion. The type of RLS shall be specified if RLS is found.

RLS = right-to-left shunt; TCD = transcranial Doppler.

Appendix 1. Standard operations (including the examination process and diagnosis standards) for the diagnosis of right-to-left shunt by transcranial Doppler (TCD).

Flow examination

Equipment

(1) TCD
(2) Low-frequency (2–2.5 MHz) ultrasound probe
(3) One 18G closed intravenous catheter, two 10-mL syringes, one three-way stopcock, and 100 mL of isotonic saline solution
(4) Option: one TCD monitoring headgear or one manometer [for use in the Valsalva maneuver (VM)]

Examination procedure

(1) The patient shall be placed in the supine position. Use the TCD by holding the probe or use the headgear to monitor the cerebral middle artery (MCA) on one side through the temporal window at a depth of 40–60 mm (preferably at 50–60 mm in clinical practice) with a sample volume of 8–10 mm. When setting dual depths for the one-way channel, it is required to adjust the sample volume to less than the difference between the two depths so as to reduce the gain. The acoustic window and monitored blood vessels shall be the same for the same individual.

Note: For MCA, press the common carotid artery on the same side to observe changes in its blood flow, if necessary, for confirmation.

(2) Insert an 18G intravenous catheter into the cubital vein of the right arm and connect the catheter to a three-way stopcock. Take two 10-mL syringes. With one syringe, containing 9 mL of isotonic saline solution and

1 mL of air (from the sterile air of the saline solution bag), withdraw one drop of the patient's blood; the other syringe is empty. Next, mix the contents of the two 10-mL syringes thoroughly using the three-way stopcock to prepare the isotonic microbubble contrast agent that contains isotonic saline solution, bubbles, and blood. Mix at least 10 times.

(3) After mixing, inject the content through an intravenous line as a bolus and observe the signal of microbubbles within the MCA spectrum of TCD.

commencing blowing, and then ask the patient to blow hard by contracting the abdominal muscles and continue for 10 seconds, in one blow, with no breathing in between. During the process of blowing, the patient shall follow the operator's instructions: start form 1 second to 10 seconds, and stop blowing. The patients usually have to practice once or twice before the examination.

(5) Recording TCD monitoring: start monitoring 30 seconds before injection of the contrast agent and continue monitoring for 1 additional minute after the end of the VM.

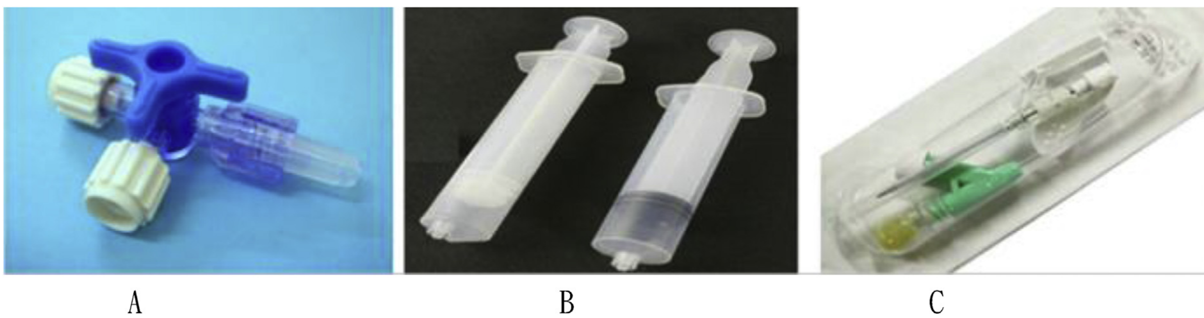

Figure 1 Devices used for the detection of right-to-left shunt by contrast transcranial Doppler: (A) three-way stopcock; (B) syringe; and (C) 18G closed IV catheter. IV = intravenous.

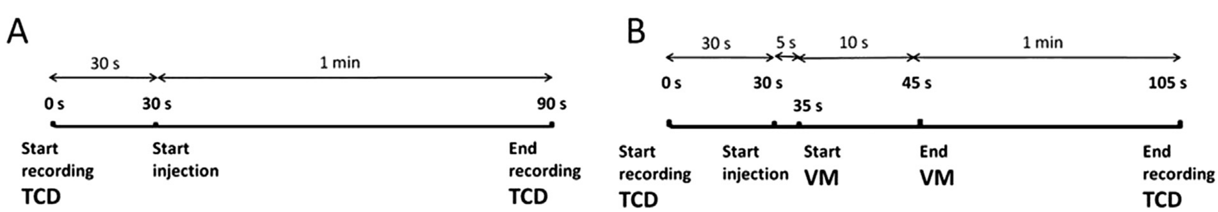

Figure 2 Flowchart used in the detection of right-to-left shunt by transcranial Doppler. (A) Resting state: the subject maintains normal breathing in the resting state, monitoring of the MCA begins 30 seconds before injection of the contrast agent, and the result is recorded for an additional minute. (B) VM state: monitoring of the MCA begins 30 seconds before injection of the contrast agent; the contrast agent is injected 5 seconds before the 10-second continuous Valsalva maneuver, and the result is recorded for an additional minute after the end of Valsalva maneuver. MCA = middle cerebral artery; TCD = transcranial Doppler; VM = Valsalva maneuver.

(4) Perform the aforementioned procedures sequentially under both resting and VM conditions (as shown in Figure 2). Start injection of the contrast agent 5 seconds before the continued 10-second VM. Start VM according to the operator's instructions. The standard for evaluation of VM operation is the curve of the blood flow velocity of the MCA or the blowing pressure during the VM phase. The standard for evaluation was a 25% reduction in the peak blood flow velocity during MCA contraction in the VM phase, or when the blowing pressure reached 40 mmHg. The method is as follows: connect a-50 mL syringe to a sphygmomanometer. Ask the patient to blow some air while watching the scale of the sphygmomanometer, and ask the patient to stop blowing when the indicator of the sphygmomanometer rises from 0 mmHg to 40 mmHg. Make sure that the patient's mouth is at the opening of the syringe before

(6) Repeat the examination after an interval of at least 5 minutes. Repeated injection of the contrast agent is safe. Examination of the VM may be repeated when necessary.

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