Postural Dependency of Right to Left Shunt
Role of Contrast-Enhanced Transcranial Doppler and Its Potential Clinical Implications

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Background and Purpose—Right to left shunt is involved in conditions in which postural changes may be pathogenically relevant. The aim of this work was to assess the frequency of posturally dependent right to left shunt.

Methods—In 109 consecutive right to left shunt-positive subjects (male/female = 40/69, age 43 ± 12 years), we assessed with contrast-enhanced transcranial Doppler the bubble load during normal breathing and after the Valsalva maneuver in both standing and recumbent position randomizing the order of testing.

Results—During normal breathing, the average bubble count was 11 ± 20 in the recumbent and 26 ± 60 in the standing position. After the Valsalva maneuver, it was 40 ± 38 and 42 ± 37, respectively. The increase of bubble load in standing position occurred in 42% of patients and was independent of the order of testing.

Conclusions—The amount of permanent right to left shunt is posture-dependent in 40% of patients. Testing in the sitting position may thus be warranted in doubtful or inconclusive results obtained with the subject in the horizontal position.

Key Words: right to left shunt • transcranial Doppler • recumbent position • standing position

Right to left shunt (RLS) is involved in many pathophysiological conditions in which postural changes may be pathogenically important.1–3 Although transesophageal echocardiography is considered the gold standard for RLS across a patent foramen ovale, contrast-enhanced transcranial Doppler is no less sensitive, much better tolerated, and moreover it allows an easier quantification of RLS in a recumbent or a standing position.4,5 Current recommendations indicate testing in the recumbent position.6 On the other hand, testing in a standing position may represent a better way to detect significant RLS occurring during normal daily activity because it reproduces the body posture usually held for most of the day.

We therefore tested postural variations of RLS, under normal breathing and Valsalva maneuver (VM), in a consecutive series of patients known to be positive for RLS while recumbent.

Patients and Methods
We prospectively evaluated 109 consecutive patients referred for contrast-enhanced transcranial Doppler confirmation of a RLS detected elsewhere with transthoracic echo for transient ischemic attack or stroke in 61 patients, migraine with or without aura in 39, neurosurgical procedures in a sitting position in 4, and miscellaneous (paroxysmal vertigo, palpitations, screening) in the remaining 5.

Contrast transcranial Doppler was performed according to the standardized procedure agreed on in the Consensus Conference of Venice.6 In brief, 10 mL of air-mixed saline was injected in the right antecubital vein with the arm lying on the stretcher while simultaneously recording the Doppler signal from the right middle cerebral artery during normal breathing and before VM with a 2-MHz transducer. During standing, the arm was lifted above the head after the injection. In case of RLS, microbubbles appearing on the spectral display were counted offline during a time interval of ≥20 seconds after the appearance of the first microbubble, thus allowing a quantitative evaluation of the amount of shunt6 in both recumbent and standing positions. In each position, VM was always tested after normal breathing, whereas the order of testing positions was random. The interval time between the 2 positions was ≥2 minutes.

Statistical Analysis
Preliminary comparisons of postural variations in the bubble count during normal breathing and after VM were performed with t test. The possible effects of order of testing, sex, and center were explored with repeated-measure analyses of variance. Data were statistically significant when P < 0.05.

Results
RLS was detected in all 109 patients (male/female = 40/69, age 43 ± 12 years).

During normal breathing, the passage from recumbent to the standing position produced an average 40 ± 69-bubble increase in 46 (42%) patients, no change in 32, and an increase in 31 (28%) patients.
average $7 \pm 9$ decrease in 31. Overall, the average bubble count increased from $11 \pm 20$ while recumbent to $26 \pm 60$ in the standing position ($t = -3.115; P = 0.002$). After VM, there was no postural variation ($-42 \pm 37$ recumbent, $40 \pm 38$ standing, $t = -0.260; P = 0.8$).

A repeated-measure analysis of variance with “position” (bubble count while recumbent versus bubble count while standing) as the within-subjects variable and “testing order” (recumbent first versus sitting first as the between-subjects variable) showed that the increase in the number of bubbles from recumbent to the standing position during normal breathing ($F = 8, 158; P = 0.005$) was independent of the order of testing ($F = 0.012; P = 0.979$).

**Discussion**

The main finding of the study is the demonstration that 42% of the patients exhibited on average a postural triplication of the bubble load (from 15 ± 26 to 56 ± 83), whereas the remaining 58% showed no variation or a much smaller change in the opposite direction (from 12 ± 15 to 5 ± 9), the latter probably reflecting more the intrinsic variability of the technique than a true difference.

Contrary to our results, Schwarze et al\(^8\) showed a significant decline of median microemboli count from recumbent to sitting position, but the number of patients evaluated in different body positions was only 13. On the contrary, Telman et al\(^8\) did not observe any significant modification of patients’ position and order of testing did not affect the number of microemboli. However, Telman et al\(^8\) used a lesser saline volume (6 mL) than standard and they performed the injection at the same time that the patient was performing the VM, thus preventing the appreciation of the spontaneous postural variations in the microbubble count. Moreover, their sample size was small.

In agreement with our results, Lao et al\(^9\) showed a significant increase of microbubble count from the recumbent to standing position. This latter study had, however, a relatively small sample size, did not randomize the order of testing, and did not clarify whether the postural effect was VM-dependent. Despite these differences, however, their results were remarkably similar to ours both for the proportion of patients with postural variations and for the 3-fold increase of the bubble load measured in the standing position.\(^9\)

In principle, the increased number of microbubbles during normal breathing in the sitting position might be explained by the relative increase in the bubble concentration in the right atrium during the standing position because of the reduction in the incoming flow from inferior vena cava, in which case the order of testing would affect the postural variation; testing in the standing position first would yield a lesser increase than when the order is reversed because of the persistence of bubble lingering in the right atrium and thus spuriously increasing the count in the recumbent position. Because we did not observe any hint of a difference in the amount of the postural variation in relation to the testing order (+41 when testing down first, +38 when testing up first, $t = 0.109; P = 0.91$), we would attribute the increased bubble load to a real increase in the amount of shunted blood from recumbent to standing position, possibly due to a gravitational stretching of patent foramen ovale.

The results of the present study suggest that postural variations of spontaneous RLS need to be taken into account not only in patients with cryptogenic stroke, but also in those conditions in which paradoxical embolism needs to be firmly avoided such as surgery in the sitting position and scuba diving. Furthermore, our as well as Lao’s et al\(^9\) findings suggest that platypnea orthodeoxia syndrome, a condition in which dyspnea and blood oxygen desaturation occur in a standing position and disappears when the patient is recumbent, might be largely underdiagnosed.

In conclusion, our study indicates that the amount of permanent RLS is posture-dependent in as many as 40% of subjects. Testing in the standing position may thus be warranted not only when doubtful results are obtained with the subject in the horizontal position, but also when postural variations of RLS may be pathogenically relevant.

**Disclosures**

None.

**References**

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