Patent Forame Ovale: Contribution of Transcranial Doppler in Patient Diagnosis

Eliza de Almeida Gripp,[1,2] *Ana Carolina de Freitas Portela,*[1] *Flávio Luis da Costa Junior,*[1] *Rafael Rabishoffsky,*[1] *Jéssica Rizkalla Corrêa Medeiros,*[1] *Arnaldo Rabischoffsky*[1]

Hospital Pró-cardíaco,[1] *Rio de Janeiro, RJ – Brazil*

Universidade Federal Fluminense,[2] *Niterói, RJ – Brazil*

Introduction

Patent forame ovale (PFO) is the most common type of interatrial shunt, with a prevalence between 25% and 27% of the adult population. It has a flap-like functioning and is generally asymptomatic. In some cases, it can be associated with clinical complications, such as brain strokes, paradoxical embolism, platypnea-orthodeoxia syndrome, and obstructive sleep apnea. The diagnosis is mainly found in young patients who present brain strokes, with no other apparent risk factor.[1]

The evaluation of PFO is commonly performed by means of transthoracic echocardiogram (TTE) and transesophageal echocardiogram (TEE). However, another important method of evaluation that is rarely used in our area is the Transcranial Doppler (TCD), which evaluates the presence of an indirect shunt in an awake patient and with high sensitivity.[2]

This article reports on two cases and demonstrates the TCD value in the initial screening in patients suspected of PFO.

Case 1

M.C., male, 57 years of age, with systemic arterial hypertension presented amaurosis fugax of the right eye. The patient underwent a cranial tomography, which presented a stroke in the region of the cerebellum. The 24-hr Holter showed no atrial fibrillation. The patient was referred to a reference center to undergo TCD, TTE, and TEE, sequentially, for etiological investigation. The TCD study was performed, following important steps. First, peripheral venous access was obtained in the right upper membrane (Figure 1A) for the injection of agitated saline solution (microbubbles), enabling the analysis in real time of the presence of high intense temporary signal (HITS) in the middle cerebral artery (MCA) directly through the transtemporal window. Next, the patient was asked to undergo the Valsalva maneuver (strain phase), and finally, shortly after the injection of microbubbles, the patient was asked to undergo the release phase. Through the Spectral Doppler of the MCA, HITS was visualized, defining the presence of the R-L shunt during the first three cardiac cycles. The image was easily acquired through the TCD resulting from the Valsalva maneuver, a situation commonly faced in the TTE. Once the presence of the shunt had been defined, the next step was to confirm its cardiac origin (Figure 1B and C).

After, the patient underwent a TTE with microbubbles, associated with the Valsalva maneuver, which showed, with the passage of the microbubbles from the right to the left atrium in the first three cycles in the apical plane, four chambers through the fossa ovalis, suggestive of PFO. Three injections of saline solution were necessary, since during the release phase of the Valsalva maneuver, there was a loss of the echocardiographic window (Figure 1C).

The TTE was conducted to adequately visualize the characteristics of the interatrial septum and PFO, focused on percutaneous closure, with no observation of an interatrial septum aneurysm, redundant Eustachian valve, or other interatrial septum defects (Figure 2).

Case 2

V.L.O.M., female, 32 years of age, with no comorbidities, but with a report of ischemic stroke. The patient was referred for echocardiographic study to evaluate the cardioembolic source. The 24-hr Holter showed atrial fibrillation. The same previous sequence of exams was carried out in this patient. During the TCD, the number of HITS was significant, suggesting a R-L shunt when compared to the previous patient (Figure 3A). The TTE (Figure 3B) and the TEE (Figure 4A and 4B) showed an interatrial septum aneurysm associated with PFO and a large shunt. It is important to highlight that, in this case, to visualize the flow through the PFO, some injections of saline solution were made due to the difficulty to conduct an effective Valsalva maneuver in a sedated patient.

Discussion

The brain stroke is the main cause of morbidity in the Brazilian population and its socioeconomic impact is highly significant, especially among young individuals, considered to be a portion of the active population of the country.[3]

The cryptogenic brain stroke (with no defined cause) occurs in a significant number of patients; however, 3% – 40% of the cases present PFO as the cause.

Keywords

Echocardiography, Doppler; Patente; Foramen Ovale; Ultrasonography, Doppler, Transcranial

Mailing Address: Eliza de Almeida Gripp •
Hospital Pró-cardíaco. Rua General Polidoro, 192. Postal Code: 22280-003. Botafogo, Rio de Janeiro, RJ – Brasil
E-mail: elizagripp@yahoo.com.br
Manuscript received February 26, 2023; revised manuscript May 7, 2023; accepted May 11, 2023
Editor responsible for the review: Daniela do Carmo Rassi Frota

DOI: https://doi.org/10.36660/abcimg.20230020i

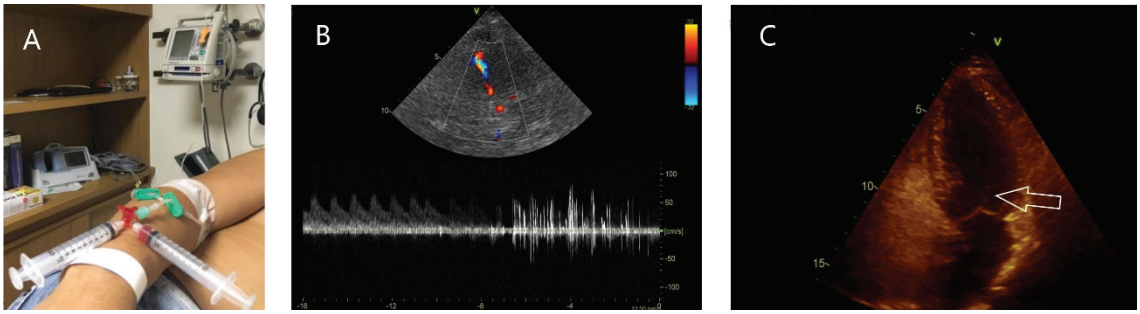

Figure 1 – *A) Illustation of the system set up for the infusion of agitated saline solution. First, the peripheral venous access is acquired in the right upper membrane, with a 24g caliber intravenouos catheter. The dual-valve short polifix is then connected to the catheter, attached to a three-valve tap: in one of the entrance valves of the polifix and in the other valve, a salinized vial with 100 ml of saline solution (this should fill the entire vial, making innumerous injections possible). Connect the two syringes of 10ml in the tap and aspirate 9ml of saline solution and 1ml of air to mix the content of the syringes until a whitish coloration is obtained. If necessary, aspirate a small quantity of blood to obtain a greater contrast. It is important to maintain the plunger of the syringe positioned upwards when introducing into the patient so as not to inject air through the syringe. B) TCD showing a flow in the MCA with the presence of HITS after the injection of saline solution. C) 4-chamber apical plane of the TTE, showing the passage of microbubbles (arrow) through the PFO, in the first three cycles after the injection of agitated saline.*

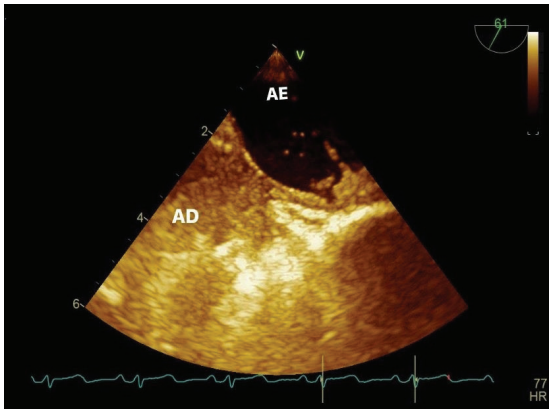

Figure 2 – *TEE showing the passage of microbubbles from the right atrium to the left atrium. LA: left atrium; RA: right atrium.*

PFO is a well-known cause of brain strokes, found in 27% of all autopsies, and the diagnosis is mainly found in young individuals with no risk factor.[4,5]

During the fetal period, the PFO is an embryonic structure resulting from an incomplete fusion of the septum primum and septum secundum, which work as a single valve, enabling the passage of oxygenated blood to the left atrium, to the left ventricle, and for systemic circulation, without passing through pulmonary circulation. After birth, PFO closure occurs, since the right atrial pressure decreases and the blood passes through pulmonary circulation. The complete fusion occurs in 75% of the cases. In those in which it remains, the PFO works as an intermittent valve, and the occurrence of the R-L shunt can lead to an embolic event.[6]

The Valsalva maneuver was described by Dr. Antonio Valsalva in 1704 in Bolonha. It is performed by asking the patient to cough, or to make an effort, such as that of

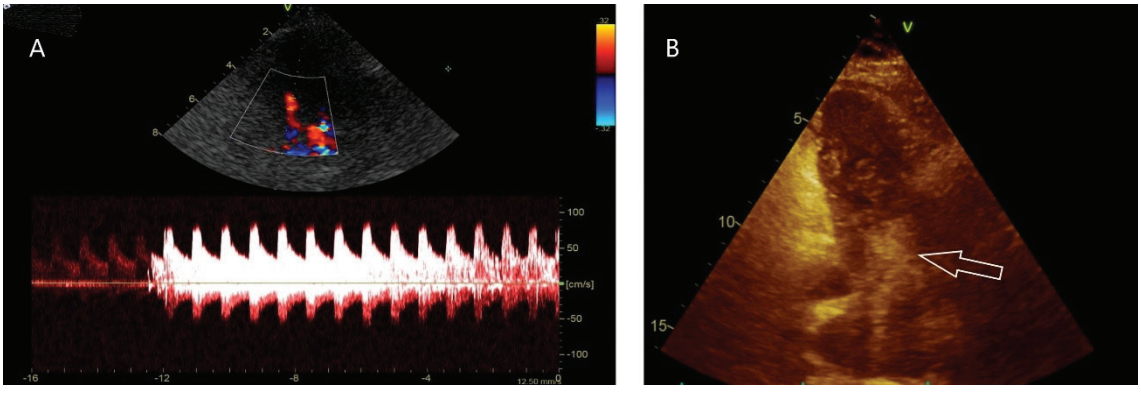

Figure 3 – *A) TCD demonstrating the presence of a significant number of HITS in the Spectral Doppler of the MCA. B) 4-chamber apical plane of the TTE with passage in the first three cardiac cycles of innumerous microbubbles through the PFO.*

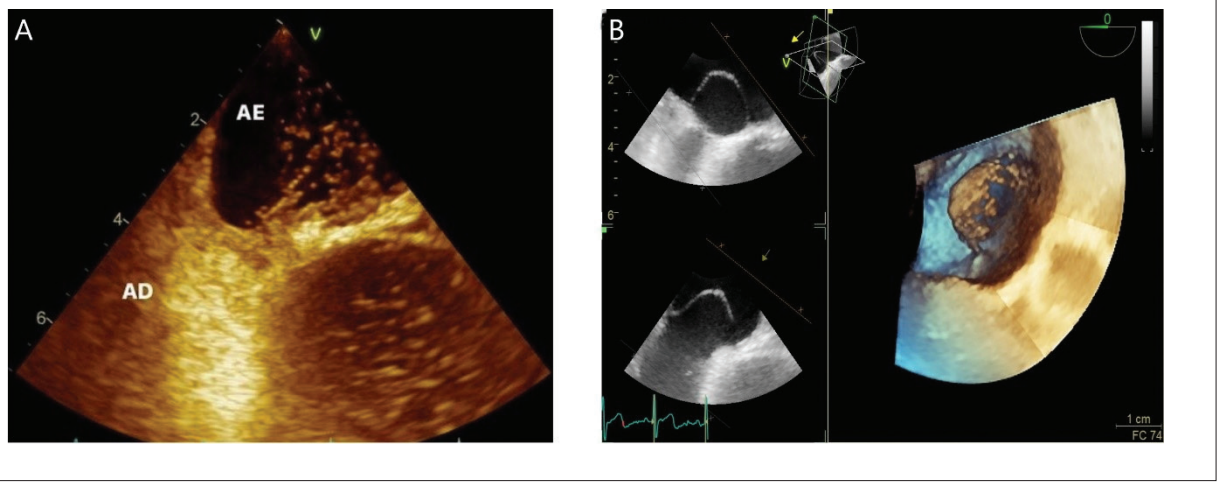

Figura 4 – *A) ETE demonstrando passagem de microbolhas do átrio direito para o átrio esquerdo. B) Imagem tridimensional do septo interatrial pela perspectiva do átrio esquerdo, evidenciando o aneurisma do septo e microbolhas em sua parede. AE: átrio esquerdo; AD: átrio direito.*

defecating or blowing in an instrument, causing an acute increase in the intrathoracic and abdominal pressure. During the strain phase, a decrease in the venous return occurs from the left to the right side, while during the release phase, the right atrium abruptly receives a large volume of blood, greater than the volume of blood through the pulmonary veins to the left atrium. The right atrial pressure in relation to the left atrium favors the appearance of PFO. One piece of data suggests that the Valsalva maneuver was effective, as was the bulge of the right atrium with agitated saline solution.[7] As these two findings are not always present in the echocardiographic studies, it is recommended that the patient receive a greater number of injections in order to increase the sensitivity of the exam. The Valsalva maneuver is, therefore, essential to detect it, since in the case of the PFO, the shunt can be transitory and is not always detected. Another piece of data that demonstrates that the maneuver was adequate is the decrease in speed of the E wave in the mitral flow by 20 cm/s, shown through the pulsed Doppler.[1,8]

The TTE with microbubbles associated with the Valsalva maneuver is the most commonly used due to its broad availability, not requiring sedation or an invasive procedure, only needing peripheral access (antecubital). The mixture of the agitated saline solution with a small quantity of blood increases the sensitivity of the exam. The study is considered positive for the R-L shunt through PFO when the passage of microbubbles occurs in the first three cardiac cycles. In this case, it is paramount that the electrocardiogram of the heart be firmly attached to the patient. The exam should perform a recording with a high number of cardiac cycles in order to safely check when the passage of the microbubbles occurs. It is important to highlight the differential diagnosis of PFO with arteriovenous pulmonary fistulas. In this pathology, a R-L shunt will occur after the fourth cardiac cycle. However, the TTE presents a low resolution and a low sensitivity when compared to the TEE with microbubbles.[2] The loss of the image in the apical plane of the four chambers is common with the Valsalva maneuver, thus hindering the diagnosis.

The TEE with microbubbles is considered to be the method of choice, as it confirms the presence of the PFO and studies the anatomy of the interatrial septum, classifying it as simple or complex, using the following variables: tunnel size (>8 mm), presence of the redundant Chiari network, fenestrations, and interatrial septum aneurysm. These data are important for the recommendation of the percutaneous closure of the PFO.[9] In addition, the TEE evaluates other sources of embolism, such as thrombi in the left atrial appendix or in the atriums, the presence of an atrial appendage, or atheromatous plaques in the thoracic aorta. In the cases in which it is difficult to conduct the Valsalva maneuver due to sedation, abdominal or inferior vena cava compression can be used to increase its sensitivity to detect the passage of the R-L flow through the PFO.[2,8]

The TCD is considered to be highly sensitive to the detection and quantification of the R-L shunt. It is a non-invasive, economical, and safe exam, which does not require sedation. However, it does have the limitation of the incapacity to define the origin of the shunt. The exam can be conducted through the transtemporal window, with the transducer index pointed to the right of the patient. The Spectral Doppler of the MCA shows the presence of HITS after the injection of microbubbles associated with the Valsalva maneuver, which does not hinder the capture of the image of the flow through the MCA. The diagnosis of the shunt is defined by the presence of one or more HITS. The intensity of the shunt can be quantified using the Spencer logarithmic scale. This can be graded from degree 0 – absence of HITS; degree 1 – 1 to 10 HITS; degree 2 – 11 to 30 HITS; degree 3 – 31 to 100 HITS; degree 4 – 101 to 300 HITS; and degree 5 – > 300 HITS ("curtain effect").[10] In a meta-analysis of 27 prospective studies, with 1,968 patients, which compared the TCD and the TEE with microbubbles, presented a 97% sensitivity and a 93% specificity to detect right-left intracardiac shunts, as compared to the TEE, which presented sensitivity values of 91-100% and specificity values of 88-97%.[2] This study shows how the TCD is an important tool that can be used in the initial screening of patients suspected of PFO.

In sum, the TCD is a diagnostic tool that should be used in the initial investigation of patients with brain strokes, especially in those in which the detection of a R-L shunt through the PFO is important for therapeutic handling.

Acknowledgements

We wish to thank Laryssa da Silva Siqueira's nursing team for their contribution to the write-up of this article.

Author Contributions

Writing of the manuscript: Gripp EA, Portela ACF, Rabischoffsky A; critical revision of the manuscript for intellectual content: Gripp EA, Costa Júnior FL, Rabishoffsky R, Medeiros JRC, Rabischoffsky A.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This article does not contain any studies with human participants or animals performed by any of the authors.

References

1. Johansson MC, Eriksson P, Guron CW, Dellborg M. Pitfalls in Diagnosing PFO: Characteristics of False-Negative Contrast Injections During Transesophageal Echocardiography in Patients with Patent Foramen Ovales. J Am Soc Echocardiogr. 2010;23(11):1136-42. doi: 10.1016/j.echo.2010.08.004.
2. Mahmoud AN, Elgendy IY, Agarwal N, Tobis JM, Mojadidi MK. Identification and Quantification of Patent Foramen Ovale-Mediated Shunts: Echocardiography and Transcranial Doppler. Interv Cardiol Clin. 2017;6(4):495-504. doi: 10.1016/j.iccl.2017.05.002.
3. Brasil. Ministério da Saúde. Anuário Estatístico de Saúde no Brasil. Brasília: Ministério da Saúde; 2001.
4. Lechat P, Mas JL, Lascault G, Loron P, Theard M, Klimczac M, et al. Prevalence of Patent Foramen Ovale in Patients with Stroke. N Engl J Med. 1988;318(18):1148-52. doi: 10.1056/NEJM198805053181802.
5. Hagen PT, Scholz DG, Edwards WD. Incidence and Size of Patent Foramen Ovale During the First 10 Decades of Life: An Autopsy Study of 965 Normal Hearts. Mayo Clin Proc. 1984;59(1):17-20. doi: 10.1016/s0025-6196(12)60336-x.
6. Wechsler LR. PFO and Stroke: What are the Data? Cardiol Rev. 2008;16(1):53-7. doi: 10.1097/CRD.0b013e31815771e4.
7. Thiagaraj AK, Hughes-Doichev R, Biederman RWW. Provocative Maneuvers to Improve Patent Foramen Ovale Detection: A Brief Review of the Literature. Echocardiography. 2019;36(4):783-6. doi: 10.1111/echo.14297.
8. Rodrigues AC, Picard MH, Carbone A, Arruda AL, Flores T, Klohn J, et al. Importance of Adequately Performed Valsalva Maneuver to Detect Patent Foramen Ovale During Transesophageal Echocardiography. J Am Soc Echocardiogr. 2013;26(11):1337-43. doi: 10.1016/j.echo.2013.07.016.
9. Vitarelli A, Mangieri E, Capotosto L, Tanzilli G, D'Angeli I, Toni D, et al. Echocardiographic Findings in Simple and Complex Patent Foramen Ovale Before and after Transcatheter Closure. Eur Heart J Cardiovasc Imaging. 2014;15(12):1377-85. doi: 10.1093/ehjci/jeu143.
10. Santos SN, Alcantara ML, Freire CMV, Cantisano AL, Teodoro JAR, Carmen CLL, et al. Vascular Ultrasound Statement from the Department of Cardiovascular Imaging of the Brazilian Society of Cardiology – 2019. Arq Bras Cardiol. 2019;112(6):809-8. doi: 10.5935/abc.20190106.

This is an open-access article distributed under the terms of the Creative Commons Attribution License