http://dx.doi.org/10.1590/0100-3984.2022.0125

Systolic spike on transcranial Doppler ultrasound in brain death determination: a matter of numbers

Dear Editor,

We read the review by Corrêa et al.[1] with interest: it is a precise overview of the role imaging plays in the determination of brain death prior to definitive clinical examination. Furthermore, it reviews several methodologies to identify cerebral circulatory arrest. Noteworthy are the data on transcranial Doppler ultrasound, a noninvasive technique which requires no contrast media, as well as being reproducible, inexpensive, and user-friendly, even at the bedside. However, we find the definition of "systolic spike" misleading as it is reported as "short (< 100 cm/s) spikes in the early systolic phase with no flow in the remaining cardiac cycle". Our considerations are as follows.

Characteristic changes are involved in the development of cerebral circulatory arrest involving the wave form velocity of the basal cerebral arteries[2]. Different steps can be identified.

1. *A rise in intracranial pressure*. When the intracranial pressure (ICP) is normal, there is a single-phase flow in systole and diastole toward the brain in the spectra. When ICP increases, there is a reduction in end-diastolic velocity (EDV). Once the ICP reaches diastolic blood pressure, EDV becomes zero. When the ICP is above diastolic blood pressure, the brain receives blood only in systole, during which the systolic flow observed on a sonogram is known as the "systolic peak". Because the cerebral perfusion pressure is still higher than the ICP, there is still a clear forward flow.

2. *Oscillating flow*. ICP increases continuously, and systolic peak duration is even shorter, thereafter, the diastolic flow is reversed. When the spectra is characterized by systolic forward and diastolic backward flows, the sonogram is said to show "oscillating flow" or a "to-and-fro" pattern. That means that the forward net current is zero, the ICP has exceeded the cerebral perfusion pressure, and the cerebral circulation has stopped.

3. *Systolic spikes*. As the ICP continues to increase, approaching the systolic blood pressure, the diastolic reverse current disappears, and isolated "systolic spikes" appear in the spectra. Systolic spikes must present a systolic peak of < 50 cm/s, rather than 100 cm/s, and a duration of < 200 ms[3], rather than 100 ms.

4. *Lack of signal*. With a very high ICP, the systolic spike amplitudes gradually decrease and in complete cessation of blood flow the signal cannot be observed. The adoption of this pattern in the diagnosis of cerebral circulatory arrest is controversial, because the lack of acoustic signal may be secondary to an inappropriate (overly thick) transtemporal window. However, identification of the flow is a must prior to the flow arrest condition[4].

In conclusion, the specific spectra observed in cerebral circulatory arrest are oscillating flow, systolic spike, and signal absence on the sonogram. In the end, the definition of systolic spike is a matter of numbers (milliseconds).

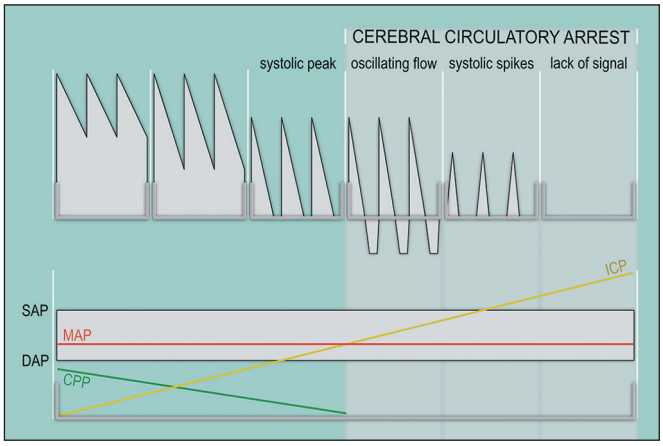

Figure 1. Doppler spectral wave forms from a normal recording to the complete extinction of flow signals due to increasing intracranial pressure. CPP, cerebral perfusion pressure; MAP, mean arterial pressure; SAP, systolic arterial pressure; DAP, diastolic arterial pressure.

REFERENCES

1. Corrêa DG, Souza SR, Nunes PGC, et al. The role of neuroimaging in the determination of brain death. Radiol Bras. 2022;55:365–72.
2. Segura T, Calleja S, Irimia P, et al.; Spanish Society of Neurosonology. Recommendations for the use of transcranial Doppler ultrasonography to determine the existence of cerebral circulatory arrest as diagnostic support for brain death. Rev Neurosci. 2009;20:251–9.
3. Kasapo lu US, Halilo lu M, Bilgili B, et al. The role of transcranial Doppler ultrasonography in the diagnosis of brain death. Turk J Anaesthesiol Reanim. 2019;47:367–74.
4. Ducrocq X, Hassler W, Moritake K, et al. Consensus opinion on diagnosis of cerebral circulatory arrest using Doppler-sonography: Task Force Group on cerebral death of the Neurosonology Research Group of the World Federation of Neurology. J Neurol Sci. 1998;159:145–50.

Nicola Morelli[1,2,a], Davide Colombi[2,b], Marco Spallazzi[3,c], Eugenia Rota[4,d], Emanuele Michieletti[2,e]

1. Neurology Unit, Guglielmo da Saliceto Hospital, Piacenza, Italy. 2. Radiology Unit, Guglielmo da Saliceto Hospital, Piacenza, Italy. 3. Neurology Unit, Hospital of Parma, Parma, Italy. 4. Neurology Unit, San Giacomo Hospital, Novi Ligure, Alessandria, Italy.

Correspondence: Nicola Morelli, MD. Neurology and Radiology Unit, Guglielmo da Saliceto Hospital. Via Taverna 49, 29121 – Piacenza, Italy. Email: nicola.morelli.md@gmail.com.

a. https://orcid.org/0000-0003-3787-2243; b. https://orcid.org/0000-0002-2794-5237; c. https://orcid.org/0000-0002-8091-2063; d. https://orcid.org/0000-0003-3154-7634; e. https://orcid.org/0000-0003-2962-1559.

Received 23 December 2022. Accepted 27 December 2022.

Reply

Dear Editor,

We thank Morelli et al. for their interest in our paper on the role of neuroimaging in the determination of brain death, as well as for their comments on the transcranial Doppler ultrasound features of brain death, since this allows a more in-depth debate on the topic. After carefully reading the letter, we understand that the authors concerns are based on the numeric values of the systolic spike pattern, considering the peak velocity at the beginning of systole as well as the duration of this peak. The aim of our article was to review the key neuroimaging features of brain death, with emphasis on computed

tomography and magnetic resonance imaging. Because these methods are not considered as ancillary tests in the determination of brain death, they are often disregarded in the assessment of such. Therefore, we did not delve into the technical details and controversies of the other imaging methods.

However, we included all of the neuroimaging examinations considered as ancillary tests for brain death determination in Brazilian Federal Council of Medicine Resolution 2.173, including transcranial Doppler ultrasound. According to the 2014 "Latin American consensus on the use of transcranial Doppler in the diagnosis of brain death"[1], systolic spikes are "very short sonograms with a duration of less than 200 ms, appearing at the beginning of the systolic phase without a flow signal in the remainder of the cycle, and a systolic velocity ≤ 100 cm/s"[1], as we considered in the article. Hassler et al.[2] also described the systolic spike pattern as being characterized by a sharp narrow peak at the beginning of systole, with a maximum flow velocity of up to 100 cm/s. Nevertheless, we recognize that other studies, including the "Brazilian guidelines for the application of transcranial ultrasound as a diagnostic test for the confirmation of brain death"[3], which was published in 2012, define short systolic peaks as those with a peak velocity of less than 50 cm/s[3,4].

In conclusion, we agree with Morelli et al. that the definition of systolic spike on transcranial Doppler ultrasound in brain death is a matter of numbers. Systolic spikes appear at the beginning of the systolic phase without a flow signal in the remainder of the cycle, with a duration of less than 200 ms and a low systolic peak velocity. Some authors define low systolic peak velocity as less than 100 cm/s, whereas others define it as less than 50 cm/s.

REFERENCES

1. Consensus Group on Transcranial Doppler in Diagnosis of Brain Death. Latin American consensus on the use of transcranial Doppler in the diagnosis of brain death. Rev Bras Ter Intensiva. 2014;26:240–52.
2. Hassler W, Steinmetz H, Pirschel J. Transcranial Doppler study of intracranial circulatory arrest. J Neurosurg. 1989;71:195–201.
3. Lange MC, Zétola VHF, Miranda-Alves M, et al. Brazilian guidelines for the application of transcranial ultrasound as a diagnostic test for the confirmation of brain death. Arq Neuropsiquiatr. 2012;70:373–80.
4. Escudero D, Otero J, Quindós B, et al. Transcranial Doppler ultrasound in the diagnosis of brain death. Is it useful or does it delay the diagnosis? Med Intensiva. 2015;39:244–50.

Diogo Goulart Corrêa[1,2,a], Simone Rachid de Souza[3,b], Paulo Glukhas Cassar Nunes[3,c], Antonio Carlos Coutinho Jr.[1,4,d], Luiz Celso Hygino da Cruz Jr.[1,e]

1. Departamento de Radiologia, Clínica de Diagnóstico por Imagem (CDPI)/Dasa, Rio de Janeiro, RJ, Brasil. 2. Departamento de Radiologia, Universidade Federal Fluminense (UFF), Niterói, RJ, Brasil. 3. Departamento de Patologia, Universidade Federal do Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brasil. 4. Departamento de Radiologia, Fátima Digittal, Casa de Saúde Nossa Senhora de Fátima, Nova Iguaçu, RJ, Brasil.

Correspondência: Dr. Diogo Goulart Corrêa. Clínica de Diagnóstico por Imagem (CDPI)/Dasa – Departamento de Radiologia. Avenida das Américas, 4666, Barra da Tijuca. Rio de Janeiro, RJ, Brasil, 22640-102. E-mail: diogogoulartcorrea@yahoo.com.br.

a. https://orcid.org/0000-0003-4902-0021; b. https://orcid.org/0000-0002-2021-7317; c. https://orcid.org/0000-0002-3077-5101; d. https://orcid.org/0000-0003-1158-1720; e. https://orcid.org/0000-0002-9771-5832.

Recebido para publicação em 28/12/2022. Aceito em 30/12/2022.