Systodiastolic Separation Expresses Cerebral Circulatory Arrest?

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ABSTRACT

There is a situation before the cerebral circulatory cessation phase, the systodiastolic separation in transcranial Doppler (TCD), which may raise doubts to the operator technician who performs it. A total of 266 studies were performed in 188 neurocritical patients over a 9-year period: 88 cases (77%) corresponded to cerebral circulatory arrest (CCA) which accompanies brain death (BD); 9 (5%) presented the systodiastolic separation pattern. In 1 of those 9 there was persistence of cough reflex and spontaneous breathing; in 5, CCA was not reached; only 3 evolved to CCA. The finding of a minimal persistent neurologic semiology is a categoric fact that would rule out the clinical correlation between this pattern and BD diagnosis.

TRANSCRANIAL DOPPLER (TCD) ultrasonography has meant a significant advance in the diagnosis of brain death (BD). Observed changes in the ultrasound of a patient who is developing cerebral circulatory arrest (CCA) are due to the increase in intracranial pressure (ICP) [1]. The Task Force of the World Federation of Neurosonologists is straightforward in the definition of CCA patterns by TCD which accompany BD. However, there is a situation before the cerebral circulatory cessation phase, the systodiastolic separation in the TCD, which may raise doubts in the operator technician who performs the study. Transplant operators and those well versed in TCD must know the patterns clearly and precisely, because they might allow them to identify CCA at an early stage and to implement the strategy for its follow-up.

The aim of this work was to demonstrate whether a clinical correlation exists between the systodiastolic separation seen in TCD and the BD diagnosis.

TCD, as a method for evaluating cerebral blood flow velocities (CBF), has been disseminated among intensivist physicians because it integrates multimodal neuromonitoring (MMN) for the monitoring of neurocritical patients. It is extremely useful for transplant coordination because determining CCA that accompanies BD allows shortening the waiting times in the organ and tissue procurement process. In the case of being nondonant, the BD diagnosis enables mechanical respiratory assistance (MRA), which contributes to the adequate management of beds of the intensive care unit (ICU).

METHODS

A total of 266 TCD studies were carried out with the use of an apparatus belonging to the National Institute of Donations and Transplants, the Sonara-Tek. The considered periods extended from December 2007 to December 2016. A retrospective analysis was carried out in which the following variables were considered: total number of studies, distribution according to sex, causal pathologies of structural neurologic damage, BD and demographic distribution, most frequent CCA patterns, cases of systodiastolic separation, pathology most frequently associated with systodiastolic separation, and whether there was any neurologic activity in the individual with that pattern during clinical exploration. According to the Task Force of the World Federation of Neurosonologists, inverted, oscillating, or reverberant diastolic flux, systolic spike, and the absence of flux were considered for the diagnosis of the CCA. Absence of flow was considered to be valid when there was a previous recording with continuous flow in the insulated bone window and the study was performed by the same operator.

RESULTS

A total of 266 studies were conducted in 188 patients with acute brain injury (Table 1) admitted to different ICUs, both in the capital as well as in other parts of the country. Some of the ICUs belonged to the public sector, others to the private sector. A total of 147 (55.3%) of the studies were conducted in men and 119 (44.7%) in women. The structural neurologic pathologies that received the largest number of studies in the series were: subarachnoid hemorrhage (SAH) and severe skull trauma (SST), including caused by firearm injury (FI), with 86 studies (32%) each, followed by cerebrovascular accident (CVA) with 41 (15%;

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Table 1. Characteristics of the Studied Population

Characteristic	CCA	Systodiastolic Separation	Continuous Flow Pattern
n (total = 188)	88 (47%)	9 (5%)	91 (48%)
Age, y	45 ± 19	41 ± 22	42 ± 21
Causes			
TBI	31	3	31
SAH	26	2	26
CVA	13	2	20
Anoxo-ischemic	8	0	6
Other*	10	2	8
Sex			
M	45 (51%)	6 (67%)	59 (65%)
F	43 (49%)	3 (33%)	32 (35%)

All studies were performed with figures of TAM equal to or greater than 70 mm Hg, according to the Guide for the use of TCD in the diagnosis of CCA, from the Spanish Society of Neurosonology (SONES).
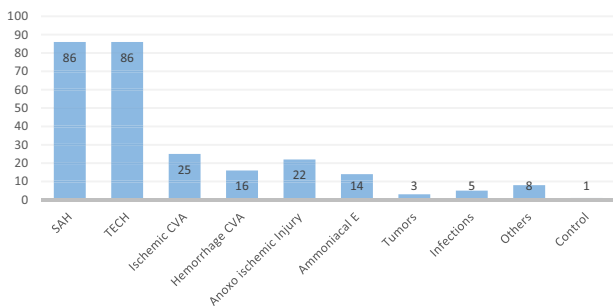
Abbreviations: CCA, cerebral circulatory arrest; TBI, traumatic brain injury; SAH, subarachnoid hemorrhage; CVA, cerebrovascular accident.

*Infectious, tumoral, and hydrocephalus pathologies.

Table 2. Study Frequencies and Patterns in Cerebral Circulatory Arrest Cases

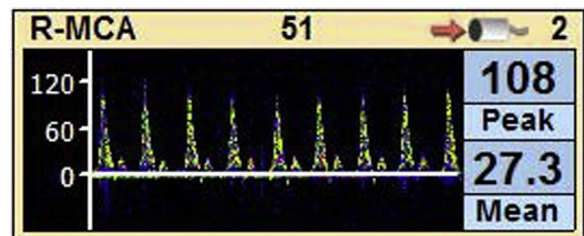| Pattern	n	%
Inverted diastolic flow	66	75
Systolic spikes	48	54.5
Absence of flow	2	2.3
Total	116*	

*It should be noted that the sum of the values of frequencies is greater than the brain death found in the study (n = 88) owing to the coexistence of patterns in different studies.

they were performed at 8 pm, 6 pm, and 9 pm, respectively, with a mean of 16 hours after systodiastolic separation was evident.

DISCUSSION

The CCA that accompanies BD happens when the ICP exceeds the patient's systolic blood pressure (SBP). In 1988 criteria for diagnosis of BD with the use of TCD were published by the Task Force of the World Federation of Neurosonologists [2]. CCA is identified by characteristic changes in the shape of the sonogram and its velocity. Four stages can be differentiated:

1. When the ICP exceeds the SBP, the brain blood flow velocity at the end of the diastole is zero, and there is a persisting flow only during systole. Average speed is >10 cm/s and there is still some net flow, while the pulsability index is very high. These findings happen in situations of severe intracranial hypertension and may be considered a pre-CCA pattern.
2. When the ICP is equal or superior to the SBP, the patient's cerebral perfusion stops. In this phase the pattern known as reverberant flux appears, also known as oscillating biphasic flux or diastolic inverted flux, produced by the elasticity of the arterial wall; it is characterized by an anterograde systolic flux accompanied by a diastolic inverted or retrograde flux, that are approximately equal in the same cardiac cycle and the net flux being zero. The pattern has a short systolic phase [3]. All of these findings are correlated with CCA in arteriography [4] (Fig 4).

Fig 1). We focus on 88 (46%) of the total number of studies which corresponded to CCA accompanying BD.

Among the patients that evolved BD, 45 (51%) were male and 43 (49%) female. The mean age was 45 ± 19 years. The CCA patterns most frequently found in the series were: inverted, oscillating, or reverberating diastolic flow in 66 studies (75%); systolic spikes in 48 (54.5%); and absence of flow in only 2 cases (2.3%; Table 2).

Among the 88 patients that evolved BD, 9 (5%) of them presented the systodiastolic separation pattern. The pathologies in which this pattern was most frequently demonstrated were: SST (3/9), SAH (2/9) and ischemic CVA (2/9). Among these 9 cases, 1 of them showed persistence of cough reflex and spontaneous breathing (22-year-old man, with severe TECH due to a traffic accident [Figs 2 and 3]), and in 5 patients the pattern did not reach the CCA diagnosis that accompanies BD, dying in a situation of cardiopulmonary arrest (CPA). In these cases, it could be hypothesized that CPA was the expected evolution for patients who previously showed BD, and the diagnosis could not be done for various reasons which were not analyzed in this study. Finally, 3 patients evolved to CCA. Among these 3 patients, whose 2nd studies confirmed CCA,

Fig 1. Frequency distribution of studies in the pathologies.

Fig 2. Image that shows systo-diastolic separation registered in the Right Middle Cerebral Artery. Male 22 years old. TECH caused by traffic accident.