Contrast-Enhanced Transcranial Color Sonography in the Diagnosis of Cerebral Circulatory Arrest


ABSTRACT

Objective. We sought to determine the utility of contrast-enhanced transcranial color sonography (TCCS) in the diagnosis of cerebral circulatory arrest in cases of difficult acoustic window.

Materials and Methods. From January 2007 to July 2008, we prospectively studied 50 patients who fulfilled clinical criteria of brain death. In all cases, we performed TCCS aiming to insonate both middle cerebral arteries (MCA) and the basilar artery (BA). In those cases in which insonation of any vessel was not possible, we repeated the exploration after injecting a 2.5-mL bolus of sulphurhexafluoride dispersion. Afterward, we compared the rate of insonation of the vessels and the number of conclusive studies.

Results. The mean patient age was 53.2 ± 15.9 years. Thirty-two were men (64%). The most frequent neurologic injury was hemorrhagic stroke and traumatic brain injury. Contrast-enhanced TCCS resulted in an increased rate of insonation in both MCA and in BA, and in the number of conclusive studies.

Conclusions. Contrast-enhanced TCCS increased the number of conclusive studies with cerebral circulatory arrest, which minimized the importance of a previous study in cases with a poor acoustic window.

TRANSCRANIAL SONOGRAPHY constitutes a common tool to monitor neurocritically ill patients. It is used in the diagnosis of cerebral circulatory arrest (CCA) is clearly established. Patients with CCA present various sonographic patterns. Transcranial color-coded sonography (TCCS) allows a complete study of cerebral hemodynamics in such patients. A recent report stated its sensitivity and specificity for the diagnosis of brain death to range from 91% to 100% and 97% to 100%, respectively.

However, there are some difficulties in brain-dead patients who usually present devastating injuries, with displaced cerebral vessels. In addition, these patients display low acoustic signals, which presents difficulties for insonation of cerebral vessels. Some authors have supported the use of alternative acoustic windows in these cases. In those cases in which insonation is not possible, it is mandatory to have a previous study with accurate insonation of cerebral vessels to diagnose the absence of cerebral flow. This fact constitutes the major limitation of transcranial sonography for the diagnosis of CCA, accounting for 10% to 15% of patients.

Based on their biochemical properties, the use of ultrasound contrast agents (UCAs) results in quantitative and qualitative improvements in TCCS examinations, especially among patients with a poor acoustic window. Therefore, the aim of our study was to evaluate the benefit of using UCAs to assess cerebral sonographic patterns among brain-dead patients.

METHODS

Patients

From January 2007 to July 2008, we prospectively studied 50 consecutive patients suffering neurologic disorders and fulfilling clinical criteria of brain death according to Spanish law. They were admitted to the Intensive Care Unit of our third level University Hospital. TCCS was performed to demonstrate CCA. Following the recommendations of the Spanish Society of Neurosonology, we attempted to insonate both middle cerebral arteries (MCA) and the basilar artery (BA). In cases where it was
not possible to insonate any of the vessels, we performed an UCA-enhanced TCCS. All patients were mechanically ventilated with PCO₂ maintained between 35 and 40 mmHg, hemoglobin at >10 g/dL, and mean arterial pressure >70 mmHg using vasoactive agents when necessary. The institutional Research Committee approved the study and we obtained informed consent from relative’s.

Technique
TCCS was performed using a Vivid 7 (GE Medical Systems) equipped with a 2- to 4-MHz phased array transducer. In those cases where the study was not conclusive (any MCA or BA were not insonated), an UCA-enhanced TCCS study was performed following the protocol: Insonation plane set at 16 cm to obtain diencephalic examination plane. After injection of 2.5 mL of UCA followed by a 10 mL-saline bolus through a central catheter with the distal tip placed in the superior cava vena, system parameters were adapted to obtain an accurate image that insonated both MCA and BA.

UCA
As UCA, we used a 2.5-mL bolus of sulphurhexafluoride dispersion (SonoVue, Bracco Altana Pharma). This agent has been approved by the European Medicines Agency and is routinely used in neurosonology for the study of the basal arteries in patients with an insufficient acoustic window.14 Careful hemodynamic monitoring is recommended.14

Data Analysis
Data are presented as mean values and standard deviations (SD) or N (%) as appropriate. Comparisons between groups were performed using the χ² or Fisher exact tests for categorical variables. A 2-tailed P value <.05 was considered significant. Data were analyzed using SPSS version 14.0 (SPSS Inc, Chicago, Ill).

RESULTS
Thirty-two patients were men (64%). The overall mean age was 53.2 ± 15.9 years (range, 19–77). The causes of initial neurologic injury are detailed in Table 1. The use of UCA resulted in an increased rate of both MCA and BA. Overall, in 10/50 patients (20%), it was not possible to insonate any of the vessels, we performed an UCA-enhanced TCCS. All patients were mechanically ventilated with PCO₂ maintained between 35 and 40 mmHg, hemoglobin at >10 g/dL, and mean arterial pressure >70 mmHg using vasoactive agents when necessary. The institutional Research Committee approved the study and we obtained informed consent from relative’s.

Table 1. Initial Neurologic Injuries

<table>
<thead>
<tr>
<th>Neurologic Injuries</th>
<th>n (%)</th>
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<tbody>
<tr>
<td>Traumatic brain injury</td>
<td>17 (34)</td>
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<tr>
<td>Ischemic cerebrovascular disease</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Hemorrhagic cerebrovascular disease</td>
<td>17 (34)</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>7 (14)</td>
</tr>
<tr>
<td>Postanoxic cardiac arrest</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Meningitis</td>
<td>2 (4)</td>
</tr>
<tr>
<td>Others</td>
<td>3 (6)</td>
</tr>
</tbody>
</table>

Our study has some limitations. We have not systematically compared TCCS with other complementary techniques for the diagnosis of brain death, such as cerebral angiography, which is considered the gold standard technique. Therefore, this study did not permit us to assess the sensitivity or specificity of UCA enhanced TCCS for the diagnosis of cerebral circulatory arrest.

transcranial sonography to diagnose CCA. These studies have used conventional transcranial Doppler technology,3,15–18 demonstrating that sensitivity and specificity ranging from 91% to 100% and 97% to 100%, respectively.4 However, the use of TCCS has not been extensively studied for the diagnosis of brain death. The study by Poularas et al19 demonstrated excellent agreement between TCCS and angiography, which is considered the gold standard technique. However, among 50 patients, 10% were not studied because of an insufficient acoustic window before the brain death declaration. Among the 40 patients ultimately studied, 5 cases (12.5%) showed no demonstrable flow among patients in whom cerebral flow had previously been insonated. Overall, in 10/50 patients (20%), it was not possible to obtain a complete pattern of cerebral circulatory arrest. This is the major pitfall of transcranial ultrasonography to study CCA, making it mandatory to have a previous study demonstrating cerebral circulatory arrest. In ideal conditions, this previous study should be performed under the same conditions and preferably by the same, experienced physician.

In our study, we evaluated for the first time an improvement in the quality of studies after using UCA for the diagnosis of CCA. It was not necessary to have a previous study before brain death was declared. The use of UCAs in cases in which insonating a CCA pattern in both MCA and BA was not possible resulted in an increase in conclusive studies with insonation of various vessels. This is relevant, minimizing the importance of having a previous study constitutes the major limitation of transcranial sonography in the diagnosis of CCA. The only patient who we were not able to insonate deserves major explication. She was a 75-year-old Caucasian woman whose acoustic window was so deficient that we were not able to correctly insonate the contralateral skull, which usually presents a strong hyperintensity. In this case, before and after using UCAs, we were able to insonate the BA through the suboccipital approach. Age and female gender are well-known factors associated with a poor acoustic window in transcranial sonography studies.20

Our study has some limitations. We have not systematically compared TCCS with other complementary techniques for the diagnosis of brain death, such as cerebral angiography, which is considered the gold standard technique. Therefore, this study did not permit us to assess the sensitivity or specificity of UCA enhanced TCCS for the diagnosis of cerebral circulatory arrest.
In conclusion, the use of UCAs increased the number of patients with conclusive studies of cerebral circulatory arrest, minimizing the importance of a previous study for cases with a poor acoustic window.

REFERENCES

12. REAL DECRETO 2070/1999, de 30 de diciembre, por el que se regulan las actividades de obtención y utilización clínica de órganos humanos y la coordinación territorial en material de donación y transplante de órganos y tejidos