CEREBRAL CIRCULATORY ARREST

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BRAIN DEATH IS THE IRREVERSIBLE LOSS OF FUNCTION OF THE ENTIRE BRAIN INCLUDING THE BRAIN STEM

Conventional Confirmatory Tests: EEG, CEREBRAL AGF, BRAIN SCINTIGRAPHY

LOGISTICAL PROBLEMS

TCD evaluation is used in several countries as a confirmatory test to assess CBF arrest
DISADVANTAGES OF CONVENTIONAL CONFIRMATORY TESTS

CEREBRAL AGF
BRAIN SCINTIGRAPHY

- Invasive
- Expensive
- Commonly require the transportation of critical patients

EEG

- Time consuming because of the required setup time and strict technical standards
- Unreliable in patients treated with sedative drugs
Computed tomographic angiography for diagnosis of brain death

Adnan I. Qureshi, MD; Jawad F. Kirmani, MD; Andrew R. Xavier, MD; and Amir M. Siddiqui, MD

Abstract—The authors report two patients with suspected brain death who required confirmatory tests other than clinical examination because of prolonged barbiturate administration for intracranial hypertension. Absence of intracranial blood flow was documented on CT angiography and confirmed by CT perfusion images. Cerebral angiography confirmed the findings consistent with brain death. CT angiography with CT perfusion may represent a rapid noninvasive method for diagnosis of brain death.

NEUROLOGY 2004;62:652–653

Diagnóstico de muerte encefálica mediante tomografía computarizada multicorte: angio-TC y perfusión cerebral

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Y F. TABOADAa

aServicio de Medicina Intensiva. bServicio de Radiología. Hospital Universitario Central de Asturias. Oviedo. Asturias. España.

Med Intensiva. 2007;31(6):335-41
TCD

ADVANTAGES

- Non-invasive
- Inexpensive
- Bed-side performable
- Repeatable as often as needed

DISADVANTAGES

- Depends on the examiner’s experience and skill
- Difficult environmental conditions and outside influences
- IAW (8-9%)
**Transcranial Doppler in brain death**

Allan H. Ropper, MD; Susan M. Kehne, MD; and Larry Wechsler, MD


**Transcranial Doppler study of intracranial circulatory arrest.**

**Hassler W, Steinmetz H, Pirschel J.**

Department of Neurosurgery, University of Tubingen, West Germany.

To investigate the hemodynamics of intracranial circulatory arrest, the authors correlated the findings of noninvasive transcranial Doppler ultrasonography (TCD) with those of transfemoral four-vessel angiography in 65 patients following brain death and intracranial circulatory arrest due to severe intracranial hypertension. The three TCD stages of intracranial circulatory arrest, which have been described previously, corresponded with different levels of extracerebral angiographic cessation of flow. With TCD progression from the first stage (oscillating flow) to the third stage (no flow), the level where the dye stopped descended caudad from subarachnoid to cervical levels. The study shows that, in progressing intracranial hypertension, arterial circulatory standstill within the cranial cavity develops in a distal-to-proximal direction. The basal cerebral arteries remain patent in the early stages of intracranial circulatory arrest. Experimental evidence from the literature, together with the findings of the present investigation, points to the capillary bed as the initial site of the flow obstruction in progressing intracranial hypertension.
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

Xavier Ducrocq, Werner Hassler, Kouzo Moritake, David W. Newell, Gerhard-Michael von Reutern, Toshiyuki Shiogai and Robert R. Smith

“Extracranial and intracranial Doppler Sonography are useful confirmatory tests to establish irreversibility of cerebral circulatory arrest as an optional part of brain death protocol”

“Doppler-sonography is of special value when therapeutic use of sedative drugs renders EEG unreliable”
TCD PATTERN OF CEREBRAL CIRCULATORY ARREST IN INTRA-AND EXTRACRANIAL VESSELS
Summary of findings
Increased Intracranial Pressure (ICP) and Cerebral Circulatory Arrest

<table>
<thead>
<tr>
<th>INDICATION</th>
<th>SENSITIVITY (%)</th>
<th>SPECIFICITY (%)</th>
<th>REFERENCE STANDARD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cerebral Circulatory Arrest and Brain Death</td>
<td>91-100</td>
<td>97-100</td>
<td>Conventional angiography, EEG, clinical outcome</td>
</tr>
</tbody>
</table>

Recommendation: TCD is a useful adjunct test for the evaluation of cerebral circulatory arrest associated with brain death (Type A*, Class II evidence).
false negatives due to:
- therapeutic decompressive craniotomy
- Complete flow arrest occurring shortly after cardiac arrest in the no reflow phase
- ventricular derivation

false positives due to:
- acute intracranial hypertension due to bleeding from an aneurysm that can be associated with transient flow patterns similar to those in cerebral circulatory arrest
- infratentorial brain damage
- severe cerebral atrophy
PATHOPHYSIOLOGY OF HEMODYNAMIC CHANGES POSSIBLY LEADING TO CEREBRAL CIRCULATORY ARREST

CPP = MABP - ICP

MABP

ICP

CVP
VARIATIONS OF TCD PATTERNS OCCURRING AS INTRACRANIAL HYPERTENSION PROGRESSES TO BRAIN DEATH

VARIATIONS OF TCD PATTERNS OCCURRING AS INTRACRANIAL HYPERTENSION PROGRESSES TO BRAIN DEATH

normal \textdownarrow{} diastolic velocity systolic peaks reverberating flow systolic spikes no signal

IRREVERSIBLE INTRACRANIAL CIRCULATORY ARREST

\begin{itemize}
  \item MABP
  \item ICP
  \item CPP
\end{itemize}
## European brain death codes: a comparison of national guidelines

<table>
<thead>
<tr>
<th>Country</th>
<th>Age of Anoxic Period</th>
<th>Interval Between Anoxia and Assessment of Brain Death</th>
<th>EEG Test</th>
<th>Doppler Test</th>
<th>Angiography</th>
<th>No of Physicians for Confirmation</th>
<th>Mandatory Confirmation Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria (1997)</td>
<td>+</td>
<td>+</td>
<td>12 or confirmatory test</td>
<td>1 or 2</td>
<td>Facultative</td>
<td>EEG, Doppler + angiography</td>
<td></td>
</tr>
<tr>
<td>Belgium (1993)</td>
<td></td>
<td>+</td>
<td>3</td>
<td>Facultative</td>
<td>EEG (repeat 24 h) angiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Denmark (1990, 1995)</td>
<td></td>
<td>+</td>
<td>2</td>
<td>Facultative</td>
<td>Angiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Finland (1971)</td>
<td></td>
<td>+</td>
<td>1</td>
<td>Facultative</td>
<td>EEG angiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France (1968, 1996)</td>
<td></td>
<td>+</td>
<td>2</td>
<td>Mandatory</td>
<td>EEG (2×) angiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany (1982, 1997)</td>
<td></td>
<td>+</td>
<td>2</td>
<td>Facultative</td>
<td>EEG scintigraphy Doppler angiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy (1993)</td>
<td></td>
<td>+</td>
<td>1 or more</td>
<td>Mandatory</td>
<td>EEG (3×) angiography</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luxembourg (1983)</td>
<td></td>
<td>+</td>
<td>1</td>
<td>Mandatory</td>
<td>EEG, EP and angiography or scintigraphy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Netherlands (1997)</td>
<td></td>
<td>+</td>
<td>1 or more</td>
<td>Mandatory</td>
<td>EEG (Angiography if EEG or apnoe test impossible)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poland (1996)</td>
<td></td>
<td>+</td>
<td>3</td>
<td>1</td>
<td>NO</td>
<td></td>
<td></td>
</tr>
<tr>
<td>United Kingdom (1993)</td>
<td></td>
<td>+</td>
<td>2</td>
<td>NO</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hirntoddiagnostik

**Supratentoriell:**

2. Klinische Untersuchung oder apparativ

Beobachtungszeitraum

- primäre Hirnschädigung: 12 Stunden
- sekundäre Hirnschädigung: 72 Stunden

**Infratentoriell:**

Apparative Diagnostik obligat!

EEG, TCD, Hirnperfusionsszintigraphie, SEP, AEP
Recomendaciones sobre el uso del Doppler transcraneal para determinar la existencia de paro circulatorio cerebral como apoyo diagnóstico de la muerte encefálica

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Neurología 2007;22(7):441-447
Recomendaciones del Doppler transcranial en el diagnóstico de la muerte encefalica

En nuestra experiencia la realización de una exploración ultrasonográfica única, utilizando las ventanas temporales y suboccipital en el contexto de un enfermo en el que la exploración clínica es diagnóstica de muerte encefálica y siempre que en esta única exploración se detecten los patrones típicos descritos por los autores¹, es suficiente para la realización del diagnóstico.

El Real Decreto 1070/1999, de 30 de diciembre, que regula las actividades de obtención y utilización clínica de órganos humanos recoge la posibilidad de utilizar exploraciones complementarias como medio para acortar el periodo de observación⁴, algo cada vez más necesario cuando el diagnóstico de muerte encefálica va unido a un programa de donación de órganos, por lo que, a nuestro parecer, retrasar 30 min más este diagnóstico podría alterar aún más las precarias condiciones homeostáticas de los posibles donantes y reducir las posibilidades de extracción de órganos⁵.
Critères paracliniques

- Légaux :
  - EEG
  - angiographie

- Admis :
  - angioTDM

- Non admis :
  - doppler TC
  - potentiels évoqués

Décret n°96-1041 du 2 décembre 1996 (JO)
“La vélocimétrie Doppler transcrânienne n’a pas de valeur réglementaire pour le diagnostic de la ME.
Cependant, non invasive et facilement réalisée et répétée au lit du malade, elle est prédicitive de ME avec une spécificité de 100% et une sensibilité de l’ordre de 90 % en visualisant l’arrêt circulatoire cérébral.”

Décret n°96-1041 du 2 décembre 1996 (JO)
4.2 Reversible Causes of Coma
Potentially reversible causes of coma must be excluded and include:

1) Sedative drugs: Narcotics, hypnotics and tranquillisers may have prolonged action, particularly when hypothermia coexists or in the context of renal or hepatic failure. It is therefore essential that the drug history should be carefully reviewed. Any possibility of intoxication being the cause of, or contributing to, the patient's comatose state should preclude certification of death by brain stem testing.

Excluding the effects of sedatives may be difficult, particularly after prolonged infusions of long acting cumulative sedatives such as thiopentone. This may involve prediction according to pharmacokinetic principles, the measurement of drug concentrations which may be time consuming or the use of antagonists in the case of opioids or benzodiazepines. If the patient is thought to be brain stem dead, the decision is either to wait to perform the tests when the effect of such sedatives can be excluded, or to withdraw further active treatment on the basis of futility. If sedation cannot be excluded it may be appropriate to consider the use of imaging techniques such as four vessel cerebral angiography or transcranial Doppler to demonstrate the absence of cerebral blood flow, so assisting decision making by confirming futility, even though these do not currently form part of the diagnostic requirements for the diagnosis of brain stem death.
CONFIRMING TEST OF CIRCULATORY ARREST IN ITALY

update April 11th 2008*

1. Children younger than one year old

2. The presence of concomitant factors (drug depressors of CNS, hypothermia, metabolic alterations, systemic hypotension) that can interfere on the clinical evaluation ...

... among the methodologies now in use for the assessment of cerebral blood flow are to Cerebral Angiography, Brain Scintigraphy and Transcranial Doppler are accepted and recommended "

*(no changes compared to previous guidelines about the diagnosis of the absence of cerebral blood flow)
TRANSCRANIAL DOPPLER PROCEDURE FOR THE DIAGNOSIS OF CEREBRAL BLOOD FLOW ARREST

- SOVRATENTORIAL BILATERAL EXAMINATION (through the temporal acoustic windows)

- INFRATENTORIAL EXAMINATION (through the occipital acoustic window)
IN ORDER TO EXCLUDE CEREBRAL BLOOD FLOW TRANSIENT ARREST DUE TO HYPOTENSION, DURING THE TCD EXAMINATION, SYSTEMIC ARTERIAL BLOOD PRESSURE VALUES MUST ALWAYS BE CHECKED (SYSTOLIC VALUES HAVE TO BE > 70mmHg)
Arterial Hypotension

SBP mm Hg
Diagnostic TCD Patterns of cerebral circulatory arrest

1) Reverberating Flow

2) Systolic Spikes

3) No signal
3) **No signal pattern is accepted only in the two following cases:**

I. When through each of the three acoustic windows the signal in at least one vessel is detectable, with one of the patterns described at point 1 or 2

II. When, during a previous examination, performed by the same physician in the same patient, TCD signal was detected in basal arteries
TCD PATTERNS OF BRAIN DEATH MUST BE DETECTED IN AT LEAST TWO EXAMINATIONS PERFORMED IN NOT LESS THAN THIRTY MINUTES ONE FROM THE OTHER.
“Brain death is the principal requisite for the donation of organs for transplantation”
CONCLUSIONS

Time delay in the diagnosis of BD is one of the main causes for the relatively small number of organ donors.

TCD is superior to conventional confirmatory tests in reducing the waiting time for a firm diagnosis of brain death.

TCD examination allows an useful cut of waiting time for organ donation.

In particular clinical conditions it can be considered the first choise- confirmatory test of BD.