



The use of Cerebral CT Angiography as an Ancillary Investigation to support a clinical Diagnosis of Death using Neurological Criteria

A consensus guideline

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Endorsing Organisations

British Society of Neuroradiologists

Intensive Care Society

Neuro Anaesthesia and Critical Care Society

Paediatric Critical Care Society

Society of British Neurological Surgeons

The Faculty of Intensive Care Medicine

The Royal College of Radiologists

The Society of Radiographers

Review

Three years. FICM is the responsible organisation for document control.

Conflicts of interest

Dr Omer Aziz and Dr Dale Gardiner have paid roles with NHS Blood and Transplant.

Disclaimer

The ultimate responsibility for the interpretation and application of this guideline, the use of current information and a patient's overall care and wellbeing resides with the treating clinician.

Feedback

If you would like to provide feedback on this guideline email FICM on contact@ficm.ac.uk

Summary of Recommendations

Where there is an intention to diagnose death using neurological criteria:

1. Ancillary investigation is required in the following circumstances:
 - Where a comprehensive neurological examination, including the apnoea test, is not possible.
 - Where continuing effects of confounding conditions (e.g., red flags) cannot be excluded.
2. Ancillary investigation should be considered in the following additional circumstances:
 - Uncertainty regarding the interpretation of possible spinally mediated movements.
 - To promote understanding of the clinical confirmation of death using neurological criteria to families who are uncertain or unaccepting of such a diagnosis.
3. Cerebral CT angiography (CTA) becomes the standard ancillary investigation of choice for supporting the diagnosis of death using neurological criteria (DNC) in the United Kingdom.
4. Requests for CTA must be made by direct discussion between the treating intensive care consultant and radiology consultant. It should be made clear that the request is to support the clinical diagnosis of DNC.
5. The CTA should be reported by a consultant radiologist, after consultation with a regional neuroradiologist.
6. A clinical diagnosis of DNC cannot be supported if the CTA demonstrates contrast opacification of any of the vessels specified in the 4-point criteria, as described by Frampas in 2009.
7. There is insufficient evidence to make a consensus recommendation for the use of CTA as an ancillary investigation to support the clinical diagnosis of DNC in paediatrics. Where CTA is used it should be reported by a neuroradiologist experienced in paediatrics. Ancillary investigations should not be used in infants less than 2 months.
8. There is insufficient evidence to make a consensus recommendation for the use of CTA as an ancillary investigation to support the clinical diagnosis of DNC in patients receiving extracorporeal membrane oxygenation.
9. A system of auditing national practice on the use and outcomes of ancillary investigations to support a diagnosis of DNC should be established. We suggest that this is done by inclusion into the Potential Donor Audit which already collects data on all patients in the UK in whom a diagnosis of DNC is undertaken.
10. The process of diagnosing death using neurological criteria should be guided and documented using the forms endorsed by the Faculty of Intensive Care Medicine and the Intensive Care Society and the paediatric versions endorsed by the Royal College of Paediatrics and Child Health and Paediatric Critical Care Society.

Introduction

In 2021 the Faculty of Intensive Care Medicine (FICM) and the Intensive Care Society (ICS) recommended that United Kingdom (UK) consensus guidance on ancillary investigations to support the clinical diagnosis of death using neurological criteria (DNC) should be developed. In collaboration with the British Society of Neuroradiologists, a consensus group has established a standardised protocol for CT angiography (CTA) when used as an ancillary investigation to support the clinical diagnosis of DNC.

Background

The Academy of Medical Royal Colleges (AoMRC) Code of Practice for the Diagnosis and Confirmation of Death was updated in 2008 [1]. This provides guidance on how doctors should diagnose and confirm DNC. Courts in the UK continue to uphold the confirmation of DNC when the recommendations of the AoMRC Code of Practice are followed [2].

The diagnosis of DNC in the UK is primarily a clinical diagnosis, made by at least two doctors. Both should have been fully registered with the General Medical Council (or equivalent Professional Body) for more than five years and be competent in the conduct and interpretation of the clinical tests. At least one of the doctors must be a consultant. Testing should be undertaken by the nominated doctors acting together and must always be performed on two occasions.

In the UK the diagnosis of DNC is almost exclusively undertaken by Intensive Care doctors. Since 2012, FICM and the ICS have endorsed the use of standardised testing forms as an aid in making this diagnosis, with the Royal College of Paediatrics and Child Health endorsing standardised forms in 2019 [3-5]. These forms are consistent with, and should be used in conjunction with, the AoMRC Code of Practice.

The AoMRC Code of Practice does not recommend the routine use of an ancillary investigation to support the clinical diagnosis of DNC. In the majority of cases this diagnosis is made clinically by establishing the cause of the irreversible coma and apnoea, excluding confounders and by demonstrating the loss of brainstem reflexes and apnoea.

In certain situations, it may not be possible to perform or complete all the clinical tests necessary to diagnose DNC. The AoMRC Code of Practice advises that in such circumstances, ancillary investigations may be necessary to support clinical testing to confirm DNC. The FICM/ ICS endorsed testing forms also identify eight red flag groups from the literature or clinical experience, as cases where irreversibility of the apnoea and coma is more difficult to establish [3,4]. In circumstances where the red flag cannot be resolved, ancillary investigations may be beneficial in supporting a clinical diagnosis of DNC.

Current UK Practice

Data from the Potential Donor Audit conducted by NHS Blood and Transplant shows that testing for DNC is undertaken in approximately 1,500 persons per annum in the United Kingdom [6]. Further analysis by NHS Blood and Transplant reveals that over the last four years, testing for DNC occurs on 45% of occasions in hospitals with a neuroscience intensive care unit and 55% of occasions in hospitals without a neuroscience intensive care unit (data excludes stand-alone paediatric hospitals). The proportion of tests undertaken in hospitals without a neuroscience intensive care unit has increased from 53% of occasions in 2018, to 58% in 2021.

Most ancillary investigations are designed to either confirm the absence of cerebral blood flow or absence of neurophysiological activity. The ancillary investigation undertaken depends on local availability and access to expertise to interpret the result. No single ancillary investigation has world-wide consensus though there has been a shift toward ancillary investigations that confirm the absence of cerebral blood flow [7].

The AoMRC Code of Practice does not make recommendations as to which ancillary investigation should be used. The choice of investigation is decided by the individual intensive care unit and radiology / neurophysiology departments. There is no accurate information available for how often ancillary investigation is undertaken in the UK to support a clinical diagnosis of DNC.

Indications for an ancillary investigation

Ancillary investigation is indicated only when there is **strong clinical suspicion** that death has occurred. The ancillary investigation should be **additional** to the fullest examination and clinical testing, carried out to the best of the two doctors' capabilities in the given circumstances.

It is recommended that ancillary investigation is **required** in the following circumstances:

- Where a comprehensive neurological examination, including the apnoea test, is not possible (e.g., extensive facio-maxillary injuries, high spinal cord injury).
- Where continuing effects of confounding conditions cannot be excluded (e.g., residual sedation, metabolic or pharmacological derangement, decompressive craniectomy or another unresolvable red flag scenario).

It is recommended that ancillary investigation should be **considered** in the following additional circumstances:

- Uncertainty regarding the interpretation of possible spinally mediated movements.
- To promote understanding of the clinical confirmation of death using neurological criteria to families who are uncertain or unaccepting of such a diagnosis.

Which ancillary investigation

In the UK the ancillary investigation that is most widely available in hospitals (not just neuroscience centres) is CTA. CTA is commonly performed for other indications at most acute hospitals, and the acquisition can be highly protocolised to reduce variation in technique.

We acknowledge that the World Brain Death Project does not currently recommend CTA for this purpose, but CTA is a well-established ancillary investigation in Europe [8-12]. Many of the other techniques recommended by the World Brain Death Project are less available in the UK context, as is the expertise in acquisition and interpretation. The World Brain Death Project rightly notes that clinicians should first follow national guidelines that take account of any necessary variation in national practice [7].

We recommend that CTA becomes the standard ancillary investigation of choice for supporting the clinical diagnosis of DNC in the UK. Specifically, we recommend that the 4-point CTA criteria, as described by Frampas in 2009 should be adopted [8]. These criteria have a considerable evidence base and best fit current UK practice [9-15]. The 4-point CTA criteria has been shown to have a 100% specificity in confirming DNC [8,13]. The false negative rate of 15% (85% sensitivity) for the 4-point CTA criteria is acceptable; as it represents a safe standard which prioritises specificity over sensitivity [14].

Other methods for assessing the images in the future may improve the sensitivity of CTA in confirming DNC and may prove useful when further evidence is available to support their adoption [10,12].

Requesting

Requests must be made by direct discussion between the treating intensive care consultant and radiology consultant. The request should be made specifically as an ancillary investigation to support the clinical diagnosis of DNC to ensure the correct CTA technique is protocolled.

CT Angiography Technique

The scan should be performed by a suitably trained radiographer following the protocol described below.

- The patient should have an 18-g (or larger) canula sited in a large vein.
- Immediately prior to scanning, a mean arterial pressure above 60mmHg (or age-appropriate parameters in paediatrics) should be confirmed and documented.
- Three similar acquisitions are performed starting at the C2 level to the convexity.
- The **first scan** is acquired before the injection of contrast.
- Non-ionic contrast medium (120 ml (1-2 ml/kg in paediatrics); minimum iodine concentration of 340 mg/ml is injected at a rate of 3 ml/s using a power injector.
- The **second scan** is acquired at 20 seconds after commencing the contrast injection.
- The **third scan** is acquired at 60 seconds after commencing the contrast injection.
- Images are acquired with a section thickness of ≤ 1.25 mm or less at 120 kV, 250 mm field of view, and 512 x 512 matrix.
- Images must be clearly labelled as to whether they are the pre-injection, 20 second or 60 second runs.
- The localisation images (including the scanned range) should be saved and included in the image set sent to the picture archiving and communication system.

Reporting

The scan should be reported by a consultant radiologist. The reporting radiologist is advised to review the images using multiplanar reformats of the axial datasets as appropriate. Sagittal and coronal reformats may either be pre-specified reformats on the scan protocol that are generated automatically or produced by the reviewing radiologist in the image viewing software, according to local preference.

In centres that do not have an available in-house neuroradiologist, a consultant neuroradiology review of the images should be sought from the regional neurosciences centre, and the opinion (along with the name of the neuroradiologist) should be documented in the formal report of the CTA.

CTA criteria for supporting a clinical diagnosis of Death using Neurological Criteria

- The pre-injection acquisition is inspected for any pre-existing vascular density which could confound interpretation, such as intravenous contrast from a recent previous contrast-enhanced imaging study, hyperdense intravascular thrombus or vascular calcifications.
- Opacification of superficial temporal arteries is assessed on the second acquisition at 20 seconds to confirm the correct injection of contrast medium.
- The third acquisition at 60 seconds is used to evaluate opacification of intracranial vessels at 4 anatomical locations:
 1. cortical segments (M4) of the left middle cerebral artery
 2. cortical segments (M4) of the right middle cerebral artery
 3. left internal cerebral vein; and
 4. right internal cerebral vein.
- **A clinical diagnosis of DNC cannot be supported if the CTA demonstrates contrast opacification in any one of the 4 vessels specified above.**
- Provisional reports should not be issued. The final typed and verified report should be issued by the consultant radiologist at the earliest opportunity, and the intensive care consultant made aware of the availability of the report on the computer system.

Example template for consultant radiologist reporting

The paragraphs below provide suggested wording for consultant radiologists reporting the scans. The radiologist should adapt these according to the specific situation, adding other relevant findings as appropriate as per normal practice.

“Scan performed and reported according to the UK consensus protocol for the use of CT Angiography as an Ancillary Investigation to support a clinical Diagnosis of Death using Neurological Criteria.”

“The pre-contrast acquisition shows [*radiologist to comment on presence / absence of hyperdensity in the intracranial arteries and veins which could confound interpretation, for example due to thrombus or intravascular contrast from recent radiological studies, as well as other relevant imaging features as per normal practice*].”

“The early arterial (20-second) phase scan shows opacification of the superficial temporal arteries confirming adequate arterial delivery of contrast.”

OR

“The early arterial (20-second) phase scan does not show opacification of the superficial temporal arteries indicating inadequate arterial delivery of contrast, and hence the late arterial (60-second) phase scan is not reliable for interpretation of intracranial arterial opacification.”

If superficial temporal artery opacification is confirmed on the 20-second scan, the radiologist should describe the intracranial vessels showing opacification on the 60-second scan and comment specifically on opacification of the cortical segments (M4) of the middle cerebral arteries bilaterally and the internal cerebral veins bilaterally.

“Conclusion: In a patient fulfilling all other criteria for the diagnosis of Death using Neurological Criteria, the angiographic findings support this diagnosis.”

OR

“Conclusion: The presence of contrast in [*mention target vessels*] means that the CT angiographic criteria supporting the diagnosis of Death using Neurological Criteria are not met.”

Special circumstances

Paediatrics

Use of ancillary investigations to support a clinical diagnosis of DNC is not possible in neonates less than 2 months of corrected gestational age [16]. There is a paucity of evidence addressing the use of CTA in the paediatric population of patients (less than 16 years of age), which is also reflected in the scant practical experience in the United Kingdom. Currently, until further evidence is available, we are not in a position to make consensus recommendations for the use of ancillary investigations in the paediatric population. In clinical situations where ancillary investigations are considered necessary there should be a local case-by-case discussion. Magnetic Resonance angiography may have a role in UK paediatric populations given its accessibility and use in this population and increasing recognition for its role in supporting the diagnosis of DNC worldwide [17].

Extracorporeal membrane oxygenation (ECMO)

Currently, until further evidence is available, we are not in a position to make consensus recommendations for the use of ancillary investigations in patients receiving ECMO. In clinical situations where ancillary investigations are considered necessary there should be a local case-by-case discussion.

Auditing these recommendations

We recommend that a system of auditing national practice on the use and outcomes of ancillary investigations to support a clinical diagnosis of DNC is established. We suggest that this is done by inclusion into the Potential Donor Audit which already collects data on all diagnosis of DNC undertaken in the UK.

We also recommend that the process of diagnosing death using neurologically criteria is guided and documented using the forms endorsed by the Faculty of Intensive Care Medicine and the Intensive Care Society [18], and the paediatric version available from the Paediatric Critical Care Society. This will help standardise the process and increase the opportunities for useful audit.

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