

A CODE OF PRACTICE FOR THE DIAGNOSIS AND CONFIRMATION OF DEATH

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FOREWORD

I welcome the publication of this updated Code of Practice as an authoritative source of guidance on the clinical aspects of the diagnosis of death.

Whilst the vast majority of deaths are predictable and confirmation is straightforward, recent advances in medicine, together with new legislation means that a new Code of Practice is necessary to cover all situations now met in clinical practice.

This revised Code of Practice builds upon the earlier Code published in 1998 and updates a number of important aspects. It provides clear, scientifically rigorous criteria for confirming death, both in clinical settings where confirmation of death by brain-stem testing is appropriate, and where confirmation of death following cardiac arrest is required.

I believe the relatives of the deceased, society in general and the medical nursing and other professional staff involved can accept this Code with confidence.



Sir Liam Donaldson
Chief Medical Officer

October 2008

This Code of Practice has been approved by the Academy of Medical Royal Colleges as a statement of current practice in the diagnosis and confirmation of death. It does not (and could not) seek to provide guidance for every single clinical situation where a doctor is required to diagnose death or to be a comprehensive statement of clinical and/or legal obligations for medical staff towards their patients in this complex area of practice. Doctors and other healthcare workers should bear in mind the need to consider the Guidance carefully and, using their own clinical judgment, to consider whether it is appropriate to any individual case. Any medical professional who has concerns about interpretation of the Guidance or whether it should be followed in any clinical situation should discuss the matter with professional colleagues, seek advice from their employer's ethics committee or legal advisors, or contact their Medical Defence Organisation

MEMBERS OF THE WORKING PARTY

This revised Code of Practice has been prepared by a Working Party established through the Royal College of Anaesthetists on behalf of the Academy of Medical Royal Colleges. The document produced has been consulted upon widely through networks supplied by the Academy of Medical Royal Colleges, the Human Tissue Authority and UK Transplant.

A list of those individuals and organisations responding to the consultation is included in Appendix 6. Where considered appropriate by the Working Party, comments received have been incorporated into the final document. The membership of the Working Party was:

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1. INTRODUCTION

The diagnosis and confirmation of death is required in a number of different situations, both as a result of a natural process and also in situations where artificial interventions are sustaining cardiorespiratory function in the absence of a patient's ability to breathe independently. This Code of Practice is designed to address the diagnosis and confirmation of death in all situations and to make practical recommendations, which are acceptable both to the relatives of the deceased, to society in general and also to the medical, nursing and other professional staff involved. The Working Party has included some members of the group which drew up the 1998 Code of Practice and also new members to reflect the wider professional and lay interests that are now involved. We have drawn upon much of the comment received over the existing guidelines, together with documentation prepared in particular by the Intensive Care Society (www.ics.ac.uk).

This revised Code of Practice is a working document, aimed primarily at doctors and other healthcare workers who are responsible for the diagnosis and confirmation of death, rather than the lay public. For this reason, it has been written using medical terminology. Accepting, however, that it will be read more widely, we have added a Glossary of the medical terms used. In addition and as an aid to those unfamiliar with some of the terminology or technical aspects used in this Code of Practice, a lay explanation of the diagnosis of death following irreversible cessation of brain-stem function is included in Appendix 5.

Unlike the 1998 Code, this revised version has taken on a different format. The Working Party decided that it was important to separate completely the diagnosis and confirmation of death from anything to do with the issues surrounding organ donation and transplantation. This document deals solely with the diagnosis and confirmation of death, whatever the cause, allowing this to be carried out in a variety of circumstances where further intervention aimed at sustaining life can be of no further benefit to patients. We intend that the advice in this document should be used in conjunction with the existing guidelines on organ donation and transplantation from the Intensive Care Society and with the Codes of Practice from the Human Tissue Authority, thus forming a portfolio of documents which are consistent and clearly linked.

It is our hope that the revised Code, like the original Code, will be of help to those concerned with the care of the dying, by reaffirming the criteria for the diagnosis of death whether following the irreversible cessation of cardiorespiratory function, or by testing brain-stem reflexes in comatose, apnoeic, ventilated patients with a heartbeat. When a patient is comatose, apnoeic and receiving artificial ventilation of their lungs, the criteria for determining irreversible cessation of brain-stem function will be the irreversible loss of brain-stem reflexes, diagnosed by clinical neurological testing. The Code also clarifies the confirmation of death following cardiorespiratory arrest.

In this way, relatives, partners and carers may be spared the ordeal of witnessing an intervention which is prolonged and not in the patient's best interest. Equally, professionals ordinarily responsible for protecting life can be confident about the professional and legal acceptability of discontinuing interventions that serve merely to prolong somatic function. This latter point is of particular significance with regard to those who argue that the diagnosis of irreversible cessation of brain-stem function as a criterion for the diagnosis of death itself is irretrievably wedded to the desire to acquire organs for transplantation. The fact is that there is no logical relationship between them. With advances in the technology of assisted respiration, it is essential that the diagnosis of death be independent of such assistance. This is of the utmost importance in circumstances where relatives and staff may otherwise be unreasonably reticent to accept that treatment of this kind, along with other forms of life-sustaining therapy, can be of no further benefit to the deceased. A definition of human death should not be related to organ transplantation.¹

It is essential that relatives, partners and carers be kept fully informed of the clinical condition of the patient and that they be given an explanation regarding the condition and prognosis. They should be given appropriate explanation of the investigations being undertaken and of their interpretation throughout the process of the determination of death, in a sympathetic, timely and appropriate fashion by those concerned with the management of the patient.

2. DIAGNOSIS AND CONFIRMATION OF DEATH

Death entails the irreversible loss of those essential characteristics which are necessary to the existence of a living human person and, thus, the definition of death should be regarded as the irreversible loss of the capacity for consciousness, combined with irreversible loss of the capacity to breathe. This may be secondary to a wide range of underlying problems in the body, for example, cardiac arrest.

2.1 Death following the irreversible cessation of brain-stem function

The irreversible cessation of brain-stem function whether induced by intra-cranial events or the result of extra-cranial phenomena, such as hypoxia, will produce this clinical state and therefore irreversible cessation of the integrative function of the brain-stem equates with the death of the individual and allows the medical practitioner to diagnose death.

Three things should be noted in this regard:

First, the irreversible loss of the capacity for consciousness does not by itself entail individual death. Patients in the vegetative state (VS) have also lost this capacity (see section 6.9). The difference between them and patients who are declared dead by virtue of irreversible cessation of brain-stem function is that the latter cannot continue to breathe unaided without respiratory support, along with other life-sustaining biological interventions. This also means that even if the body of the deceased remains on respiratory support, the loss of integrated biological function will inevitably lead to deterioration and organ necrosis within a short time.

Second, the diagnosis of death because of cessation of brain-stem function does not entail the cessation of all neurological activity in the brain. What does follow from such a diagnosis is that none of these potential activities indicates any form of consciousness associated with human life, particularly the ability to feel, to be aware of, or to do, anything. Where such residual activity exists, it will not do so for long due to the rapid breakdown of other bodily functions.

Third, there may also be some residual reflex movement of the limbs after such a diagnosis. However, as this movement is independent of the brain and is controlled through the spinal cord, it is neither indicative of the ability to feel, be aware of, or to respond to, any stimulus, nor to sustain respiration or allow other bodily functions to continue.

In short, while there are some ways in which parts of the body may continue to show signs of biological activity after a diagnosis of irreversible cessation of brain-stem function, these have no moral relevance to the declaration of death for the purpose of the immediate withdrawal of all forms of supportive therapy. It is for this reason that patients with such activity can no longer benefit from supportive treatment and legal certification of their death is appropriate.²

The current position in law is that there is no statutory definition of death in the United Kingdom. Subsequent to the proposal of the 'brain death criteria' by the Conference of Medical Royal Colleges in 1976,^{3,4} the courts in England and Northern Ireland have adopted these criteria as part of the law for the diagnosis of death.^{5,6} There is no reason to believe that courts in other parts of the United Kingdom would not follow this approach.

Section 26(2)(d) of the Human Tissue Act 2004⁷ empowers the Human Tissue Authority to develop a series of Codes of Practice, including the definition of death for the purposes of that Act only. The Codes published thus far are available at www.hta.gov.uk/guidance/codes_of_practice.cfm

2.2 Death following cessation of cardiorespiratory function

For people suffering cardiorespiratory arrest (including failed resuscitation), death can be diagnosed when a registered medical practitioner, or other appropriately trained and qualified individual, confirms the irreversible cessation of neurological (pupillary), cardiac and respiratory activity. Diagnosing death in this situation requires confirmation that there has been irreversible damage to the vital centres in the brain-stem, due to the length of time in which the circulation to the brain has been absent.

3. DIAGNOSING AND CONFIRMING DEATH AFTER CARDIORESPIRATORY ARREST

Confirmation of death is as important in the large number of patients in whom death is expected, either in the primary care setting or in hospital, as it is in cases of unexpected death. Death after cardiorespiratory arrest has long been identified by the simultaneous and irreversible onset of apnoea, unconsciousness and absence of the circulation. In these circumstances irreversible cessation of brain-stem function rapidly ensues. However, unlike confirmation of death using neurological assessment of cessation of brain-stem reflexes (section 6), there are currently no standardised criteria for the confirmation of death following irreversible cessation of cardiorespiratory function. As a result current practice varies from confirming death as soon as the heart stops of its own accord, or when attempts at cardiopulmonary resuscitation are abandoned, to waiting ten minutes or longer after the onset of asystole and apnoea. While such practice continues to be appropriate, particularly within primary care, the increasing practice of non-heartbeating organ donation has also focused attention on the need in a hospital setting, for a standard approach to confirming death.

Whilst dying is a process rather than an event, a definition of when the process reaches the point (death) at which a living human being ceases to exist is necessary to allow the confirmation of death without an unnecessary and potentially distressing delay. This is especially so within a primary or secondary care environment, where clear signs that are pathognomonic of death (hypostasis, rigor mortis) are present. However, in the absence of such signs, we recommend that the point after cardiorespiratory arrest at which death of a living human being occurs is identified by the following conditions:

- The simultaneous and irreversible onset of apnoea and unconsciousness in the absence of the circulation
- Full and extensive attempts at reversal of any contributing cause to the cardiorespiratory arrest have been made. Such factors, which include body temperature, endocrine, metabolic and biochemical abnormalities, are considered under section 5

- One of the following is fulfilled:
 - the individual meets the criteria for not attempting cardiopulmonary resuscitation⁸
 - attempts at cardiopulmonary resuscitation have failed
 - treatment aimed at sustaining life has been withdrawn because it has been decided to be of no further benefit to the patient and not in his/her best interest to continue and/or is in respect of the patient's wishes via an advance decision to refuse treatment
- The individual should be observed by the person responsible for confirming death for a minimum of five minutes^{9,10} to establish that irreversible cardiorespiratory arrest has occurred. The absence of mechanical cardiac function is normally confirmed using a combination of the following:
 - absence of a central pulse on palpation
 - absence of heart sounds on auscultation

These criteria will normally suffice in the primary care setting. However, their use can be supplemented in the hospital setting by one or more of the following:

- asystole on a continuous ECG display
 - absence of pulsatile flow using direct intra-arterial pressure monitoring
 - absence of contractile activity using echocardiography
- Any spontaneous return of cardiac or respiratory activity during this period of observation should prompt a further five minutes observation from the next point of cardiorespiratory arrest
 - After five minutes of continued cardiorespiratory arrest the absence of the pupillary responses to light, of the corneal reflexes, and of any motor response to supra-orbital pressure should be confirmed
 - The time of death is recorded as the time at which these criteria are fulfilled.

It is obviously inappropriate to initiate any intervention that has the potential to restore cerebral perfusion after death has been confirmed.

4. DIAGNOSIS AND CONFIRMATION OF DEATH IN A PATIENT IN COMA

When managing a patient in coma, treatment decisions must be made in the patient's best interests. The first objective for the healthcare team is to determine the cause and depth of coma, to maintain life while this is being done (respecting any valid advance decision to refuse treatment), and attempt to restore function. Such measures are often successful, but when the brain-stem has been damaged in such a way, and to such a degree, that its integrative functions (which include the neural control of cardiac and pulmonary function and consciousness) are irreversibly destroyed, death of the individual has occurred and the heart will inevitably stop beating subsequently, although the time over which this occurs may vary considerably (see 6.4).

When death has been diagnosed by the methods to be described, the patient is dead even though respiration and circulation can be artificially maintained successfully for a limited period of time. The appropriate course of action is then to consider withdrawal of mechanical respiratory support, the ethical justification for which has passed, and to allow the heart to stop. This imposes an unnecessary and distressing vigil on the relatives, partners and carers, who should be kept fully informed by the local care team of the diagnosis, the inevitable outcome and the likely sequence of events.

5. CONDITIONS NECESSARY FOR THE DIAGNOSIS AND CONFIRMATION OF DEATH

All of the following conditions must be fulfilled to allow the diagnosis of death following irreversible cessation of brain-stem function to be undertaken.

5.1 Aetiology of irreversible brain damage

There should be no doubt that the patient's condition is due to irreversible brain damage of known aetiology. It may be obvious within hours of a primary intra-cranial event such as a severe head injury or spontaneous intra-cranial haemorrhage that the condition is irreversible. When, however, a patient has suffered primarily from cardiac arrest or severe circulatory insufficiency with an ill-defined period of cerebral hypoxia or a cerebral air or fat embolism, it may take longer to establish the diagnosis and to be confident of the prognosis. If significant diagnostic uncertainties remain, brain-stem testing cannot be undertaken. However, there are patients in whom a final diagnosis for the cause of cessation of brain-stem function is never fully established despite extensive investigation (e.g., following presumed hypoxic brain injury, cerebral air or fat embolism, drug overdose, encephalitis). In this situation brain-stem testing should be undertaken only if, after continuing clinical observation and investigation, there is no possibility of a reversible or treatable underlying cause being present.

5.2 Exclusion of potentially reversible causes of coma

The patient is deeply comatose, unresponsive and apnoeic, with his/her lungs being artificially ventilated.

5.2.1 There should be no evidence that this state is due to depressant drugs

The action of narcotics, hypnotics and tranquillisers may be prolonged, particularly when hypothermia coexists or in the presence of renal or hepatic failure. Similarly in infants and children, altered metabolism and excretion of drugs should be taken into account. Some sedatives (e.g., the benzodiazepines) and analgesics are markedly cumulative and persistent in their actions and are commonly used as anticonvulsants or to assist synchronisation with mechanical ventilators.

It is therefore essential that the recent history of what drugs have been ingested or administered should be carefully reviewed and any possibility of intoxication being the cause of, or contributing to, the patient's comatose state should preclude a diagnosis of death. It is important to recognise that, in some patients, hypoxia may have followed the ingestion of a drug, but in this situation the criteria for death will not be applicable until such a time as the primary effects of the drug have been excluded as a continuing cause of

the unresponsiveness. Excluding the effects of sedative drugs, however, may be difficult.

The length of time between discontinuation of depressant drugs and undertaking brain-stem testing depends on several factors including total dose, duration of treatment, the underlying renal and hepatic function and the availability of measurement of drug concentrations. If assays of thiopentone are available, it is recommended that brain-stem testing should not be undertaken if the level is $>5\text{mg/L}$. If levels are not available then determining an adequate duration to exclude the effects of depressant drugs will involve prediction according to pharmacokinetic principles in both adults and children.

If opioids or benzodiazepines are thought to be contributing to the coma, specific antagonists such as naloxone or Anexate should be used. If midazolam levels are available brain-stem testing should not be undertaken if the level is $>10\mu\text{g/L}$. In other circumstances, residual sedative effects must be predicted according to pharmacokinetic principles in both adults and children. If there is any doubt, specific drug levels should be measured before proceeding. In exceptional circumstances, if the effects of sedation cannot be excluded, ancillary investigations may be necessary to confirm the diagnosis (see section 6.7).

5.2.2 Primary hypothermia as the cause of unconsciousness must have been excluded

Temperatures between $32\text{--}34^\circ\text{C}$ are occasionally associated with an impaired level of consciousness but brain-stem reflexes tend to be lost if the temperature falls below 28°C . These deficits are potentially reversible. In clinical practice, patients remain awake and conscious with temperatures $>34^\circ\text{C}$ unless other factors are present. We therefore recommend that the core temperature should be greater than 34°C at the time of testing.

5.2.3 Potentially reversible circulatory, metabolic and endocrine disturbances must have been excluded as the cause of the continuation of unconsciousness

While trying to provide broad guidance on the magnitude of metabolic and endocrine disorders which are likely to influence the testing of brain-stem reflexes, it is essential to bear in mind that the most important factor is the establishment of an unequivocal cause for the individual's unconsciousness.

It is recognised that circulatory, metabolic and endocrine disturbances (e.g., hyponatraemia, diabetes insipidus) are likely accompaniments of death as a result of cessation of brain-stem function. It is important to emphasise that these may be the effect rather than the cause of cessation of brain-stem function and do not preclude the diagnosis of death by neurological testing of brain-stem reflexes. Furthermore it may be detrimental to correct such abnormalities too rapidly and, equally, to delay testing of brain-stem reflexes unnecessarily, simply because of strict adherence to the requirement to attain a predetermined blood electrolyte concentration. It is necessary to maintain circulation and respiration prior to testing. The mean arterial pressure should be consistently >60mmHg with maintenance of normocarbica and avoidance of hypoxia, acidaemia or alkalaemia ($P_a\text{CO}_2 < 6.0\text{KPa}$, $P_a\text{O}_2 > 10\text{KPa}$ and pH 7.35 –7.45)

As guidance, we would emphasise that the effects of hyponatraemia depend on the rate of its development but it is rare for patients to become unresponsive if the serum sodium concentration is 115mmol/L or above. If severe hyponatraemia is corrected too rapidly the patient may develop unresponsive, but potentially reversible coma due to central pontine myelinolysis. Sodium levels above 160mmol/L are associated with unresponsiveness and this should be borne in mind if the primary cause of coma prior to testing is uncertain.

Profoundly low levels of serum potassium may cause myopathy and levels below 1mmol/L have been reported to cause flaccid quadriplegia. Whilst there is no clear evidence concerning the central effects of hypokalaemia, as a guide we would recommend that testing of brain-stem reflexes should not be undertaken in the face of a serum potassium concentration below 2mmol/L.

Similarly, profound elevation or lowering of phosphate or magnesium may be associated with severe neuromuscular weakness that may culminate in flaccid quadriplegia. Although there is little evidence to suggest a central component or to guide the clinician in determining at what levels brain-stem testing can safely be undertaken, clinically

significant weakness is unlikely unless levels of magnesium or phosphate are <0.5 or >3.0mmol/L. In addition a peripheral nerve stimulator should be used to ensure that there is good neuromuscular transmission and some muscle response.

Hyperglycaemia in diabetic ketoacidosis or hyperosmolar non-ketotic coma may cause a state of unresponsiveness which mimics irreversible cessation of brain-stem function, but this state is extremely unlikely with blood glucose levels less than 20mmol/L. Severe hypoglycaemia is associated with coma or stupor and testing of brain-stem reflexes should not be undertaken if the glucose level is below 3.0mmol/L. Since blood glucose concentrations change rapidly in critically ill patients, a blood sugar measurement should always be made immediately prior to the testing of brain-stem reflexes. Patients in thyroid storm may present in acute coma or with acute thyrotoxic myopathy. Myxoedema may also cause a deep unresponsive coma. Addisonian crisis may be associated with severe neuromuscular weakness causing an acute ascending paralysis or encephalopathy proceeding to coma. These conditions are extremely rare and unlikely to co-exist in the presence of known primary pathologies. If there is any clinical reason to expect these disturbances then it is obligatory to ensure appropriate hormonal assays are undertaken.

5.3 Exclusion of potentially reversible causes of apnoea

The patient is being maintained on the ventilator because spontaneous respiration has ceased. Relaxants (neuromuscular blocking agents) and other drugs must have been excluded as the cause of respiratory inadequacy or failure. Immobility, unresponsiveness and lack of spontaneous respiration may be due to the use of neuromuscular blocking drugs and the persistence of their effects should be excluded by confirmation of the presence of deep-tendon reflexes or by the demonstration of adequate neuromuscular conduction with a conventional nerve stimulator. Persistent effects of hypnotics or narcotics must be excluded as the cause of respiratory failure. Profound neuromuscular weakness resembling the absence of brain-stem reflexes may occur as a consequence of a number of neurological disorders emphasising the importance of establishing a clear diagnosis of irremediable brain damage of known aetiology.

When coma follows a head injury, the presence of a cervical spine injury must be excluded in the usual way using clinical criteria, plain X-rays, CT and MRI scans as indicated. If there are reasons to suspect that an underlying high cervical spine injury and associated cord injury are causing the apnoea, then the apnoea test (see section 6.1.6) becomes invalid. In this rare scenario, cessation of brain-stem function can be established only by confirming the absence of other brain-stem reflexes and by using ancillary investigations (see section 6.7 and Appendix 3).

6. THE DIAGNOSIS OF DEATH FOLLOWING IRREVERSIBLE CESSATION OF BRAIN-STEM FUNCTION

Fulfilment of the clinical criteria for the diagnosis of death following irreversible cessation of brain-stem function, specified by the Conference of Medical Royal Colleges during the period 1976–1981,^{3,4,11,12} is followed, without further active support, by subsequent cessation of the heart beat, though the time taken for this to occur may vary¹³ (see section 6.4). This has been confirmed in all published series and has therefore been adequately validated.

Concern is sometimes expressed over continuing function within the brain-stem, occurring beneath the level at which any motor, somatosensory or breathing reflexes can be elicited and also over continuing function in other parts of the brain. However, as has already been indicated, both are irrelevant when evaluating function against these clinical criteria of death resulting from irreversible cessation of brain-stem function, which demonstrate the permanent absence of consciousness and thus the ability to feel or do anything, along with the inevitable and rapid deterioration of integrated biological function. The following paragraphs recapitulate the criteria in the conference guidelines, with the addition of notes on how they may be elicited.

6.1 Absence of brain-stem reflexes

6.1.1 The pupils are fixed and do not respond to sharp changes in the intensity of incident light.

6.1.2 There is no corneal reflex – care should be taken to avoid damage to the cornea.

6.1.3 The oculo-vestibular reflexes are absent.

No eye movements are seen during or following the slow injection of at least 50mls of ice cold water over one minute into each external auditory meatus in turn. Clear access to the tympanic membrane must be established by direct inspection and the head should be at 30° to the horizontal plane, unless this positioning is contraindicated by the presence of an unstable spinal injury.

In the case of 6.1.1, 6.1.2 and 6.1.3, testing of these reflexes may be prevented on one or other side by local injury or disease but this does not invalidate the diagnosis of death as a result of cessation of brain-stem reflexes. In the case of bilateral injury or disease, ancillary testing should be considered.

6.1.4 No motor responses within the cranial nerve distribution can be elicited by adequate stimulation of any somatic area.

No motor response can be elicited within the cranial nerve or somatic distribution in response to supraorbital pressure.

6.1.5 There is no cough reflex response to bronchial stimulation by a suction catheter placed down the trachea to the carina, or gag response to stimulation of the posterior pharynx with a spatula.

6.1.6 The process for testing the respiratory response to hypercarbia (apnoea test) should be the last brain-stem reflex to be tested and should not be performed if any of the preceding tests confirm the presence of brain-stem reflexes.

Confusion has arisen in the past over the way in which the test should be performed and the frequency with which it should be repeated. This guidance deals specifically with these problems and the testing process also takes into account the developments in monitoring that have occurred. The general availability of end tidal carbon dioxide ($E_t\text{CO}_2$) monitoring and instant access to blood gas analysis allows their routine utilisation to:

- Eliminate the risk of the development of significant hypoxia during the apnoea test
- Minimise the risk of the development of excessive hypercarbia and/or rapid changes in carbon dioxide tension
- Minimise the development of changes in mean arterial pressure and as a result, minimise the risk of further injury to potentially recoverable brain tissue, in case death of the brain-stem has not actually occurred¹⁴. For the above reasons and to avoid undue stress or loss of confidence in such tests, they should not be formally carried out unless ongoing bedside observations indicate that brain-stem function has ceased irreversibly.

When the patient is not acidaemic, the procedure recommended to induce moderate hypercarbia and mild acidaemia is as follows:

- Increase the patient's $F_i\text{O}_2$ to 1.0
- Check arterial blood gases to confirm that the measured $P_a\text{CO}_2$ and $S_a\text{O}_2$ correlate with the monitored values
- With oxygen saturation greater than 95%, reduce minute volume ventilation by lowering the respiratory rate to allow a slow rise in $E_t\text{CO}_2$
- Once $E_t\text{CO}_2$ rises above 6.0KPa, check arterial blood gases to confirm that $P_a\text{CO}_2$ is at least 6.0KPa and that the pH is less than 7.40
- The aim should be to ensure that this, and not a substantially greater, degree of hypercarbia and acidaemia is achieved for those with no previous history of respiratory disease or bicarbonate administration

- In patients with chronic CO_2 retention, or those who have received intravenous bicarbonate, the achievement of a mild but significant acidaemia as described would be achieved by allowing the $P_a\text{CO}_2$ to rise to above 6.5KPa to a point where the pH is less than 7.40
- The patient's blood pressure should be maintained at a stable level throughout the apnoea test
- If cardiovascular stability is maintained, the patient should then be disconnected from the ventilator and attached to an oxygen flow of 5L/min via an endotracheal catheter and observed for five minutes
- If the maintenance of adequate oxygenation proves difficult, then CPAP (and possibly a prior recruitment manoeuvre) may be used
- If, after five minutes, there has been no spontaneous respiratory response, a presumption of no respiratory centre activity will be documented and a further confirmatory arterial blood gas sample obtained to ensure that the $P_a\text{CO}_2$ has increased from the starting level by more than 0.5KPa
- The ventilator should be reconnected and the minute volume adjusted to allow a gradual return of the blood gas concentrations to the levels set prior to the commencement of testing.

6.2 Children

A report of a Working Party of the British Paediatric Association of 1991 supported by the Council of the Royal College of Physicians suggested that, in children over the age of two months, the criteria used to establish death should be the same as those in adults. Between thirty-seven weeks of gestation and two months of age, it is rarely possible confidently to diagnose death as a result of cessation of brain-stem reflexes, and below thirty-seven weeks of gestation the criteria to establish this cannot be applied.¹⁵ This document endorses the 1991 Report, which is reproduced in full as Appendix 4 without any modification of the original text. The text of the report is preceded in the Appendix by an introductory section indicating how the 1991 Report should be read in relation to these current guidelines.

6.3 Repetition of testing

The diagnosis of death by brain-stem testing should be made by at least two medical practitioners who have been registered for more than five years and are competent in the conduct and interpretation of brain-stem testing. At least one of the doctors must be a consultant. **Those carrying out the tests must not have, or be perceived to have, any clinical conflict of interest and neither doctor should be a member of the transplant team.** Testing should be undertaken by the nominated doctors acting together and must always be performed on two occasions. A complete set of tests should be performed on each occasion, i.e., a total of two sets of tests will be performed. Doctor A may perform the tests while Doctor B observes; this would constitute the first set. Roles may be reversed for the second set. The tests, in particular the apnoea test, are therefore performed only twice in total.

If the first set of tests shows no evidence of brain-stem function there need not be a lengthy delay prior to performing the second set. A short period of time will be necessary after reconnection to the ventilator to allow return of the patient's arterial blood gases and baseline parameters to the pre-test state, rechecking of the blood sugar concentration and for the reassurance of all those directly concerned. Although death is not confirmed until the second test has been completed the legal time of death is when the first test indicates death due to the absence of brain-stem reflexes.⁹

6.4 The beating heart in individuals certified dead as a result of cessation of brain-stem reflexes

Even if ventilation and cardiovascular support are continued, both adults and children will ultimately suffer cessation of heartbeat. Often this occurs within a few days, but may take weeks or even months if aggressive support is maintained,¹³ although there are no verified reports of patients recovering brain-stem function during this time.

6.5 Endocrine, metabolic and circulatory abnormalities

Abnormalities, such as diabetes insipidus, hypo or hypernatraemia, hypothermia and disturbance of cardiac rhythm or blood pressure, commonly occur in patients who suffer irreversible cessation of brain-stem function following anoxic, haemorrhagic or traumatic cerebral injury. These abnormalities are a direct result of brain-stem failure and must be differentiated from abnormalities of endocrinological, biochemical or autonomic function contributing to impaired brain-stem function (see section 5.2.3).

6.6 Limb and trunk movements

Reflex movements of the limbs and torso may still occur in the presence of irreversible cessation of brain-stem function, even after this has been diagnosed. The doctor must explain clearly the significance of these movements to relatives, partners, carers and other staff, who should be given sufficient information and explanation to enable them to understand that they are of spinal-reflex origin and do not represent the higher functioning of the brain.

6.7 Investigations

The accuracy of the clinical criteria for the diagnosis of death as a result of cessation of brain-stem reflexes over the past thirty years provides justification for not including the results of neurophysiological or imaging investigations as part of these criteria. However, death cannot be diagnosed by the testing of brain-stem reflexes alone in instances where a comprehensive neurological examination is not possible (e.g., extensive facio-maxillary injuries, residual sedation and some cases of paediatric hypoxic brain injury), where a primary metabolic or pharmacological derangement cannot be ruled out or in cases of high cervical cord injury (see section 5.3). In such cases a confirmatory test may reduce any element of uncertainty and possibly foreshorten any period of observation prior to formal testing of brain-stem reflexes.

The various tests available, together with an assessment of their relative benefit and complexity, are listed in Appendix 3. All such investigations are prone to artifice and each has attracted its own literature defining false positive and negative rates. All ancillary investigations require appropriate training and experience both to perform and to interpret, which may not be available in all hospitals or outside normal office hours. Patients with the provisional diagnosis of irreversible cessation of brain-stem reflexes are frequently physiologically unstable and their transfer to another part of the hospital for further investigation may carry a significant risk, were the provisional diagnosis subsequently proven to be wrong. Where appropriate, such cases should be referred for a specialist neurological or neurosurgical opinion. In this situation, further time may be required before death may be confirmed. The increasingly widespread availability of spiral CT angiography may prove to be a helpful advance but further validation studies are required.

6.8 Peripheral neurological syndromes of intensive care

There is a range of overlapping neuropathic, neuromuscular and myopathic syndromes which may occur in the context of intensive therapy and may cause problems in weaning a patient from a ventilator. This is not true apnoea (respiratory centre paralysis) and should not be taken as evidence for neurological testing of brain-stem function.

6.9 The vegetative state

Problems relating to the diagnosis and management of the vegetative state (VS) must not be confused with those relating to death, and the Guidelines endorsed by the Conference of Medical Royal Colleges emphasise the important differences.¹⁶ Brain-stem death is not part of the VS, which has been defined as a clinical condition of unawareness of self and environment in which the patient breathes spontaneously, has a stable circulation, and shows cycles of eye closure and opening which may simulate sleep and waking.¹⁶

7. MANAGEMENT OF THE PATIENT

It is important that decisions made on behalf of living patients, who lack the capacity to make decisions for themselves, are made in line with the Mental Capacity Act¹⁷ and take account of the patient's best interests. The implications of this requirement are laid out in the MCA Code of Practice [<http://www.publicguardian.gov.uk/mca/code-of-practice.htm>]. This Code of Practice refers both to an individual before death, who lacks capacity and after death has been diagnosed and confirmed, when the question of best interests no longer arises.

7.1 Maintenance of therapy

The maintenance of normal homeostasis by attempting to ensure adequate fluid intake, electrolyte balance, normal blood pressure, the monitoring of urine output by catheter collection and the use of other therapeutic agents, is part of the standard medical care of the patient where death has not been conclusively established.

7.2 Cessation of respiration

Some patients, who are thought to have sustained irreversible brain damage and are receiving partial ventilatory assistance, may continue to make respiratory efforts, precluding the confirmation of death. In such patients it is important to decide at an early stage whether it is appropriate to initiate full mechanical ventilation at the onset of apnoea, to allow the exclusion of other causes for the deterioration and to allow the confirmation of death by confirming the irreversible cessation of brain-stem function. If this course of action is not considered appropriate in the evaluation of the benefit of further treatment aimed at sustaining life, then neither is the partial ventilatory support being provided. In such a case, withdrawing ventilatory assistance following discussion with the patient's relatives or relevant others may be the most appropriate course as being in the best interests of the patient.

In deciding whom to involve in decisions of this nature, the Mental Capacity Act¹⁷ specifically includes a requirement to involve family and others as appropriate when making a decision about the patient's best interests (MCA Section 4/7). Whilst In England and Wales, the Mental Capacity Act applies, in Scotland, the Adults with Incapacity (Scotland) Act 2000 applies and in Northern Ireland, there remains the common law approach to best interests. Anyone making decisions on behalf of a person who lacks capacity "must consider, so far as is reasonably ascertainable –

- (a) the person's past and present wishes and feelings (and, in particular, any relevant written statement made by him when he had capacity),
- (b) the beliefs and values that would be likely to influence his

decision if he had capacity, and (c) the other factors that he would be likely to consider if he were able to do so."

Further, anyone making decisions "must take into account, if it is practicable and appropriate to consult them, the views of –

- (a) anyone named by the person as someone to be consulted on the matter in question or on matters of that kind,
- (b) anyone engaged in caring for the person or interested in his welfare,
- (c) any donee of a lasting power of attorney granted by the person, and
- (d) any deputy appointed for the person by the court, as to what would be in the person's best interests."

7.3 Elective ventilation

Where a patient has been intubated and ventilated as part of a resuscitation (e.g., a cardiac arrest or multiple injury) or in order to facilitate an investigation (such as a CT head scan), additional information may subsequently become available that was not known at the time of the decision to intubate and ventilate. This new information may be related to the patient's pre-existing medical conditions or may be related to the present condition (e.g., a CT scan showing gross cerebral trauma or cerebral haemorrhage). With the new information, it may become clear that, whether or not death of the brain has actually occurred, the patient's condition is inevitably going to be fatal. In such a case, withdrawal of ventilatory support, ideally following discussion with the patient's relatives, may be the most appropriate course. If further intensive care is not considered appropriate because it can be of no benefit, nor in the patient's best interests, then neither is a continuation of the respiratory support being provided. In deciding which relative to involve in decisions of this nature, we recommend following the recommendations made in the Mental Capacity Act¹⁷, outlined in 7.2.

The patient will usually (but not invariably) start to make some respiratory effort for a period of time following withdrawal of ventilatory support. In this situation, although further active treatment is inappropriate, transfer to a Critical Care Unit may allow the family to spend time with their dying relative, during which palliative care can be provided in an environment that is dignified for the patient and supportive for the relatives. A similar situation exists in the case of a spontaneously breathing baby with a lethal congenital anomaly such as anencephaly. In both these situations endotracheal intubation and artificial ventilation of the patient should only be initiated and maintained to further the patient's benefit and not as a means of preserving organ function.

APPENDIX 1

PROCEDURE FOR THE DIAGNOSIS AND CONFIRMATION OF CESSATION OF BRAIN-STEM FUNCTION BY NEUROLOGICAL TESTING OF BRAIN-STEM REFLEXES

Diagnosis is to be made by two doctors who have been registered for more than five years and are competent in the procedure. At least one should be a consultant. Testing should be undertaken by the doctors together and must always be performed completely and successfully on two occasions in total.

Patient Name:

Unit No:

Pre-conditions

Are you satisfied that the patient suffers from a condition that has led to irreversible brain damage?

Specify the condition:

Dr A:

Dr B:

Time of onset of unresponsive coma:

Dr A:

Dr B:

Are you satisfied that potentially reversible causes for the patient's condition have been adequately excluded, in particular:

	DR A:	DR B:
DEPRESSANT DRUGS		
NEUROMUSCULAR BLOCKING DRUGS		
HYPOTHERMIA		
METABOLIC OR ENDOCRINE DISTURBANCES		

TESTS FOR ABSENCE OF BRAIN-STEM FUNCTION	1 ST SET OF TESTS	2 ND SET OF TESTS	1 ST SET OF TESTS	2 ND SET OF TESTS
DO THE PUPILS REACT TO LIGHT?				
ARE THERE CORNEAL REFLEXES?				
IS THERE EYE MOVEMENT ON CALORIC TESTING?				
ARE THERE MOTOR RESPONSES IN THE CRANIAL NERVE DISTRIBUTION IN RESPONSE TO STIMULATION OF FACE, LIMBS OR TRUNK?				
IS THE GAG REFLEX PRESENT?				
IS THERE A COUGH REFLEX?				
HAVE THE RECOMMENDATIONS CONCERNING TESTING FOR APNOEA BEEN FOLLOWED?				
WERE THERE ANY RESPIRATORY MOVEMENTS SEEN?				

Date and time of first set of tests:

Date and time of second set of tests:

Dr A Signature:

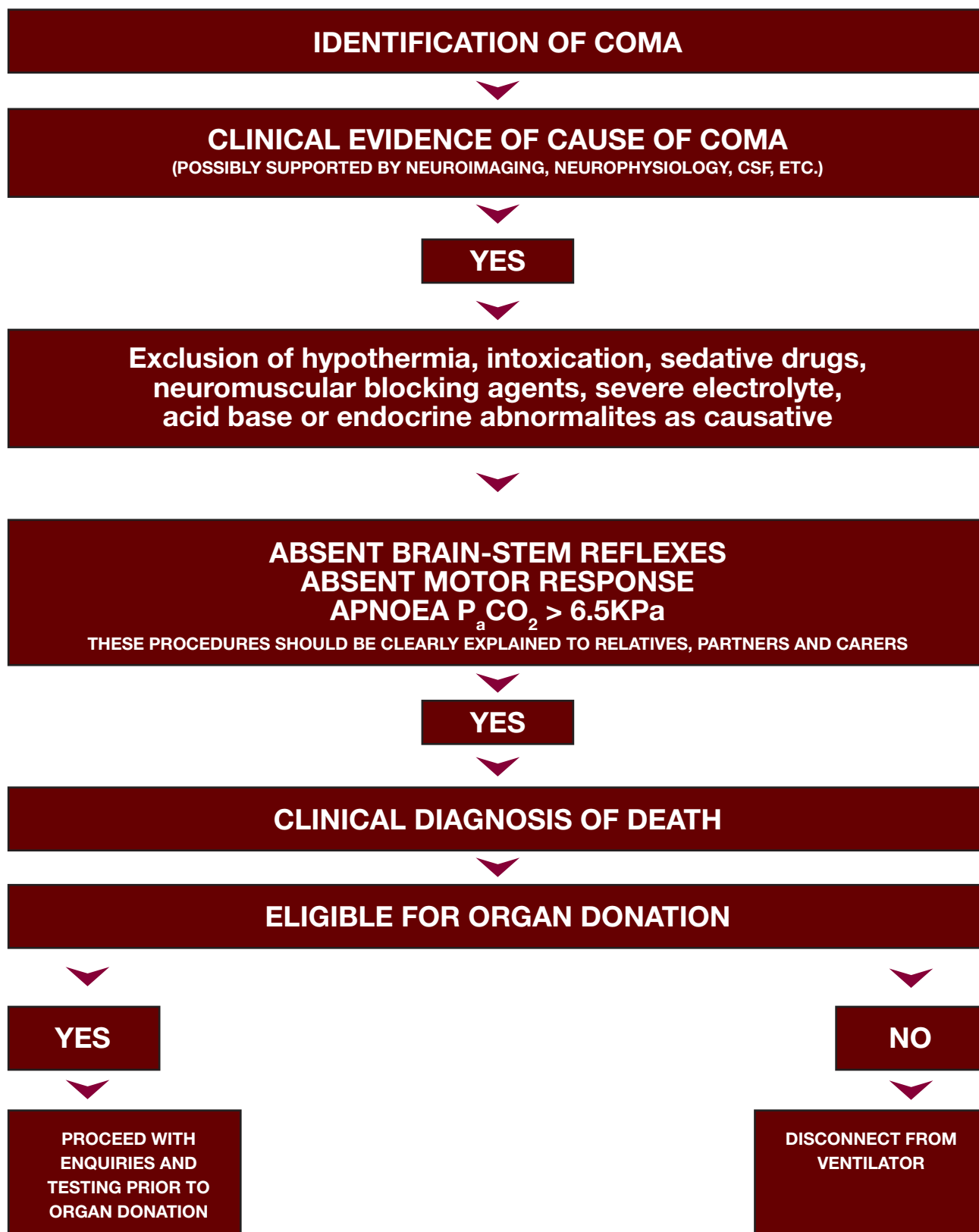
Dr B Signature:

Status:

Status:

APPENDIX 2

DIAGNOSTIC AND MANAGEMENT ALGORITHM



APPENDIX 3

SUMMARY AND ASSESSMENT OF THE RELATIVE BENEFIT AND COMPLEXITY OF THE VARIOUS SUPPORTIVE NEURORADIOLOGICAL AND NEUROPHYSIOLOGICAL TESTS THAT ARE AVAILABLE

TEST	RELIABILITY / ACCURACY	AVAILABILITY
BLOOD FLOW IN THE LARGER CEREBRAL ARTERIES:		
4 VESSEL ANGIOGRAPHY	GOOD	NEUROSCIENCE UNITS
TRANSCRANIAL DOPPLER	MIXED	VARIABLE
MR ANGIO	?	VARIABLE
SPIRAL CT ANGIO	?	WIDE

TEST	RELIABILITY / ACCURACY	AVAILABILITY
BRAIN TISSUE PERFUSION:		
HMPAO SPECT	GOOD	LIMITED
XENON CT	?	LIMITED
POSITRON EMISSION TOMOGRAPHY	GOOD	VERY RESTRICTED

TEST	RELIABILITY / ACCURACY	AVAILABILITY
NEUROPHYSIOLOGY		
EEG	MIXED	VARIABLE
EVOKED POTENTIALS	GOOD	VARIABLE

[Reliability/accuracy as reflected by the literature which is often sparse and anecdotal. There is insufficient literature on such new techniques as MR spectroscopy and diffusion weighted imaging to form any opinion. All these tests require that the operator is performing such examinations frequently for other reasons and is confident in their knowledge and understanding of the artefacts and pitfalls in their application to the diagnosis of irreversible cessation of brainstem reflexes.]

PORTABILITY	EXPERTISE TO PERFORM	EASE OF INTERPRETATION	RISKS
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NOT	HIGH	GOOD	<1%
YES	HIGH	NOT ALWAYS STRAIGHTFORWARD	0
NOT	HIGH	?	MINIMAL
NOT	MODERATE	GOOD (LIMITED LITERATURE)	MINIMAL

PORTABILITY	EXPERTISE TO PERFORM	EASE OF INTERPRETATION	RISKS
-------------	----------------------	------------------------	-------

NOT	MODERATE	NOT ALWAYS STRAIGHTFORWARD	0
conventional CT – not portable CT – possible quantification required	HIGH	?	0
NOT	HIGH	GOOD	0

PORTABILITY	EXPERTISE TO PERFORM	EASE OF INTERPRETATION	RISKS
-------------	----------------------	------------------------	-------

YES	HIGH	NOT ALWAYS STRAIGHTFORWARD	0
YES	HIGH	GOOD	0

APPENDIX 4

1991 REPORT OF A WORKING PARTY OF THE BRITISH PAEDIATRIC ASSOCIATION ON THE DIAGNOSIS OF BRAIN-STEM DEATH IN INFANTS AND CHILDREN

This, the 2008 Code of Practice endorses the 1991 Report, which is reproduced in full below, without any modification of the original text. The following four remarks below indicate how the 1991 Report should be read in relation to this revised Code of Practice.

1. Terminology

The concepts of 'brain death' and 'brain-stem death' are not employed in the 1991 report. The terminology that has been adopted in the 1991 report rest on the concept of a unitary state of death, as defined in the introduction. The 2008 Working Party recommends that the terminology in the 2008 Code of Practice should be substituted for the form of words used within the 1991 Report.

2. Children older than two months

Part b) of this section of the 1991 Report.

The preconditions specified in the 1991 Report are a subset of the preconditions laid out in section 5 of these guidelines. The Working Party recommends that the preconditions in both the 1991 report and this one should be fulfilled.

Part c) of this section of the 1991 Report.

The qualifications specified are no longer applicable as the 'senior registrar' grade no longer exists. The Working Party recommends that the assessments should be carried out, as specified in the guidelines, by at least two medical practitioners who have been registered for more than five years, have been trained in this field and are not members of the transplant team. In addition one of them should be a consultant, one of them should normally be a paediatrician or should have experience with children and one of them should not be primarily involved in the child's care.

3. Thirty-seven weeks to two months of age and infants below thirty-seven weeks gestation

The Working Party supports the conclusions and recommendations of the 1991 Working Party.

4. Appendix to 1991 Report

The criteria and exclusions for the diagnosis of death following irreversible cessation of brain-stem function in children older than two months and adults are laid out more fully in sections 5 and 6 of these 2008 guidelines which should be used in preference to the Appendix of the 1991 report. The Appendix of the 1991 report lists one criterion in the procedure for 'testing for brain-stem death' that is not mentioned in the equivalent sections of this 2008 or previous Working Party reports, viz, 'Doll's-eye reflex'. However, the oculomotor responses to caloric stimulation and passive head turning relate to each other as if the two stimuli differed only in degree, the first being stronger than the second. The only conditions in which absence of caloric responses accompanies preserved oculo-cephalic responses are bilateral lateral brain-stem lesions involving the vestibular nuclei or destruction of both labyrinths (e.g., streptomycin toxicity).¹⁸ The 2008 working party does not consider it necessary to include the Doll's-eye reflex when establishing the presence of irreversible and non-survivable cessation of brain-stem function in any age group.

DIAGNOSIS OF BRAIN-STEM DEATH IN INFANTS AND CHILDREN

**A WORKING PARTY REPORT OF THE BRITISH
PAEDIATRIC ASSOCIATION**

SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS TO 1991 REPORT

These guidelines apply to infants and children who are comatose, totally apnoeic, and being ventilated.

1. Children older than two months.

The working party recommends that:

- a) The formal assessment of brain-stem death is approached in an unhurried manner and time is spent ensuring that all the pre-conditions are satisfied.
- b) It is prudent to measure body levels of barbiturates (or other drugs) to confirm that they play no part in potentiating coma. Reversal of neuromuscular blockade must be demonstrated, by the presence of peripheral reflexes or by response to nerve stimulation.
- c) The assessment should be carried out separately by two experienced clinicians or consultant or senior registrar status; at least one should be a paediatrician, one should be a consultant, and one should not be primarily involved in the child's care.

2. Thirty Seven weeks gestation to 2 months of age

The working party concluded that given the current state of knowledge it is rarely possible confidently to diagnose brain-stem death at this age.

3. Infants below 37 weeks gestation

The working party concluded that the concept of brain-stem death is inappropriate for infants in this age group. Decisions on whether to continue intensive care should be based on an assessment of the likely outcome of the condition, after close discussion with the family.

4. Electrophysiological measurements in infants and children

The working party did not feel confident, given the current state of knowledge, that these investigations are a helpful addition to the diagnosis of brain-stem death.

*Anencephalic infants are not considered in this report; use of their organs for transplantation was the subject of a report of a working party of the Conference of Medical Royal Colleges and their Faculties in the United Kingdom¹

Introduction

The awareness that a patient may be brain dead whilst still mechanically ventilated arose in the 1970's in parallel with improvements in intensive care. Clearly it would be futile to continue supporting such a patient if there was certainty that their brain was irreversibly damaged. The debate culminated in the publication in 1976 of the Conference of Medical Royal Colleges' memorandum "The diagnosis of brain death",² which set out the clinical criteria to be satisfied before stopping ventilating a comatose adult. These guidelines form the basis of clinical practice in all adult intensive care units and neurological centres.

Paediatricians and especially neonatologists, are able to offer sophisticated intensive care to even the most immature infants and are now addressing the question of when to stop ventilating an infant whose brain is irretrievably damaged. The American Task Force (1987) set out the clinical criteria they considered to be valid for the diagnosis of brain death in infants and children.³

The Concept of Brain-Stem Death

Pallis defines death as "the irreversible loss of the capacity for consciousness, combined with irreversible loss of the capacity to breathe".⁴ These functions depend on the integrity of the brain-stem. There is evidence to show that for a patient with severe structural brain damage, if all the brain-stem death criteria are satisfied, asystole will inevitably follow within a few days despite continued ventilation.⁵ In adults 50% of the cases of brain death follow severe head injury, 30% are due to subarachnoid haemorrhage and 20% are due to a severe hypoxic-ischaemic event. Thus supra-tentorial catastrophes lead to pressure effect which cause the irretrievable death of the brain-stem. In adult neurosurgical and intensive care units the ability to diagnose brain-stem death has positive advantages for the staff and relatives caring for a deeply comatose patient. Once the news that the patient is brain dead is accepted, relatives usually agree that stopping ventilation is the logical and kindest next step. The opportunity to retrieve organs for transplantation then arises but should never be the reason for arriving at a diagnosis of brain-stem death.

The Clinical Criteria

The criteria for diagnosing brain-stem death are tabulated in the Appendix. All the pre-conditions must be satisfied and there should be demonstrably no pharmacological or metabolic reason for the coma before formally testing the integrity of the brain-stem reflexes. Persistent absence of these reflexes demonstrates widespread damage in the medulla and pons. The first two stages of the assessment are mandatory and emphasise that the assessment of a comatose patient should never be hurried. The formal testing of brain-stem reflexes is usually carried out 12–24 hours apart by two experienced clinicians.

The family often enquire about the possibility of organ donation and intensive care and neurological units are familiar with local arrangements for organ retrieval.

Physiological Measurements Used to Assess Brain Function

In adults it is generally agreed that EEG recordings in isolation are of no prognostic value and indeed an iso-electric recording may be compatible with survival. Radio-isotope, angiographic and Doppler techniques have been used to measure cerebral blood flow in adults and children. They are complex to carry out and low or absent cerebral blood flow does not necessarily equate with brain-stem death.

Brain-stem evoked potentials are a relatively new techniques whose value is still being assessed in comatose patients but may be open to the same criticisms as EEG recording.

Pallis concludes that such investigations add nothing to the bedside assessment of brain-stem death using the normal clinical criteria.⁴

Application of the Established Criteria for the Diagnosis of Brain-Stem Death to Children

The working party drew a very clear distinction between cessation of ventilation when the diagnosis of brain-stem death has been confirmed, and the agreed withdrawal of intensive care in a severely brain damaged child whose prognosis is deemed to be severe disability or a vegetative state.

This is a particular dilemma in the newborn as it is relatively uncommon to see infants who are clearly brain-stem dead. Volpe and Robinson emphasise this distinction and argue that withdrawal of life support systems is acceptable solely on the basis of the best interests of a devastatingly ill infant.^{6,7} The working party fully endorses this concept.

Children Older Than Two Months

There is a general agreement in the USA that the criteria for assessing brain death in adults are applicable. Clearly this presupposes an accurate assessment of the severity of the structural brain damage. This may be obvious from CT scanning in the case of trauma or cerebral haemorrhage but may not be assessed so easily when coma is due to an hypoxic-ischaemic encephalopathy or complicated multi-system failure.

The working party recommends that:

- a) The formal assessment of brain-stem death is approached in an unhurried manner and time is spent ensuring that all the re-conditions are satisfied.
- b) It is prudent to measure blood levels of barbiturates (or other drugs) to confirm that they play no part in potentiating coma. Reversal of neuromuscular blockade must be demonstrated, by the presence of peripheral reflexes or by response to nerve stimulation.
- c) The assessment should be carried out separately by two experienced clinicians of consultant or senior registrar status: one should normally be a paediatrician or should have experience with children, one should be a consultant, and one not primarily involved in the child's care.

37 Weeks Gestation to 2 Months of Age

The working party recognised that in this age group coma may occur for a wide variety of reasons. Perhaps the most common is an hypoxic-ischaemic encephalopathy, especially when the cerebral insult occurred in utero or at the time of birth. Such infants are very difficult to assess. It may not be possible satisfactorily to demonstrate structural brain damage and the infant may have multisystem failure. On these grounds alone it could be argued that brain-stem death should not be diagnosed.

In the USA, the Task Force considers that in certain infants, after a period of observation, it may be possible to satisfy all the pre-conditions for the diagnosis of brain-stem death. They recommend two formal clinical examinations of brain-stem function at least 48 hours apart together with an iso-electric EEG.³ Whilst there is no evidence that the standard criteria of brain-stem death will falsely identify infants in this age group as brain-stem dead, there is no published evidence that if ventilation is continued, asystole will follow in a few days. Such evidence was considered important in the development of the concept of brain-stem death in adults. The working party concluded that given the current state of knowledge it is rarely possible confidently to diagnose brain-stem death at this age.

Infants Below 37 Weeks Gestation

Apnoea and coma are common in this age group. It is extremely difficult to demonstrate irreversible brain damage in this age group, whilst hypoxia often is a complicating factor.

The development of brain-stem reflexes in the pre-term infant has not been systematically studied. There are no data on the development of the caloric reflex, whilst the pre-term infant may not respond to the tracheal stimulation by suction. Thus normal pre-term infants may fail to respond to some of the diagnostic tests for brain-stem death. Because the path-ways in the brain-stem are incompletely myelinated in very pre-term infants, it is likely that major damage in this region will have different effects to those seen in older children or adults.

Thus the working party concluded that the concept of brain-stem death is inappropriate for infants in this age group. Decisions on whether to continue intensive care should be based on an assessment of the likely outcome of the condition, after close discussion with the family.

Electrophysiological Measurements in Infants and Children

The working party reviewed the limited data available on the use of EEG, brain-stem potentials and blood flow measurements in children.

Although the American guidelines accept an iso-electric EEG as supportive evidence of brain death³, the working party did not feel confident that this investigation was of value in the diagnosis of brain death.

Radio-isotope or Doppler techniques for measuring cerebral blood flow are still being evaluated in children and neonates. They are only available in specialised centres and reports suggest that cerebral blood flow may be normal even when the child is brain-stem dead. The working party did not feel confident, given the current state of knowledge, that these investigations are a helpful addition to the diagnosis of brain-stem death.

REFERENCES TO 1991 REPORT

1. Report of a Working Party on Organ Transplantation in Neonates. Conference of Medical Royal Colleges and their Faculties in the United Kingdom. London: Department of Health and Social Security, (1988).
2. Conference of Medical Royal Colleges and their Faculties in the United Kingdom, 'Diagnosis of brain death', British Medical Journal 2:11 (1976), 1187–8
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5. Jennett, B., Gleave, J., Wilson, P., 'Brain death in three neurosurgical units', British Medical Journal 282 (1981), 533–9
6. Volpe, J. J., 'Brain death determination in the newborn', Pediatrics 80 (1987), 293–7.
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APPENDIX TO 1991 REPORT

The Criteria for Diagnosis of Brain-Stem Death

Pre Conditions

1. The patient is comatose and mechanically ventilated for apnoea.
2. The diagnosis of structural brain damage has been established or the immediate cause of coma is known.
3. A period of observation is essential.

Exclusions

1. Drugs are not the cause of coma e.g. barbiturates. Neuromuscular blockade has been demonstrably reversed.
2. Hypothermia does not exist.
3. There is no endocrine or metabolic disturbance.

Testing for Brain-Stem Death

Reflexes involving brain-stem function.

1. No pupillary response to light.
2. No corneal reflex.
3. No vestibulo ocular reflex (Caloric test).
4. Doll's eye reflex
5. No motor response to pain – in the Vth nerve distribution.
6. No gag reflex in response to suction through endotracheal tube or tracheostomy.
7. Apnoea persists despite a rise in $P_a\text{CO}_2$ to greater than 50 mmHg (6.6kPa) against a background of a normal $P_a\text{O}_2$.

WORKING PARTY MEMBERS OF 1991 REPORT

Dr M J Hardman
(Chairman)

Dr P J Fleming

Professor M I Levene
a nominee of the British Association of Perinatal Medicine

Professor R J Robinson
a nominee of the British Paediatric Neurology Association

Terms of reference:-

The working Party was established by the Council of the British Paediatric Association on 4 March 1988 to consider the diagnosis of brain-stem death in infants and children. Its terms of reference were to “establish criteria for the diagnosis of brain-stem death in infants and children which could be recommended for use by the medical profession as a whole”. The report was approved by Council of the BPA on 24 February 1989 and supported by the Council of the Royal College of Physicians of London on 8 June 1999.

ACKNOWLEDGEMENT

BPA Council is grateful to Dr C Pallis for help given to the Working Party.

APPENDIX 5

DEATH FOLLOWING THE IRREVERSIBLE CESSATION OF BRAIN-STEM FUNCTION – AN EXPLANATION

**Intensive Care Unit
The Royal London Hospital**

**Kate Torrens
Gerlinde Mandersloot
Sanet Marais**

How is death determined?

Many people don't realise that death can be determined/ diagnosed in two ways. Usually death occurs when the heart permanently stops beating and the person stops breathing. At the same time, the brain, having been starved of blood and oxygen, also dies. Sometimes, the brain dies first, breathing then stops and the heart stops soon after. (Where the heart stops first, people can occasionally be revived, provided the brain-stem hasn't died.)

In both cases, the most important point is that the brain-stem, the essential part of the brain, has died.

The brain-stem controls all the essential functions that keep us alive, most importantly our consciousness/awareness, our ability to breathe and the regulation of our heart and blood pressure. Once the brain-stem has died it cannot recover and no treatment can reverse this. Inevitably the heart will stop beating; even if breathing is supported by a machine (ventilator).

Causes of irreversible cessation of function of the brain-stem

Irreversible cessation of function of the brain-stem will occur if it has been deprived of its blood and oxygen supply. This usually occurs after the heart has stopped beating (cardiac arrest) and breathing has stopped.

It can also cease to function when other parts of the brain are affected by trauma, bleeding, infection or tumour growth. Regardless of the cause of the damage, the brain responds to the injury by swelling. This swelling is similar to what would happen if you twisted your ankle; it would swell and bruise.

However, unlike other areas of the body, there is little room for the brain to expand. This is because the skull surrounding the brain is inflexible and there is very little room inside the skull for the brain to swell. The brain swelling then causes a build-up of pressure within the skull, which can cut off the blood supply to parts of the brain as well as damaging the brain tissue and causing further damage to the brain.

Medical treatment attempts to limit this build-up of pressure;

however, despite treatment it is not always possible to stop or reverse this. If the pressure inside the skull gets too high, the brain, with no more room to expand, is forced down through the small opening in the base of the skull where it meets the spinal cord. This then causes pressure to build up in the brain-stem, cutting off its blood and oxygen supply. If this persists long enough, the brain-stem ceases to function.

When this happens, the patient's ability to regain consciousness or breathe also stops and, normally, the heart would stop shortly after. If the patient's breathing is supported artificially by a ventilator, oxygen will continue to be delivered to the heart and it will continue to beat for a period of time. However, because the body's control centre has died, the heart will eventually stop beating, despite the ventilator continuing to provide oxygen to the lungs.

How does cessation of brain-stem function differ from other conditions causing coma?

When brain-stem function ceases irrevocably, the loss of consciousness is irreversible and permanent. In other conditions causing coma, the loss of consciousness may be reversible and incomplete. The damage in these conditions is usually situated in other parts of the brain and not in the brain-stem. Also, with other types of coma the brain-stem continues to control and regulate the rest of the body, and the person retains the ability to breathe.

What makes doctors suspect that a patient on a ventilator has died?

Although the patient's breathing and thus their heartbeat are maintained by the ventilator, doctors and nurses will recognise signs which indicate that the patient may have died. Most often the patient's pupils stop reacting to light or their blood pressure and heart rate change. Also, the patient's lack of response to various types of stimulation could lead medical and nursing staff to consider that irreversible cessation of brain-stem function may have occurred.

How do doctors find out/confirm whether death following irreversible cessation of brain-stem function has occurred?

In order to find out if the patient has died, two senior doctors (one of whom has to be a consultant) have to perform a series of tests. These neurological tests are performed to confirm irreversible loss of consciousness and the inability to breathe, as well as the absence of all other brain-stem functions. If no activity can be demonstrated in the brain-stem, function cannot be restored and the heart will inevitably cease to beat subsequently.

How are the tests done?

Before the tests take place the cause of the patient's coma will have been diagnosed and any reversible causes of coma, such as a low temperature, severe metabolic abnormalities or the effect of drugs used to sedate the patient, have to be ruled out. Once this has been done, two sets of tests are performed at the bedside, each set taking about half an hour.

The tests follow strict rules and include examining the patient's response to physical stimuli, assessing whether their pupils react to light and their ability to breathe unaided. There is usually a short gap between the two sets of tests, during which findings are often discussed with relatives.

What about spontaneous movements of the arms and legs?

It is possible for primitive reflexes of the spinal cord to continue after a person has died. These can lead to a visible twitching or movement of the hands or legs. In declaring that irreversible cessation of brain-stem function has occurred, the doctors will have established that these movements are contained entirely within the spinal cord and are not connected to the brain at all.

While such movement can be very distressing it is important to realise it is not an indication of any brain-stem activity.

After the tests

After the tests have been performed, confirming the absence of any function in the brain-stem, the person will be declared dead. The doctors will discuss the results of the neurological tests of brain-stem function with you. The legal time of death will be the completion of the first set of brain-stem death tests.

What will happen next?

After the tests have confirmed that the brain-stem has stopped functioning, staff caring for your relative will discuss what happens next. The staff caring for your loved one will provide help and support to you and your family.

The Members of the Working Party are grateful to Kate Torrens, Gerlinde Mandersloot and Sanet Marais, from the Intensive Care Unit of the Royal London Hospital, for allowing them to include this information as an Appendix to this revised Code of Practice.

APPENDIX 6

LIST OF ORGANISATIONS AND INDIVIDUALS RESPONDING TO THE PUBLIC CONSULTATION

Responses to the three-month public consultation period ending in August 2006 were received from the following organisations:

British Medical Association
British Organ Donor Society
British Psychological Society
College of Emergency Medicine
Coroner's Officers Association
Donor Family Network
Faculty of Pharmaceutical Medicine
Human Tissue Authority
Intensive Care Society
National Patient Safety Agency
Nursing and Midwifery Council
Royal College of Anaesthetists Council
Royal College of Anaesthetists – Patient Liaison Group
Royal College of General Practitioners
Royal College of Nursing
Royal College of Obstetricians and Gynaecologists
Royal College of Paediatrics and Child Health
Royal College of Pathologists, Ethics Committee
Royal College of Pathologists, Specialist Advisory Committee
Royal College of Physicians of Edinburgh
Royal College of Physicians of London Council
Royal College of Physicians of London Patient and Carer Network
Royal College of Radiologists, Patient Liaison Group
Royal College of Surgeons of England, Patient Liaison Group
Scottish Intensive Care Society
UK Transplant
United Kingdom Transplant Co-ordinators Association

Responses to the three-month public consultation period ending in August 2006 were received from the following individuals:

Dr Ian Back
Dr Susan Bewley
Dr Owen Boyd
Dr Andrew Cadamy
Mr R W S Chang
Dr Nick Coleman
Dr Mary Cooke
Dr John Curran
Dr Helen Doran
Dr Mark Ehlers
Dr Andrew Eynon
Dr Iain Farquhar
Drs Dale Gardiner
Dr Keith Girling
Dr David Hill
Dr David Holland
Dr Ari Joffe
Dr Paul Lawler
Dr Joanna Lynes
Mr Mark Madams
Dr Richard Marsh
Dr Kevin Morris
Dr Keith Myerson
Mr Richard Nelson
Dr David Noble
Professor David Price
Mr Andrew Raftery
Dr P A Razis
Dr Fiona Reynolds
Dr Keith Rigg
Dr Bernard Riley
Dr David Selwyn
Dr Martin Smith
Dr David Sperry
Dr Anne Sutcliffe
Professor Sir James Underwood
Dr Christopher Wade
Dr Martin Walker
Dr Robert Winter
Dr Paddy Yeoman

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GLOSSARY

Acidosis	Increased acid state of the body
Acidaemia	Increased acid in the blood
Alkalosis	Increased alkaline state of the body
Alkalaemia	Increased alkali (base) in the blood
Auditory meatus	External opening of ear, 'ear hole'
Apnoea	Absence of breathing
Auscultation	Listening – usually to heart or breathing sounds
Asystole	Absence of heartbeat
Base	Alkali
Cerebrum	The part of brain responsible for higher mental function when brain-stem function is intact
Cranium	Skull
Cardiorespiratory arrest	Combined cessation of heartbeat and breathing
Cardiac	Related to the heart
Cardiac autoresuscitation	Spontaneous restarting of the heartbeat
Circulation	Blood flow around the body
Coma	Unconsciousness
CO₂	Carbon dioxide
CPAP	Continuous positive airway pressure a method of improving oxygenation transfer from the lungs into the blood
ECG	Electro-cardiogram; either a paper or electronic trace
EEG	Electro-encephalogram; a recoding of brainwave activity
E_tCO₂	End tidal carbon dioxide; the level at the end of a normal breath
F_iO₂	Inspired oxygen concentration
Gag reflex	Choking reflex

Hypnotics	Sedative, sleep inducing drugs
Hypoxia	Lack of oxygen
Hypo-	Low
Hyper-	High
Hypocarbica	Low carbon dioxide concentration
Hypercarbica	High carbon dioxide concentration
Hypothermia	Low body temperature
Hyperthermia	High body temperature
Hyponatraemia	Low blood sodium concentration
Hypernatraemia	High blood sodium concentration
Hypokalaemia	Low blood potassium concentration
Hyperkalaemia	High blood potassium concentration
Hypoglycaemia	Low blood sugar concentration
Hyperglycaemia	High blood sugar concentration
ICS	Intensive Care Society
ICU	Intensive Care Unit
Intra-cerebral haemorrhage	Bleeding within the brain
Intra-cranial haemorrhage	Bleeding within the skull, including the brain
KPa	Kilopascal; a unit of pressure measurement
Metabolic	To do with the energy supplies of the body
Muscle relaxants (Neuromuscular Blocking Drugs)	Paralysing drugs
Mechanical ventilation	Mechanical support of a patient's breathing, by connecting him/her to a breathing machine
Motor function	Movement of parts of the body
Narcotics	Morphine-like drugs with pain relieving, sedative and respiratory depressant properties

GLOSSARY CONTINUED

Neural/neuronal	Related to nerves and nervous function
Normocarbica	Normal carbon dioxide concentration
O₂	Oxygen
P_aO₂	Partial pressure of oxygen in arterial blood
P_aCO₂	Partial pressure of carbon dioxide in arterial blood
Palpation	Feeling for shapes or movement
Pathognomonic	Invariably diagnostic of
Respiration	Breathing
S_aO₂	Arterial oxygen saturation; normally above 90%
Supraorbital	The area above the eye
Somatic	Related to voluntary muscle function
Somatosensory	Nerve impulses generated by outside stimuli, e.g., touch, sound
Ventilatory/ventilation	To do with (artificial) breathing

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Registered Charity
Number 1056565

Form for the Diagnosis of Death using Neurological Criteria {abbreviated guidance version}

This form is consistent with and should be used in conjunction with, the AoMRC (2008) *A Code of Practice for the Diagnosis and Confirmation of Death* and has been endorsed for use by the Faculty of Intensive Care Medicine and Intensive Care Society.

HOSPITAL ADDRESSOGRAPH or

Surname
First Name
Date of Birth
NHS Number

Evidence for Irreversible Brain Damage of known Aetiology

Primary Diagnosis:

Evidence for Irreversible Brain Damage of known Aetiology:

Diagnostic caution is advised in certain '**Red Flag**' patient groups. See Page 3 for details.

Exclusion of Reversible Causes of Coma and Apnoea

	1 st Test Dr One	1 st Test Dr Two	2 nd Test Dr One	2 nd Test Dr Two
Is the coma due to depressant drugs? Drug Levels (if taken):	Yes / No	Yes / No	Yes / No	Yes / No
Is the patient's body temperature $\leq 34^{\circ}\text{C}$?	Yes / No	Yes / No	Yes / No	Yes / No
Is the coma due to a circulatory, metabolic or endocrine disorder?	Yes / No	Yes / No	Yes / No	Yes / No
Is the apnoea due to neuromuscular blocking agents, other drugs or a non brain-stem cause (eg. cervical injury, any neuromuscular weakness)?	Yes / No	Yes / No	Yes / No	Yes / No

Tests for Absence of Brain-Stem Reflexes

	1 st Test Dr One	1 st Test Dr Two	2 nd Test Dr One	2 nd Test Dr Two
Do the pupils react to light?	Yes / No	Yes / No	Yes / No	Yes / No
Is there any eyelid movement when each cornea is touched in turn?	Yes / No	Yes / No	Yes / No	Yes / No
Is there any motor response when supraorbital pressure is applied?	Yes / No	Yes / No	Yes / No	Yes / No
Is the gag reflex present?	Yes / No	Yes / No	Yes / No	Yes / No
Is the cough reflex present?	Yes / No	Yes / No	Yes / No	Yes / No
Is there any eye movement during or following caloric testing in each ear?	Yes / No	Yes / No	Yes / No	Yes / No

Brain-Stem Reflexes

Please circle as appropriate

Form for the Diagnosis of Death
using Neurological Criteria {abbreviated guidance version}

Patient Name:

NHS Number:

Apnoea Test

Apnoea Test				
	1 st Test Dr One	1 st Test Dr Two	2 nd Test Dr One	2 nd Test Dr Two
Arterial Blood Gas pre apnoea test check: (Starting PaCO ₂ ≥ 6.0 kPa and starting pH < 7.4 or [H ⁺] > 40 nmol/L)	1 st Test Starting PaCO ₂ : Starting pH/[H ⁺]:		2 nd Test Starting PaCO ₂ : Starting pH/[H ⁺]:	
Is there any spontaneous respiration within 5 (five) minutes following disconnection from the ventilator?	Yes / No	Yes / No	Yes / No	Yes / No
Arterial Blood Gas Result post apnoea test: (PaCO ₂ should rise > 0.5 kPa)	1 st Test Final PaCO ₂ : <i>Perform lung recruitment</i>		2 nd Test Final PaCO ₂ : <i>Perform lung recruitment</i>	
Document any Ancillary Investigations Used to Confirm the Diagnosis or any required Clinical Variance from AoMRC (2008) Guidance				
Completion of Diagnosis				
Are you satisfied that death has been confirmed following the irreversible cessation of brain-stem-function?	YES / NO		YES / NO	
Legal time of death is when the 1 st Test indicates death due to the irreversible loss of brain stem function. Death is confirmed following the 2 nd Test.	Date: Time: Dr One Name Grade GMC Number Signature Dr Two Name Grade GMC Number Signature		Date: Time: Dr One Name Grade GMC Number Signature Dr Two Name Grade GMC Number Signature	

Form for the Diagnosis of Death using Neurological Criteria {abbreviated guidance version}

It remains the duty of the two doctors carrying out the testing to be satisfied with the aetiology, the exclusion of all potentially reversible causes, the clinical tests of brain-stem function and of any ancillary investigations so that each doctor may independently confirm death following irreversible cessation of brain-stem function.

Guidance Summary of the AoMRC Code of Practice

The diagnosis of death by neurological criteria should be made by at least two medical practitioners who have been registered for more than five years and are competent in the conduct and interpretation of brain-stem testing. At least one of the doctors must be a consultant. Testing should be performed completely and successfully on two occasions with both doctors present. It is recommended that one doctor perform the test while the other doctor observe; roles may be reversed for the second test.

Diagnostic caution is advised in the following 'Red Flag' patient groups.

(Based on the literature and unpublished case reports.)

- | | | |
|--|---|--|
| 1. Testing < 6 hours of the loss of the last brain-stem reflex | 4. Patients with any neuromuscular disorders | 6. Prolonged fentanyl infusions |
| 2. Testing < 24 hours where aetiology primarily anoxic damage | 5. Steroids given in space occupying lesions such as abscesses | 7. Aetiology primarily located to the brain-stem or posterior fossa |
| 3. Hypothermia
(24 hour observation period following re-warming to normothermia recommended) | | |

Evidence for Irreversible Brain Damage of Known Aetiology

- There should be no doubt that the patient's condition is due to **irreversible brain damage of known aetiology**. Occasionally it may take a period of continued clinical observation and investigation to be confident of the irreversible nature of the prognosis. The timing of the first test and the timing between the two tests should be adequate for the reassurance of all those directly concerned. **If in doubt wait and seek advice.**

Children (one examining doctor should normally be a paediatrician or should have experience with children and one of the doctors should not be primarily involved in the child's care)

- Older than 2 months post term:** This guideline can be used in these children.
- Between thirty seven weeks corrected gestation (post menstrual) age to 2 months of age post term:** use the RCPCH Guidance available at www.rcpch.ac.uk
- Infants less than 37 weeks corrected gestation (post menstrual) age:** the concept of brain-stem death is inappropriate for infants in this age group.

Drugs

- The patient should not have received any drugs that might be contributing to the unconsciousness, apnoea and loss of brainstem reflexes (narcotics, hypnotics, sedatives or tranquillisers). Where there is any doubt specific drug levels should be carried out (midazolam less than < 10mcg/L, thiopentone <5mg/L). Alternatively consider ancillary investigations.
- There should be no residual effect from any neuromuscular blocking agents (atracurium, vecuronium or suxamethonium), consider the use of peripheral nerve stimulation.
- Renal or hepatic failure may prolong metabolism / excretion of these drugs.

Temperature, Circulatory, Metabolic or Endocrine Disorders

- Prior to testing aim for: temperature > 34°C, mean arterial pressure consistently >60mmHg (or age appropriate parameters for children), maintenance of normocarbia and avoidance of hypoxia, acidaemia or alkalaemia (PaCO₂ <6.0 kPa, PaO₂ >10 kPa and pH 7.35 – 7.45 / [H⁺] 45-35 nmol/L).
- Serum Na⁺ should be between 115-160mmol/L; Serum K⁺ should be > 2mmol/L; Serum PO₄³⁻ and Mg²⁺ should not be profoundly elevated (>3.0mmol/L) or lowered (<0.5mmol/L) from normal.
- Blood glucose should be between 3.0-20mmol/L before each brain-stem test.
- If there is any clinical reason to expect endocrine disturbances then it is obligatory to ensure appropriate hormonal assays are undertaken.

Form for the Diagnosis of Death

using Neurological Criteria {abbreviated guidance version}

Brain Stem Reflexes

- Pupils should be fixed in diameter and unresponsive to light.
- There should be no corneal (blink) reflex (care should be taken to avoid damage to cornea).
- Eye movement should not occur when each ear is instilled, over one minute, with 50mls of ice cold water, head 30°. Each ear drum should be clearly visualised before the test.
- There should be **no motor response** within the **cranial nerve** or **somatic** distribution in response to **supraorbital pressure**. **Reflex limb** and **trunk movements** (**spinal reflexes**) **may** still be **present**.
- There should be no gag reflex following stimulation to the posterior pharynx or cough reflex following suction catheter placed down the trachea to the carina.

Apnoea Test

- **End tidal carbon dioxide** can be used to **guide** the **starting** of each apnoea test but should not replace the pre and post arterial PaCO_2 .
- Oxygenation and cardiovascular stability should be maintained through each apnoea test.
- **Confirm $\text{PaCO}_2 \geq 6.0 \text{ kPa}$ and $\text{pH} < 7.4$ / $[\text{H}^+] > 40 \text{ nmol/L}$** . In patients with **chronic CO_2 retention**, or those who have received intravenous bicarbonate, confirm **$\text{PaCO}_2 > 6.5 \text{ kPa}$ and the $\text{pH} < 7.4$ / $[\text{H}^+] > 40 \text{ nmol/L}$** .
- Either use a **CPAP circuit** (eg Mapleson B) or **disconnect** the patient from the **ventilator** and administer **oxygen via a catheter** in the trachea at a rate of **$> 6 \text{ L/minute}$** .
- There should be **no spontaneous respiration** within a minimum of **5 (five) minutes** following disconnection from the ventilator.
- **Confirm that the PaCO_2 has increased from the starting level by more than 0.5 kPa** .
- At the conclusion of the apnoea test, manual recruitment manoeuvres should be carried out before resuming mechanical ventilation and ventilation parameters normalised.

Ancillary Investigations

- Ancillary investigations are **NOT** required for the diagnosis and confirmation of death using neurological criteria. Any ancillary or confirmatory investigation should be considered **ADDITIONAL** to the fullest clinical testing and examination carried out to the best of the two doctors capabilities in the given circumstances.

Organ Donation

- National professional guidance advocates the confirmation of death by neurological criteria wherever this seems a likely diagnosis and regardless of the likelihood of organ donation.
- NICE guidance recommends that the **specialist nurse for organ donation (SN-OD)** should be **notified** at the point **when the clinical team declare the intention to perform brain-stem death tests** and this is supported by GMC guidance.

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