BRAIN STEM DEATH AND BRAIN STEM TESTING: GUIDELINES FOR DEPLOYED UK MEDICAL STAFF

Summary

1. Patients who are brain injured may have undergone brain stem death (BSD). It is important to be able to diagnose BSD and confirm death. This is to avoid further distress to families by giving false expectation of survival and to avoid inappropriate medical transfer of the deceased.

2. The number of patients who may satisfy the preconditions for brain stem testing (BST) on operations has historically been small and is expected to remain so[1]. Where the preconditions are not met and if any doubt exists, testing should not be carried out. If BST is not undertaken, alternative treatment pathways are to be considered by the clinical team[2]. This may include rearward evacuation where that is indicated[3].

Scope

3. This leaflet provides guidance specifically for UK medical personnel on deployed operations working in UK Medical Treatment Facilities (MTFs) or UK-led MTFs. In other circumstances, such as where UK is not the medical lead, or where other nation's personnel are being treated by UK medical personnel, guidance will need to be sought from the relevant medical commanders, PJHQ and other SMEs on a case-by-case basis[4].

4. For complete guidance all text, notes and annexes need to be read thoroughly.

Background

5. In the operational environment BSD would usually occur as a consequence of severe head injury, where there has been intracranial bleeding or other intracranial pathology[5] leading to globally increased intracranial pressure (ICP) with subsequent infarction of the brain stem.

6. Secondary effects occurring at the time of injury or immediately afterwards, such as hypoxaemia, hypoventilation and hypotension, may aggravate the cerebral insult. There may also be other causes of cerebral injury such as the energy transfer from a blast wave, hypoxaemia or hypotension secondary to haemorrhage[6]. In such cases where these are the sole cause of suspected cerebral injury it is unlikely that the patient will satisfy the primary criterion for performing BST which is absence of doubt that the patient's condition is due to irremediable brain damage.

7. Injuries arising in this latter way present a difficult diagnostic situation at the best of times and the availability of supportive investigations in the field environment is unlikely[7]. In such a situation BST should not be undertaken and the advice on general care given above should be followed.

8. There will be occasions when damage to the brain stem is irreversible and BSD has already occurred or will be inevitable. When BSD is likely and the preconditions for testing are met, the diagnosis should be made for the reasons given above. The diagnosis requires strict adherence to

[1] This is partly due to the forward use of sedative drugs, analgesia and advanced airway management, coupled with rapid evacuation to Role 4.

[2] In cases where testing cannot be undertaken all treatment options need to be considered in the best interest of the patient. Depending on clinical assessment, options may include expectant treatment, treatment limitation and treatment withdrawal, but such treatment pathways will require wide consultation within the clinical team and must be in the best interest of the patient. General Medical Council, Treatment and care towards the end of life, 20th May 2010.

[3] On occasions due to the nature of the injury, e.g. catastrophic haemorrhage, it may not be feasible to evacuate and treatment may be limited to what is available in the theatre of operations.

[4] In some operational theatres agreements may have been made and joint policy will exist, but this will still require confirmation prior to testing.

[5] Such as penetrating ballistic trauma, where a mixture of direct trauma and pressure wave effects lead to cerebral injury.

[6] This may occur where there is significant haemorrhage consequent on the injuries received.

[7] Facial and other trauma to the head and neck may also preclude testing, as will high spinal cord injury.

the guidelines for preconditions, exclusions and testing as defined by the UK Code of Practice for the Diagnosis and Confirmation of Death, which are detailed in this leaflet and annexes.

9. The clinical diagnosis of BSD[8] in the UK relies upon the lack of brain stem reflexes in a patient in apnoeic coma from a known, irreversible cause, with normal electrolytes, normothermia and in the absence of sedative drugs or muscle relaxants. Implicit to ensuring these preconditions are met is a period of observation, which will vary according to aetiology[9].

10. Additional notes on BSD are at Annex A.

Initial Treatment

11. Patients who subsequently become brain stem dead usually present deeply comatose with or without respiratory effort. The initial management of these patients is no different from any other patient: maintain life, determine the cause of coma and attempt to restore function by optimising physiological parameters.

12. Resuscitation of the patient according to the latest DMS Guidelines and training will ensure the best possible outcome from a whole body and neurological perspective. Where there is head injury steps will naturally be taken as part of the overall resuscitation strategy to optimise cerebral oxygenation[10], normocarbia and perfusion pressure. This aspect, as with all components of resuscitation, includes oxygen delivery, ventilation, acid base balance, cardiovascular adequacy, coagulation, transfusion and fluid management.

13. Once the initial threats to life have been addressed and resuscitation is optimal, assessment of any serious neurological injury may be made. If BSD is suspected BST will only be performed once the preconditions for testing have been fully met. In the majority of severe head injuries seen as a result of combat there will be confounding factors which will not allow BST to be undertaken. In the small number that should undergo BST, however, it is ethically appropriate for this to take place for the best interests of the patient to be fulfilled. This will also serve to avoid additional anguish to the deceased's family from false expectation of recovery and inappropriate medical evacuation.

Conduct Of Testing

14. **Timing of Tests.** BST should only be contemplated where there is no doubt that the patient's condition is due to irremediable cerebral damage. This may be obvious following a primary intracranial event, such as a penetrating head injury or spontaneous bleed[11]. Where a patient has suffered primarily from blast, profound hypotension, with or without cardiac arrest and hypoxia it may take longer to establish the diagnosis. This will only be achieved with continuing clinical observation and investigation[12].

15. Sufficient time must have elapsed so that resuscitation and support will have produced optimisation of whole body conditions, which include the central nervous system and cerebrum. In the case of isolated head injury resuscitation of the brain may require specific interventions to optimise conditions[13].

16. The tests are performed twice. The interval between the tests is at the discretion of the

[8] In English Law there is currently no statutory definition of death, but the courts in England and Northern Ireland have included the criteria of brain death in the law for the diagnosis of death. Ref: 'A Code of Practice For The Diagnosis and Confirmation of Death. Academy of Medical Royal Colleges 2008'. LINK: http://aomrc.org.uk/publications/reports- guidance/doc_download/42-a-code-of-practice-for-the-diagnosis-and-confirmation-of-death.html)

[9] It may be obvious in the case of a primary intracranial event such as severe head injury, however in a patient who has an ill defined anoxic insult or embolism it may take longer to establish the diagnosis to be confident of the prognosis.

[10] This means maximising the oxygen content of blood, as for other organ preservation.

[11] Unusual, but not unknown in the deployed environment.

[12] Confounding factors and the ability to call upon ancillary testing would usually result in the option of BST being inappropriate.

[13] Head up, optimising cerebral perfusion pressure (ensuring venous drainage, vasoactive agents, monitoring ICP), diuretics, hyperosmolar fluids, ventilation and oxygenation, correcting anaemia, electrolytes, etc.

patient's clinicians[14]. On each occasion of testing the complete set of tests are to be performed. During testing one medical practitioner performs the test while the other observes. These roles may be reversed for the second test if desired.

17. 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, but a period of time will be necessary after reconnection to the ventilator. This is to allow for the return of the patient's arterial blood gases and baseline parameters to the pre-test state. It also allows for rechecking of the blood sugar concentration and for the reassurance of all those directly concerned that conditions are correct for the second test to take place.

18. **Clinicians Undertaking BST.** Testing must be undertaken by 2 medical practitioners acting together. These clinicians must satisfy the following requirements:

a. **Adults**. BST must be undertaken by at least 2 medical practitioners and at least one of them must be a Consultant. Both must have been registered for more than 5 years and be competent in the conduct and interpretation of BST[15]. Neither must have, nor be perceived to have, any clinical conflict of interest[16].

b. **Children**. In the case of a child (who must be at least 2 months of age[17]), testing must be carried out by at least 2 medical practitioners who have been registered for more than 5 years and have been trained in this procedure. One of them must be a consultant. Additionally, one of them should normally be a paediatrician, or have experience with children and one should not be primarily involved in the child's care. In the deployed setting a paediatrician is unlikely to be available, but there may be deployed medical practitioners who are experienced in working with children. Regardless of this, in any case involving children, guidance should be sought from Role 4 (Paediatric Support to Operations) before BST is undertaken. If suitably experienced clinicians are not available and specialist advice cannot be obtained, BST should not be undertaken. Alternative treatment pathways are then to be considered by the clinical team, as in the adult case where BST is not undertaken (paragraph 2 of this leaflet gives guidance).

19. **Preconditions.** Prior to BST being carried out, the following conditions must be satisfied:

a. The patient must be deeply comatose, unresponsive, and apnoeic and is being artificially ventilated.

b. The patient's condition must be due to irreversible brain damage of known aetiology.

c. Potentially reversible causes of coma must have been excluded:

(1) There should be no evidence that this state is due to depressant drugs or alcohol.

(2) Primary hypothermia (i.e. core temperature below 34 degrees Celsius) has been excluded as the cause of unconsciousness. Where there have been efforts to induce

[14] The repetition of testing is to ensure there are no errors of process have occurred and are not performed to check if the first test gave a correct diagnosis. This ensures an added level of confidence to the clinicians so that they can be sure that they have followed the guidelines as intended and no portion of the test has been omitted. BST carried out as described will confirm BSD and allow the diagnosis of death.

[15] This is key to this process. If the clinician cannot satisfy the criteria they should not be involved in testing.

[16] "Nor be a member of a transplant team" this is stated in the original Academy document, but is omitted in this leaflet as it cannot be envisaged that any circumstances would present on operations where a transplant team would have involvement. It may be that other members of the medical team (the DMD for example) may be perceived to have a conflict of interest and this must be addressed before any BST is contemplated.

[17] Testing is not recommended between the ages of 37 weeks gestation and 2 months of age as it is rarely possible to confidently diagnose BSD in this age group.

hypothermia for therapeutic purposes, it must be completely reversed and sufficient time elapsed for central re-warming to have taken place[18]. Core temperature must be above 34°C.

(3) Potentially reversible circulatory, metabolic and endocrine disturbances have been excluded and cardiovascular function has been optimised (see above regarding resuscitation).

d. Potentially reversible causes of apnoea must have been excluded:

(1) Apnoea is not due to neuromuscular blocking drugs[19] (nor is lack of movement or response to stimulation).

(2) Profound neuromuscular weakness may mimic absence of reflexes. This emphasises the requirement for "*a clear diagnosis of irremediable brain damage of known aetiology"* as stated above.

20. **Signs Ruling Out BSD.** There are a number signs which indicate that BSD cannot have occurred and BST is not appropriate. These are detailed in Annex A.

21. **Brain Stem Testing.** The same clinical tests are used for adults and children over the age of 2 months:

a. **Pupillary Reflex**. Absent. The pupils are fixed[20] and do not react to sharp changes in the intensity of incident light.

b. **Corneal Reflex**. Absent.

c. **Oculo-Vestibular Reflex**. Absent.

d. **Supraorbital Pressure**. No motor response can be elicited within the cranial nerve or somatic distribution in response to supraorbital pressure[21].

e. **Cough and Gag Reflexes**. There is no cough reflex in response to bronchial stimulation, or gag reflex in response to posterior pharyngeal stimulation.

f. **Apnoea Test**. Positive, with no respiratory movements seen.

22. The apnoea test must be the last test in each sequence of tests. It should not be undertaken if any of the preceding tests indicate brain stem function.

Additional Information

23. Detailed notes on the conduct of BST are at Annex B.

24. **Time of Death.** The legal time of death is on completion of the first set of brain stem death tests, although death is not pronounced until the second tests have been completed.

25. The declarations of brain death must be recorded in the medical notes (see below) with the

[18] The cooling effect of reperfusion of limbs which have been subject to tourniquets must also be considered as should the administration of fluids that are below body temperature. The time taken for core re-warming may be longer than expected so that a generous allowance for this should be made.

[19] A peripheral nerve stimulator should be routinely used to exclude this possibility. This is particularly important with patients who have come from combat situations where recording of drug administration may occasionally be unreliable. Drug errors may also be a potential confounding factor where resuscitation has not been straightforward.

[20] Not pinpoint as this may indicate the residual influence of opioid drugs. Dilatation is seen with beta adrenergic agents such as adrenaline and anticholinergic agents such as atropine.

[21] Neither is there motor responses seen in the cranial nerve distribution by adequate stimulation of a somatic area.

date and time. A death certificate may be issued at this time, if the coroner is not involved.

26. **Recording of BST Findings.** These are to be recorded contemporaneously on the form at Annex C. The time of onset of coma and the time of death must also be recorded in the patient notes. Extant procedures for dealing with the deceased are then to be followed.

ADDITIONAL NOTES REGARDING BRAIN DEATH[1]

Some of the conditions discussed below are most unlikely to be seen in UK military personnel, however there may be exceptions.

1. **Circulatory, blood gas, metabolic and endocrine disturbances**. Potentially reversible circulatory, blood gas, metabolic and endocrine disturbances must have been excluded as the cause of the continuation of unconsciousness.

2. While trying to provide broad guidance on the magnitude of disturbances 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.

3. Circulatory, metabolic and endocrine disturbances (e.g. hypernatraemia, diabetes insipidus) are likely accompaniments of death as a result of cessation of brain-stem function. These, however, may be the effect rather than the cause of BSD and do not preclude the diagnosis of death by neurological testing of brain-stem reflexes.

4. Rapid correction of such abnormalities may be detrimental as may be delaying BST simply because of strict adherence to the requirement to attain a predetermined blood electrolyte concentration.

a. **Circulatory Disturbances**. Circulation must be maintained prior to testing. The mean arterial pressure should be consistently greater than 60mmHg. This requires meticulous attention to resuscitation, ensuring adequate vascular filling and pharmaceutical support of the circulation if required. This will serve to provide optimal whole body perfusion, including the CNS. In isolated head injury specific measures may be required to optimise cerebral perfusion pressure (CPP) where the "normal" circulation has not been compromised.

b. **Blood gases**. There should be maintenance of normocarbia and avoidance of hypoxia. Ventilation should be manipulated to achieve these goals, with the additional avoidance of acidaemia or alkalaemia. Prior to the commencement of testing $PaCO_2$ should be less than 6.0 kPa and ideally within the normal range (4.5-5.3 kPa). PaO_2 should be greater than 10 kPa and pH between 7.35 and 7.45. It is most unlikely, but not impossible that a patient encountered on operations may have pre-existing respiratory disease[2]. In the latter case normal levels of $PaCO_2$ and PaO_2 for the patient would be accepted and would need to be taken into account when undertaking the apnoea test (Annex B).

c. **Metabolic Disturbances**.

(1) **Sodium**. The effects of hyponatraemia depend on its rate of development, but it is rare for patients to become unresponsive if the serum sodium concentration is 115 mmol/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 160 mmol/L are associated with unresponsiveness and this should be borne in mind if the primary cause of coma prior to testing is uncertain.

(2) **Potassium**. Profoundly low levels of serum potassium may cause myopathy and levels below 1 mmol/l have been reported to cause flaccid quadriplegia. Whilst there is no clear evidence concerning the central effects of hypokalaemia, it is recommended that testing of brain-stem reflexes should not be undertaken in with a serum potassium concentration below 2 mmol/L.

(3) **Phosphate and Magnesium**. Profound elevation or lowering of phosphate or magnesium may also be associated with severe neuromuscular weakness leading to

[1] Academy of Medical Royal Colleges: A Code of Practice for the Diagnosis and Confirmation of Death, 2008.
[2] Visiting dignitaries, contractors, locally employed civilians or other entitled individuals.

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

(4) **Glucose.** 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 20 mmol/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 3.0 mmol/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[3].

d. **Endocrine Disturbances**. 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. **Cervical Spine Injury**. Cervical spine injury must be excluded as if there are any reasons to suspect that an underlying high cervical spine injury and associated cord injury are causing the apnoea, then the apnoea test (see Annex B) becomes invalid. In this rare scenario, BSD can be established only by confirming the absence of other brain-stem reflexes and by using ancillary investigations. This is unlikely to be possible in a deployed MTF, in which case it will be necessary to continue to manage the patient as if BSD was not suspected and provide clinical treatment pathways accordingly.

6. **Repetition of Testing.** The interval between tests is normally at the discretion of the medical staff, taking into account the views of all involved. The chief purpose of repeating the testing is to ensure that no errors in procedure occur[4] and that baseline requirements for testing are met following the first test. The time of successful completion of the first set of tests is legally the time of death and this should be recorded as such on the death certificate, not the time that ventilation is finally discontinued.

7. **Limb and Trunk Movements.** Reflex movements of the limbs and torso may still take place after BSD has occurred. These are of spinal reflex origin and do not represent the higher functioning of the brain. This must be explained clearly to those involved with the patient in order to reduce distress.

8. **Signs Ruling Out BSD.** Presence of any of the following signs indicate that BSD cannot have occurred and that BST is therefore inappropriate:

a. **Seizures**. A seizure, either generalised or focal, implies the passage of nervous impulses through the brain stem; therefore the brain stem is still viable.

b. **Abnormal Postures**. The presence of either decorticate (flexed forearms/extended legs) or decerebrate (extended and hyperpronated forearms/extended legs) posturing indicates brain stem activity.

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[3] This should be done for both sets of tests.

[4] Over the past 30 years there have been 3 case reports of supposed brain death reversing after testing, but this has not be substantiated and is not accepted after scrutiny. In addition all of the patients died as a result of their brain injury. "There is no documented case of a person who fulfils the preconditions and criteria for brain death ever subsequently developing any return of brain function". Australia and New Zealand Intensive Care Society (ANZICS) Statement on Death and Organ Donation Edition 3.1, 2010. Correctly conducted BST, in patients who are fully resuscitated and fulfil the pre-conditions for BST, will demonstrate brain stem death and allow the diagnosis of death to be made.

c. **Trismus**. Masseter spasm indicates upper motor neurone influence and intact brain stem transmission.

d. **Doll's Eye (Oculocephalic) Reflex**. This brain stem reflex is not part of the UK guidelines, but an attempt to elicit it may assist in the decision-making process. Following rotation of the head to one side and then the other (the cervical spine **must** be cleared first):

(1) In a fully alert patient, after initially staring ahead, the eyes will rapidly reorient with the head.

(2) In a patient with damaged cerebral hemispheres, but a live brain stem there will be a 'release' phenomena i.e. for a second or two there will be obvious deviation of the eyes to the opposite side as the head is rotated, followed by a realignment of the eyes with the head. A similar dissociation will occur when the head is turned in the opposite direction.

(3) In a cadaver the head and eyes will move together.

9. **Observations Made Which Are Compatible With Brain Stem Death**[5].

a. Spinal reflexes. These can be either spontaneous or elicited by stimulation, including a noxious stimulus applied to the limbs or sternum, tactile stimulation applied to palmar or plantar areas, neck flexion, limb elevation or hypoxia (such as during ventilation disconnection). Spinal reflexes are not to be confused with a pathological flexion or extension response. Spinal reflex movements may include:

(1) Extension-pronation movements of the upper limbs or non-specific flexion of the lower limbs.

(2) Undulating toe reflex (plantar flexion of the great toe, followed by brief plantar flexion sequentially of the second to fifth toes).

(3) Lazarus sign (bilateral arm flexion, shoulder adduction, hand raising to above the chest and may include flexion of the trunk, hips and knees).

(4) Deep tendon reflexes.

(5) Plantar responses, either flexor or extensor.

(6) Respiratory like movements (shoulder elevation and adduction, back arching or intercostals expansion) without significant tidal volume.

(7) Head turning.

b. Sweating, blushing tachycardia.

c. Normal blood pressure without the need for pharmacological support.

d. Absence of diabetes insipidus (preserved osmolar control mechanisms).

[5] ANZICS Statement on Death and Organ Donation, 2010.

THE CONDUCT OF BRAIN STEM TESTING: A CLINICAL GUIDE

Prior To Testing Brain Stem Function. Where confounding factors exist and they materially interfere with the conduct of BST it should not proceed. In the case of suspected presence of opioids, benzodiazepines or neuromuscular blocking drugs as confounding factors reversal with suitable agents may be considered. Resuscitation must be completed and optimisation of all of the physiological parameters required for the pre-conditions for testing must be met.

The tests in sequence are as follows:

1. **Pupillary Reflex** (Cranial nerves II and III).

   a. **Test**. Ambient light intensity should be low at the commencement of the test. A bright light is shone into each eye in turn, such that there is a sharp change in the intensity of light.

   b. **Response**.

      (1) Bilaterally the pupils remain fixed and do not react to the sharp changes in the intensity of incident light.

      Action: Continue with testing the remaining reflexes.

      (2) Change in pupil size.

      Action: Stop testing since BSD is precluded.

   c. **Potential Confounding Factors**.

      (1) Pupils should not be pinpoint (they should be at least 4mm) as this may indicate the residual presence of opioid drugs.

      (2) Anticholinergic drugs such as atropine can cause pupillary dilatation as can beta adrenergic agents such as adrenaline.

      (3) Local trauma to the eye or surrounding structures.

2. **Corneal Reflex** (Cranial nerves V and VII).

   a. **Testing**. This should be with the light touch of a sterile swab or other soft sterile material directly on the cornea (not the sclera), with care being taken not to damage the cornea.

   b. **Response**.

      (1) No blinking or withdrawal response.

      Action: Continue with testing of the remaining reflexes.

      (2) Blink reflex or withdrawal.

      Action: Stop testing since BSD is precluded.

   c. **Potential Confounding Factors**.

      (1) Local trauma to the eye or surrounding structures.

3. **Oculo-Vestibular Reflex** (Cranial nerves III, IV, VI and VIII).

   a. **Testing**. The head should be at 30 degrees to the horizontal plane, unless this is contraindicated due to possible spinal injury. Both tympanic membranes must be inspected prior to this test to ensure the auditory canal is not obstructed by cerumen, blood or foreign bodies. The reflex is tested by the slow injection (over one minute) of at least 50mls of ice cold water into each external auditory meatus in turn

   b. **Response**. No eye movements occur during or after the injection of the ice cold water. Throughout the test the eyes remain central in the orbit.

      Action: Proceed with testing of other reflexes.

      (1) Movement of the eyes, including tonic deviation or nystagmus occurs.

Action: Stop testing since BSD is precluded.

c. **Potential Confounding Factors**.

(1) Fractures to the base of the skull or petrous temporal bone may render the test void on that side.

Note: If bilateral testing of the above 3 reflexes is prevented by local injury or disease this does not necessarily invalidate the diagnosis of death as a result of cessation of brainstem reflexes. In the case of bilateral injury or disease, ancillary testing should be considered (noting that the availability of this forward of Role 4 may be limited).

4. **Cranial Nerve and Somatic Motor Responses** (Cranial nerves V and VII).

a. **Testing**. Supraorbital pressure is applied bilaterally to provide stimulation to attempt to elicit a motor response in the head, neck or the rest of the body.

b. **Response**.

(1) No motor response can be elicited within the cranial nerve or somatic distribution.

Action: Continue with testing of other reflexes.

(2) Facial or limb movement is observed.

Action: Stop testing since BSD is precluded.

c. **Potential Confounding Factors**. Severe facial and orbital trauma, head and neck burns and cervical spinal cord injury[1].

5. **Cough Reflex** (Cranial nerve X).

a. **Testing.** Stimulation is induced by a suction catheter placed into the trachea down to the carina.

b. **Response.**

(1) There is no cough reflex in response to the stimulation.

Action: Continue with the testing of the other reflexes.

(2) Cough response occurs.

Action: Stop testing since BSD is precluded.

c. **Potential Confounding Factors.** High cervical cord injury disrupts the efferent pathway via the phrenic nerve and the innovation of the thoracic and abdominal wall musculature, therefore, assessment cannot be made.

6. **Gag Reflex** (Cranial nerves IX and X)

a. **Testing.** Stimulation of the posterior pharynx is induced by an oral suction tube or oral examination spatula.

b. **Response.**

(1) There is no gag reflex in response to stimulation.

Action: Continue with the testing of the other reflexes.

(2) Gag response occurs.

Action: Stop testing since BSD is precluded.

c. **Potential Confounding Factors.** Oral intubation may make this reflex difficult to discern.

7. **Respiratory Response to Hypercarbia (Apnoea Test).** All previous tests of brain stem reflexes must have indicated their absence. The principle for this test is to prove apnoea without

[1] With intact brainstem a motor response will still occur in the facial muscles.

the risk of significant hypoxia, excessive hypercarbia or rapid changes in carbon dioxide tension while minimising the change in arterial pressure. Although these are relative risks they may be detrimental to recovering neural tissue. Testing must be discontinued if hypotension, cardiac arrhythmias or hypoxia occurs. This should be the last test conducted in the sequence on both occasions of testing. The time interval between the first and second set of tests is largely to allow return of ventilatory parameters to pre-test levels.

a. **Testing.** The recommended procedure for apnoea testing is as follows:

(1) The patient should be pre-oxygenated with 100% oxygen for 10 minutes prior to testing and baseline arterial blood gases taken.

(2) E_TCO_2, P_aCO_2 and S_aO_2 should be compared to ensure correlation where S_aO_2 and E_TCO_2 are used to monitor changes in oxygenation and carbon dioxide during the lead up to and during testing.

(3) Prior to testing the P_aCO_2 should be brought up to at least 6.0 kPa (45 mmHg) and should rise to at least 6.5 kPa (49 mmHg) during the test, giving a rise of at least 0.5 kPa[31].

(4) To bring the P_aCO_2 to 6.0 kPa decrease the minute ventilation by reducing the respiratory rate until this is achieved. E_TCO_2 may be used to monitor the rise in CO_2, where this correlates well with P_aCO_2, but a confirmatory blood gas is still required to ensure that the $PaCO_2$ is at least 6.0 kPa. The pH should also be below 7.4 before the test commences.

(5) If the patient has chronic CO_2 retention or has received intravenous bicarbonate the $PaCO_2$ should be allowed to rise above 6.5 kPa to a level where the pH becomes less than 7.4.

(6) Following this adjustment, if cardiovascular stability is maintained, the patient is then disconnected from the ventilator. Oxygenation is continued by administering 5 L/min of oxygen via a catheter[2] inserted down the endotracheal tube and placed above the carina. Alternately a T-piece or Continuous Positive Airways Pressure (CPAP) breathing system[3] may be used to supply oxygen.

(7) The patient should be observed continuously for 5 minutes for any respiratory effort. A blood gas should be taken at the end of this period to ensure that the P_aCO_2 has risen above 6.5 kPa (49 mmHg) or at least 0.5 kPa above the $PaCO_2$ measured at the commencement of the test and the pH is less than 7.4. If this has not occurred a further period of 5 minutes should be allowed to pass and gases taken again. If during any of this period S_aO_2 falls below 90% or there is a malignant cardiac arrhythmia or hypotension the test must be discontinued.

(8) The patient is then reconnected to the ventilator and minute ventilation adjusted to allow a gradual return to the levels of blood gases measured prior to the test.

b. **Response.**

(1) There is a positive apnoea test, with no respiratory movements or breathing efforts seen[4].

Action: Testing is completed when the patient has been reconnected to the ventilator.

(2) Respiratory muscle activity seen.

Action: Apnoea test is negative and brain stem death is precluded.

[2] Too high a flow, or wedging the catheter, may lead to barotrauma so care needs to be exercised when placing the catheter.
[3] Back up apnoea ventilation needs to be switched OFF, as does triggering (gas flow may be triggered by cardiac activity).
[4] There must be no respiratory muscle activity that results in abdominal or chest excursions nor any activity of accessory respiratory muscles.

ANNEX C

RECORD OF DIAGNOSIS OF BRAINSTEM DEATH[1]. To be used in conjunction with JSP 950 Lft 2-5-2 Annex B

- Diagnosis must be made by 2 medical practitioners, both with at least 5 years registration and at least one must be a Consultant.
- Both must be competent in the conduct and interpretation of the tests.
- Neither must have, nor be perceived to have, any clinical conflict of interest.
- Tests must be undertaken by the doctors together and must always be performed completely and successfully on 2 occasions.
- Diagnosis using these criteria can be used on any patient, fulfilling the pre-condition criteria, over the age of 2 months. At ages less than 2 months BSD cannot be diagnosed.
- The same doctors should carry out both sets of tests.
- There should be a time interval between sets of tests.

TEST DETAILS		
	Test 1	**Test 2**
Date		
Time		
Location		

PATIENT DETAILS			
Name		**Service/ Civ**	
Rank/ Status		**Corp/Regt/Employer**	
Service/ Staff Number (if applicable)		**Date of Birth**	

DOCTORS' DETAILS		
	Doctor A	**Doctor B**
Name		
Rank / Status		
GMC Number		
Service/Staff Number		

[1] These Criteria are based on English Law and on the Academy of Medical Royal Colleges document: A Code of Practice for the Diagnosis and Confirmation of Death, 2008.

PRE CONDITIONS

Diagnosis should not made within 6 hours on coma onset (24 hours if post cardiac arrest)

	Doctor A	Doctor B
PRE CONDITIONS Specify condition and time of onset of coma		
Confirm the condition which has led to irremediable brain injury.		
DTG[1] onset of the injury		
Is resuscitation complete and physiological parameters optimised?		
Is the patient deeply comatose; unresponsive; apnoeic and being ventilated?		
In the case of isolated head injury is central nervous system support optimal?		
If there has been hypothermia due to environmental conditions or for therapeutic purposes has sufficient time been allowed to confidently state core temperature is over 34^{o}C?		
Are there any signs present which would rule out brain stem death and therefore preclude testing?		

[1] Date Time Group

EXCLUSIONS	**Doctor A**		**Doctor B**	
Are you satisfied potentially reversible causes of coma have been excluded?				
Are there any confounding factors which might render testing difficult or impossible?				
Are the potential effects of depressant drugs excluded?				
Neuromuscular - blocking drugs excluded? Neuromuscular function tested?				
	Test 1	**Test 2**	**Test 1**	**Test 2**
Hypothermia excluded? (core temp must be >34^{o}C and be documented)	Temp: ^{o}C	Temp: ^{o}C	Temp: ^{o}C	Temp: ^{o}C
Metabolic/endocrine disturbances excluded? Document any other relevant electrolyte values. Explain why (in the comments box at end of document) if abnormal results are accepted.	Na^{+}: mmol/L K^{+}: mmol/L Mg^{2+}: mmol/L Other:	Na^{+}: mmol/L K^{+}: mmol/L Mg^{2+}: mmol/L Other:	Na^{+}: mmol/L K^{+}: mmol/L Mg^{2+}: mmol/L Other:	Na^{+}: mmol/L K^{+}: mmol/L Mg^{2+}: mmol/L Other:
Blood glucose immediately prior to test (must be 3 – 20 mmol/L)	Glucose: mmol/L	Glucose: mmol/L	Glucose: mmol/L	Glucose: mmol/L
Signature				
Date				

TESTS FOR ABSENCE OF BRAIN STEM FUNCTION

	Test 1		Test 2	
DOCTOR	**A**	**B**	**A**	**B**
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 there a gag reflex?				
Is there a cough reflex?				
Have the recommendations concerning testing for apnoea been followed?[1]				
Were there any respiratory movements seen on apnoea testing?[2][3][8]				
Was the circulation stable throughout testing?				
Was oxygenation maintained during testing? How was this achieved?				
Were any abnormal movements seen during testing? If so to what were they attributed?				

[1] PaO_2 >10 kPa, $PaCO_2$<6 kPa – print of results of blood gases attached / write values in comment box. Pre- oxygenation with 100% oxygen for 10 minutes etc

[2] Apnoea test should last at least 5 minutes and document a $PaCO_2$ of at least 6.65 kPa at the end of the test with a pH of less than 7.4

PRONOUNCEMENT AND CERTIFICATION OF DEATH	
Time Death Pronounced[1]	
Legal Time of Death[2]	
Death Certificate Required?	
Death Certificate Completed?	

CONFIRMATION OF ADHERENCE TO GUIDELINES				
I confirm that I have carried out these tests in accordance with the Academy of Medical Royal Colleges' Code of Practice for the Diagnosis and Confirmation of Death.				
	Test 1		**Test 2**	
Doctor	**A**	**B**	**A**	**B**
Signature (Print name)				
Date				

Comments:

Once completed, this form is to be filed in the patient record. A statement regarding the BST should be annotated in the notes along with the time of death to ensure the records are complete.

[1] Following completion of the 2nd set of tests.
[2] The legal time of death is on completion of the 1st set of tests.