سلطنة عُمان
SULTANATE OF OMAN
وزارة الصِّحَّة

قرار وزاري
رقم ١٤ /٢٠٢٣
بشأن ضوابط إثبات الموت الدماغي

استنادا إلى المرسوم السلطاني رقم ٢٠١٤/٣٦ بتحديد اختصاصات وزارة الصحة ،
والى المرسوم السلطاني رقم ٢٠٢٠/٨٠ باعتماد الهيكل التنظيمي لوزارة الصحة ،
والى قانون تنظيم مزاولة مهنة الطب والمهن الطبية المساعدة الصادر بالمرسوم السلطاني رقم ٢٠١٩/٧٥ ،
والى اللائحة التنظيمية لنقل وزراعة الأعضاء والأنسجة البشرية الصادرة بالقرار الوزاري رقم ٢٠١٨/١٧٩ ،
وبناء على ما تقتضيه المصلحة العامة .

المادة الأولى
يعمل في شأن إثبات الموت الدماغي بالضوابط المرفقة .

المادة الثانية
يجب على المؤسسات الصحية الالتزام بالإبلاغ عن الحالات المثبت موتها دماغيا إلى الدائرة المختصة بالوزارة ، وذلك على النموذج المعتمد .

المادة الثالثة
يعمل بهذا القرار من تاريخ صدوره ، وعلى المختصين تنفيذه كل في مجال اختصاصه.

سلطنة عمان - وزارة الصحة
SULTANATE OF OMAN - MINISTRY OF HEALTH
مكتب الوزير

صدر في : ٢٤ جمادى الاخرة ١٤٤٤هـ
الموافق : ١٧ يناير ٢٠٢٣م

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SULTANATE OF OMAN
MINISTRY OF HEALTH

National Clinical Protocol for Determination of Brain Death

Nov 2022

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Acronyms

PEEP	Positive end-expiratory pressure
CPAP	Continuous positive airway pressure
CTA	Computed tomography angiography
MAP	Mean arterial pressure
MCA	Middle cerebral artery
OVR	Oculovestibular reflexes
OCR	Oculocephalic reflexes

Introduction

Brain death is both a legal and clinical term used to describe the status of complete and irreversible cessation of whole-brain function. There have been major advances in the diagnosis of brain death since first described in 1959 by Mollaret and Goulon. Whilst the fundamentals of the guidance for the diagnosis of brain death are common, worldwide, specific criteria are inconsistent between countries with considerable variation related to the diversity of culture and religious beliefs. In Oman, the first protocol for the diagnosis of brain death was established in 1994. In recent years, there have been major advances in supplementary diagnostic techniques as well as advancements in organ transplantation. This necessitated a review of the current protocol.

Aim and Objectives

This revised protocol outlines current recommendations set for the diagnosis of brain death in adults and children, with a focus on diagnostic criteria, clinical examination and ancillary testing. It will standardise the process and procedure of brain death diagnosis in all health care institutes in Oman.

Procedures

I. Adult

1. Brain Death Definition

1.1. Brain death is defined as complete and permanent loss of brain function as defined by an unresponsive coma with loss of capacity for consciousness, brainstem reflexes, and the ability to breathe independently.

1.2. Brain death may result from the permanent cessation of oxygenated circulation to the brain and/or after a devastating brain injury.

1.3. A patient determined to be brain dead is clinically dead.

2. Minimum Clinical Criteria for Determination of Brain Death

2.1. Prerequisites

2.1.1. The diagnosis of brain death is primarily clinical.

2.1.2. The clinical history and neuroimaging demonstrate that the person has experienced an acute **irreversible** brain injury with clear aetiology, leading to loss of all brain functions demonstrated by unresponsive coma, absence of brain stem reflexes, and apnea.

2.1.3. A minimum core temperature of 36 C^{o} (defined by oesophageal, bladder, rectal, central venous, or arterial catheter temperature).

2.1.4. Adults should have a systolic blood pressure of at least 100 mmHg, or a mean arterial pressure of at least 60 mmHg, with the use of vascular volume expanders, vasopressors, and/or inotropes as needed.

2.1.5. A minimum of 24 hours is recommended to perform the brain death examination in cases with an anoxic brain injury after resuscitated cardiac arrest.

2.1.6. There are no confounders that mimic irreversible brain death:

2.1.6.1. Severe metabolic, acid-base and endocrine derangements that could affect the examination must be corrected. These include glucose, electrolytes (including phosphate, calcium, and magnesium), inborn errors of metabolism, and liver and renal dysfunction. If these derangements cannot be corrected and are judged to be potentially contributing to the loss of brain function, ancillary testing should be performed.

2.1.6.2. Pharmacologic paralytic medications & central nervous system (CNS) depressing medications must be excluded.

2.1.6.3. If neuromuscular junction blocking agents have been used and there is a doubt of persistent effect, there should be evidence of neuromuscular transmission (e.g. presence of a train of 4 twitches or preferably a five seconds titanic stimulus producing a sustained muscle contraction without fade) before beginning the determination of brain death.

2.1.6.4. Patients admitted for the treatment of drug overdose should have confirmatory tests to ensure that drug levels have decreased to clinically insignificant levels. If in doubt, a consultation with a toxicology centre should be sought.

2.1.6.5. If intoxicants are present, a reasonable practice is to wait for 5 half-lives (assuming normothermia, normal hepatic and renal function). In the case of alcohol consumption, the blood alcohol level of 0.08% may serve as a practical threshold below which an examination to determine brain death can be performed.

2.1.6.6. Ancillary tests can be used in cases of intoxication that cannot be corrected or judged to be potentially contributing to loss of brain function.

2.1.6.7. Other mimickers of brain death must be excluded: severe peripheral neuropathy, Guillain barre syndrome, locked-in syndrome and high cervical spine injury.

3. Brain Death Clinical Examination

Determination of brain death consists of two sets of clinical examinations performed not less than 6 hours apart. The examination should be performed by two consultants from neurology or intensive care or anaesthesia, and none of them is part of the organ transplant team.

3.1. Examination for brain death confirmation

3.1.1. Coma

3.1.1.1. There is no evidence of arousal or awareness of maximal external stimulation (including noxious, visual, auditory, and tactile stimulation).

3.1.2. Pupillary reflexes

3.1.2.1. Test

Shine a bright light into each of the person's eyes, looking for pupillary constriction and measuring the diameter of the pupils. The use of a magnifying glass and/or pupilometer is suggested.

3.1.3. Response consistent with brain death

3.1.3.1. There should be an absence of ipsilateral and contralateral pupillary responses, with pupils fixed in a midsize or dilated position (equal or more than 4 mm), in both eyes.

3.1.4. Considerations

3.1.4.1. Constricted pupils are not consistent with brain death and suggest the possibility of drug intoxication or locked-in syndrome.

3.1.4.2. Pupils can be of any shape (round/oval/irregular).

3.1.4.3. Corneal trauma or prior ophthalmic surgery may influence pupillary reactivity and preclude adequate evaluation, necessitating ancillary testing.

3.1.4.4. Ocular instillation of drugs may artificially produce transiently nonreactive pupils.

3.1.4.5. In the setting of anophthalmia or inability to see the pupils, ancillary testing is recommended.

3.2. Oculocephalic (OCR) and oculovestibular (OVR) reflexes

3.2.1. Test

3.2.1.1. **OCR**: Rotate the head briskly horizontally to both sides. There should be no movement of the eyes relative to head movement. Testing vertically is optional.

3.2.1.2. **OVR**: Examine the auditory canal for patency and an intact tympanic membrane. Elevate the head to 30° to place the horizontal semicircular canals in the correct vertical position. Irrigate with at least 30mL of ice water for at least 60 seconds using a syringe or a syringe attached to a catheter placed inside the canal. Test both sides separately, with a 5-minute interval between to allow the endolymph temperature to equilibrate.

3.2.2. Response consistent with brain death

3.2.2.1. There should be an absence of extraocular movements. The detection of any extraocular movements are not compatible with brain death.

3.2.3. Considerations

3.2.3.1. Confirm the integrity of the cervical spine before proceeding with the OCR test. If the OCR cannot be performed, but the OVR is performed and there are no extraocular movements, ancillary testing is not required.

3.2.3.2. Ensure the integrity of the tympanic membrane. The presence of a ruptured tympanic membrane does not negate the clinical testing but may risk introducing infections in the ear.

3.2.3.3. A fracture of the base of the skull or petrous temporal bone may obliterate the response on the side of the fracture, and ancillary testing is recommended in this instance.

3.2.3.4. Severe orbital or scleral oedema or chemosis may affect the free movement of the globes, and ancillary testing is recommended in this instance.

3.2.3.5. In the setting of anophthalmia, ancillary testing is recommended.

3.3. Corneal reflex

3.3.1. Touch the cornea of both eyes with a cotton swab on a stick at the external border of the iris, applying light pressure and observing for any eyelid movement.

3.3.2. Response consistent with brain death

3.3.2.1. No eyelid movement should be seen.

3.3.3. Considerations

3.3.3.1. Care should be taken to avoid damaging the cornea.

3.3.3.2. In the setting of anophthalmia, severe orbital oedema, prior corneal transplantation, or scleral oedema or chemosis, ancillary testing is recommended.

3.4. Motor responses of the face and limbs

3.4.1. Test

3.4.1.1. Apply deep pressure to all of the following:

3.4.1.1.1. The condyles are at the level of the temporomandibular joints.

3.4.1.1.2. The supraorbital notch bilaterally.

3.4.1.1.3. The sternal notch.

3.4.1.1.4. All 4 extremities, both proximally and distally.

3.4.1.2. Insert a cotton swab on a stick in each nostril to perform "nasal tickle" testing.

3.4.1.3. Response consistent with brain death

3.4.1.3.1. Noxious stimuli should not produce grimacing, facial muscle movement, or a motor response of the limbs other than spinally mediated reflexes.

3.4.1.3.2. Noxious stimuli above the foramen magnum should not produce any movement in the face or body. Noxious stimuli below the foramen magnum should not produce any movement in the face but may elicit spinally mediated peripheral motor reflexes.

3.4.2. Considerations

3.4.2.1. The clinical differentiation of spinal from brain-mediated motor responses requires expertise. Consultation with an experienced practitioner is recommended if the origin of the response is unclear. Alternatively, if the interpretation is unclear, ancillary testing is recommended.

3.4.2.2. Ancillary testing is recommended if a person has a pre-existing severe neuromuscular disorder, such as amyotrophic lateral sclerosis or a pre-existing severe sensory neuropathy.

3.4.2.3. Ancillary testing is not required if a person does not have all 4 limbs; the absence of a limb does not preclude motor testing to pain on that side of the body.

3.4.2.4. Severe facial trauma or swelling may preclude evaluation of facial motor response, so ancillary testing is recommended in this setting.

3.5. Gag and cough reflexes

3.5.1. Tests

3.5.1.1. Gag reflex: stimulate the posterior pharyngeal wall bilaterally with a tongue depressor or suction catheter.

3.5.1.2. Cough reflex: stimulate the tracheobronchial wall to the level of the carina with the deep endotracheal placement of a suction catheter.

3.5.2. Response consistent with brain death

3.5.2.1. Absence of gag and cough.

3.5.3. Considerations

3.5.3.1. The efferent limb for the cough reflex includes the phrenic nerve, which may be injured in persons with high cervical cord injuries, so ancillary testing is recommended in this setting.

3.6. Apnea testing

3.6.1. The absence of a breathing drive is tested with a CO_2 challenge by documentation of an increase in $PaCO_2$ above normal levels.

3.6.2. The test should be performed last, after other brainstem reflexes have been tested and proven to be absent.

3.6.3. To be performed after documenting the absence of spontaneous breathing effort on mechanical ventilation.

3.6.4. Prerequisites

3.6.4.1. Absence of high cervical spine injury.

3.6.4.2. Systolic BP >100 mmHg and mean BP >60 mmHg (vasopressors can be used).

3.6.4.3. Temperature >36 C^0.

3.6.4.4. Preoxygenation with 100% oxygen for 10 minutes.

3.6.4.5. Adjustment of minute ventilation to achieve normocarbia ($PaCO_2$ 35-45 mmHg).

3.6.4.6. No prior evidence of severe CO_2 retention (i.e chronic obstructive pulmonary disease, severe obesity).

3.6.5. Procedure

3.6.5.1. Adjust vasopressors to a systolic blood pressure >100 mmHg.

3.6.5.2. Preoxygenate for at least 10 minutes with 100% oxygen.

3.6.5.3. Reduce ventilation frequency to 10 breaths per minute to eucapnia.

3.6.5.4. Reduce positive end-expiratory pressure (PEEP) to 5 cm H2O (oxygen desaturation with decreasing PEEP may suggest difficulty with apnea testing).

3.6.5.5. If pulse oximetry oxygen saturation remains >95%, obtain a baseline blood gas (PaO_2, $PaCO_2$, pH, Bicarbonate, Base Excess).

3.6.5.6. Disconnect the patient from the ventilator.

3.6.5.7. Preserve oxygenation (e.g. place an insufflation catheter through the endotracheal tube and close to the level of the carina and deliver O_2 at 6 L/min).

3.6.5.8. Look closely with exposure of the chest and abdomen for respiratory movements for 8–10 minutes. Respiration is defined as abdominal or chest excursion and may include a brief gasp.

3.6.5.9. If no respiratory drive is observed after approximately 8 minutes, repeat blood gas (PaO_2, $PaCO_2$, pH, bicarbonate, base excess).

3.6.5.10. If respiratory movements are absent and arterial $PaCO_2$ is >60 mmHg (or 20 mmHg increase in arterial $PaCO_2$ over the baseline), the apnea test result supports the clinical diagnosis of brain death.

3.6.5.11. If the test is inconclusive but the patient is hemodynamically stable during the procedure, it may be repeated for a longer period of time (10–15 minutes) after the patient is again adequately pre oxygenated.

3.6.6. Apnea test should be aborted in the following conditions:

3.6.6.1. Hemodynamic instability: unstable cardiac arrhythmias or systolic blood pressure decreases to < 90 mmHg on high inotropic support.

3.6.6.2. If oxygen saturation measured by pulse oximetry is < 85% for 30 seconds. Retry the procedure with T-piece, CPAP 10 cm H2O, and O_2 12 L/min. Reconnect the ventilator and immediately draw an arterial blood sample and analyse arterial blood gas.

3.6.6.3. If $PaCO_2$ is ≥ 60 mm Hg or $PaCO_2$ increases ≥ 20 mm Hg over the baseline, the apnea test result supports the diagnosis of brain death.

3.6.6.4. If $PaCO_2$ is < 60 mm Hg and $PaCO_2$ increases < 20 mm Hg over the baseline, the result is indeterminate.

4. Ancillary Tests for Diagnosis of Brain Death

4.1. Prerequisites

4.1.1. Ancillary tests are not routinely required for determination of brain death but may be indicated to support or to supplement the clinical examination when extenuating circumstances preclude a complete brain death examination. Ancillary tests rely on demonstrating the absence of parenchymal blood flow. One ancillary test is sufficient.

4.1.2. When imaging is required, it must be preceded by undertaking those parts of the clinical examination that are possible. Testing for brain perfusion should be deferred until responsiveness, examinable brainstem reflexes and breathing effort are all absent.

4.1.3. Imaging should only be performed if the systemic blood pressure is adequate (as a guide, systolic blood pressure >100 mmHg, MAP >60 mmHg in an adult) and should be performed by a specialist or above in radiology or nuclear medicine.

4.1.4. Although the absence of brain perfusion is determined by a radiologist or nuclear physician, it is the responsibility of two medical practitioners who have clinically examined the patient to determine that the patient has died.

4.1.5. When ancillary studies are used, a second clinical examination and apnea test should be performed, and components that can be completed must remain consistent with brain death. In this instance, the observation interval may be shortened, and the second neurologic examination and apnea test (or all components that are able to be completed safely) can be performed at any time thereafter. Death is declared when these above criteria are fulfilled.

4.1.6. If the ancillary study is equivocal or if there is concern about the validity of the ancillary study, the patient cannot be pronounced dead. The patient should continue to be observed until brain death can be declared on clinical examination criteria and apnea testing, or a follow-up ancillary study can be performed to assist with the determination of brain death.

4.1.7. A waiting period of 24 hours is recommended before further clinical reevaluation or repeat ancillary study is performed. Supportive patient care should continue during this time period.

4.2. Indications for ancillary tests

4.2.1. Presence of confounding factors that preclude the performance of brain death clinical examination.

4.2.2. Inability to complete one or both clinical brain death examinations due to conditions like high cervical spine injury, inability to examine at least one eye and one ear, or the inability to complete an apnea test.

4.2.3. Uncertainty of motor response to pain, defined as an inability to distinguish between a spinal reflex and a true motor response to noxious stimuli.

4.3. Recommended ancillary tests

The choice of an ancillary test is dictated in large part by practical considerations, i.e. availability, advantages, and disadvantages of the tests. The ancillary tests are listed below, in alphabetical order:

4.3.1. Four vessels cerebral angiography

4.3.1.1. Intra-arterial contrast must be absent above the level of the carotid siphon in the anterior circulation and above the foramen magnum in the posterior circulation.

4.3.2. Multiphasic CT angiography (CTA)

4.3.2.1. Criteria for absent brain perfusion under the four-point scale are:

4.3.2.1.1. Absent enhancement of both middle cerebral artery (MCA) cortical branches (i.e. beyond the Sylvian branches).

4.3.2.1.2. Absent enhancement of both internal cerebral veins.

4.3.3. Radionuclide imaging with Tc-99m HMPAO SPECT

4.3.3.1. Absence of radiotracer activity upon imaging of the intracranial vault compared to the presence of the radionuclide extracranially.

II: Paediatrics and Neonates

This Part applies to patients 37 weeks gestational age to <13 years

1. Brain Death Definition

1.1. Complete and permanent loss of brain function as defined by an unresponsive coma with loss of capacity for consciousness, brainstem reflexes, and the ability to breathe independently.

1.2. Brain death may result from permanent cessation of oxygenated circulation to the brain and/or after devastating brain injury.

1.3. A patient determined to be brain dead is clinically dead.

2. Minimum Clinical Criteria for Determination of Brain Death

2.1. Prerequisites

2.1.1. The diagnosis of brain death is primarily clinical.

2.1.2. The clinical history and neuroimaging demonstrate that the person has experienced an acute irreversible brain injury with a clear aetiology, leading to loss of all brain functions demonstrated by unresponsive coma, absence of brain stem reflexes, and apnea and thus is compatible with brain death.

2.1.3. A minimum core temperature of 36C^{o} (defined by rectal, oesophageal, bladder, central venous or arterial catheter temperature).

2.1.4. Normotensive (systolic BP not less than 2 standard deviations below age-appropriate norm) based on age; with use of intravascular volume and/or inotropes as needed. Blood pressure is preferably measured by an indwelling arterial catheter. Alternatively, hypotension is defined as systolic blood pressure or mean arterial pressure below the 5th centile of normal values for age norms.

Definition of Hypotension by Systolic Blood Pressure and Age	
Age	**Systolic Blood Pressure**
Term neonates (0 to 28 days)	<60 mm Hg
Infants (1 to 12 months)	<70 mm Hg
Children 1 to 10 years (5th BP percentile)	<70 mm Hg + (age in years x 2) mm Hg
Children >10 years	<90 mm Hg

2.1.5. For newborn infants, initial assessment for brain death should not be performed before 48 hours of life. For all others, a minimum of 24 hours is recommended to perform the brain death examination in patients with anoxic brain injury, cardiopulmonary resuscitation, other etiologies of severe acute brain injury and after rewarming from therapeutic hypothermia.

2.1.6. There are no confounders or conditions that mimic brain death:

2.1.6.1. Pharmacologic paralytic agents & central nervous system (CNS) depressants must be excluded.

2.1.6.2. If neuromuscular junction blocking agents have been used and there is a doubt of persistent effect, there should be evidence of neuromuscular transmission (e.g. presence of a train of 4 twitches or preferably a five seconds titanic stimulus producing a sustained muscle contraction without fade) before beginning the determination of brain death.

2.1.6.3. All sedative agents should be discontinued for at least 24 hours (assuming normothermia and normal hepatic and renal function).

2.1.6.4. Patients admitted for the treatment of drug overdose should have confirmatory tests to ensure that drug levels have decreased to clinically insignificant levels. If in doubt, consult the toxicology centre.

2.1.6.5. If intoxicants are present, a reasonable practice is to wait for 5 half-lives (assuming normothermia, normal hepatic and renal function).

2.1.6.6. Ancillary tests can be used to confirm brain death in cases of intoxication that cannot be corrected or judged to be potentially contributing to loss of brain function.

2.1.7. Severe metabolic, acid-base and endocrine derangements that could affect the examination must be corrected. These include serum glucose, electrolytes (including phosphate, calcium and magnesium), inborn errors of metabolism, liver and renal dysfunction. If these derangements cannot be corrected and are judged to be potentially contributing to the loss of brain function, ancillary testing should be performed.

2.1.8. Un-resuscitated shock.

2.1.9. Other mimickers of brain death must be excluded: severe peripheral neuropathy, Guillain barre syndrome, locked-in syndrome.

3. Brain Death Clinical Examination

Determination of brain death consists of two sets of clinical examinations, each performed by two consultants not less than 6 hours apart. Neonates < 30 days of life should have an observation period of at least 24 hours between the two sets of clinical exams.

The examination should be performed by two consultants from neurology or intensive care or anaesthesia, and none of them is part of the organ transplant team.

4. Examination for Brain Death Confirmation

4.1. Coma

There is no evidence of responsiveness. Eye opening or eye movement to noxious stimuli is absent. Noxious stimuli should not produce a motor response other than spinally mediated reflexes.

4.2. Pupillary reflexes

4.2.1. Test

4.2.1.1. Shine a bright light into each of the child's eyes, looking for pupillary constriction and measuring the diameter of the pupils. Use of a magnifying glass and/or pupilometer is suggested.

4.2.2. Response consistent with brain death

4.2.2.1. There should be an absence of ipsilateral and contralateral pupillary response, with pupils fixed in a midsize or dilated position (equal or more than 4 mm), in both eyes.

4.2.3. Considerations

4.2.3.1. Constricted pupils are not consistent with brain death and suggest the possibility of drug intoxication or locked-in syndrome.

4.2.3.2. Pupils can be of any shape (round/oval/irregular).

4.2.3.3. Corneal trauma or prior ophthalmic surgery may influence pupillary reactivity and preclude adequate evaluation, necessitating ancillary testing.

4.2.3.4. Ocular instillation of drugs may artificially produce transiently nonreactive pupils.

4.2.3.5. In the setting of anophthalmia or inability to see the pupils, ancillary testing is recommended.

4.3. Oculocephalic (OCR) and oculovestibular (OVR) reflexes

4.3.1. Test

4.3.1.1. **OCR**: Hold the eyelids open. The examiner moves the patient's head from side to side briskly.

4.3.1.2. **OVR**: Examine the auditory canal for patency and an intact tympanic membrane. Elevate the head to 30° to place the horizontal semicircular canals in the correct vertical position. Irrigate with at least 30mL of ice water for at least 60 seconds using a syringe or a syringe attached to a catheter placed inside the canal. Test both sides separately, with a 5-minute interval between to allow the endolymph temperature to equilibrate.

4.3.2. Response consistent with brain death

4.3.2.1. There should be an absence of extraocular movements. Detection of any extraocular movements is not compatible with brain death.

4.3.3. Considerations

4.3.3.1. Confirm the integrity of the cervical spine before proceeding with the OCR test. If the OCR cannot be performed, but the OVR is performed and there are no extraocular movements, ancillary testing is not required.

4.3.3.2. Ensure the integrity of the tympanic membrane. Presence of a ruptured tympanic membrane does not negate the clinical testing but may risk introducing infections in the ear.

4.3.3.3. A fracture of the base of the skull or petrous temporal bone may obliterate the response on the side of the fracture, and ancillary testing is recommended in this instance.

4.3.3.4. Severe orbital or scleral oedema or chemosis may affect the free motion of the globes, and ancillary testing is recommended in this instance.

4.3.3.5. In the setting of anophthalmia or anotia, ancillary testing is recommended.

4.4. Corneal reflex

4.4.1. Test

4.4.1.1. Touch the cornea of both eyes with a cotton swab on a stick at the external border of the iris, applying light pressure and observing for any eyelid movement.

4.4.2. Response consistent with brain death

4.4.2.1. No eyelid movement should be seen.

4.4.3. Considerations

4.4.3.1. Care should be taken to avoid damaging the cornea.

4.4.3.2. In the setting of anophthalmia, severe orbital oedema, prior corneal transplantation, or scleral oedema or chemosis, ancillary testing is recommended.

4.5. Sucking reflex

4.5.1 Test

4.5.1.1 Place gloved finger in the baby's oral cavity and observe for rhythmic sucking

4.5.2 Response consistent with brain death:

4.5.2.1 No sucking movement should be seen.

4.5.3 Considerations

4.5.3.1 This test should only be applied for neonates <30 days of life.

4.6 Motor responses of the face and limbs

4.6.1 Test

4.6.1.1 Apply deep pressure to all of the following:

4.6.1.1.1 The condyles are at the level of the temporomandibular joints.

4.6.1.1.2 The supraorbital notch bilaterally.

4.6.1.1.3 The sternal notch.

4.6.1.1.4 All 4 extremities, both proximally and distally.

4.6.1.2 Insert a cotton swab on a stick in each nostril to perform "nasal tickle" testing.

4.6.2 Response is consistent with brain death

4.6.2.1 Noxious stimuli should not produce grimacing, facial muscle movement, or a motor response of the limbs other than spinally mediated reflexes.

4.6.2.2 Noxious stimuli above the foramen magnum should not produce any movement in the face or body. Noxious stimuli below the foramen magnum should not produce any movement in the face but may elicit spinally mediated peripheral motor reflexes.

4.6.3 Considerations

4.6.3.1 The clinical differentiation of spinal from brain-mediated motor responses requires expertise. Consultation with an experienced practitioner is recommended if the

origin of response is unclear. Alternatively, if the interpretation is unclear, ancillary testing is recommended.

4.6.3.2 Ancillary testing is recommended if a person has a pre-existing severe neuromuscular disorder, such as amyotrophic lateral sclerosis or a pre-existing severe sensory neuropathy.

4.6.3.3 Ancillary testing is not required if a person does not have all 4 limbs; absence of a limb does not preclude motor testing to pain on that side of the body.

4.6.3.4 Severe facial trauma or swelling may preclude evaluation of facial motor response, so ancillary testing is recommended in this setting.

4.7 Gag and cough reflexes

4.7.1 Test

4.7.1.1 Gag reflex: Stimulate the posterior pharyngeal wall bilaterally with a tongue depressor or suction catheter.

4.7.1.2 Cough reflex: Stimulate the tracheobronchial wall to the level of the carina with deep endotracheal placement of a suction catheter.

4.7.2 Response is consistent with brain death

4.7.2.1 Absence of gag and cough.

4.7.3 Considerations

4.7.3.1 The efferent limb for the cough reflex includes the phrenic nerve, which may be injured in persons with high cervical cord injuries, so ancillary testing is recommended in this setting.

5. Apnea Testing

5.1. Absence of a breathing drive is tested with a CO_2 challenge by documentation of an increase in $PaCO_2$ above normal levels.

5.1.1. Should be performed last, after other brainstem reflexes have been tested and proven to be absent.

5.1.2. Should be performed after documenting the absence of spontaneous breathing effort on mechanical ventilation.

5.2. Prerequisites

5.2.1. Absence of high cervical spine injury.

5.2.2. Normotensive (systolic BP not less than 2 standard deviations below age-appropriate norm or systolic blood pressure or mean arterial pressure below the 5th centile of normal values for age norms) with or without the use of vasopressors (see table above).

5.2.3. Core temperature 36 C^0.

5.2.4. Pre-oxygenation with 100% oxygen for at least 10 minutes.

5.2.5. $PaCO_2$ 35-45 mmHg (assuming previously healthy lungs).Higher $PaCO_2$ is acceptable in patients with conditions leading to chronic CO_2 retention (e.g Chronic Lung Disease, cystic fibrosis).

5.3. Procedure

5.3.1. Pre-oxygenate for at least 10 minutes with 100% oxygen.

5.3.2. Disconnect the ventilator and administer 6 L/min by placing a catheter through the endotracheal tube and close to the level of the carina. Alternatively, use a T-piece with 10 cm H20 CPAP and deliver 100% O2, 12 L/min. For neonates <30 days, switch the ventilator to CPAP Mode via Endotracheal tube with PEEP 7cmH20 and FiO_2 100%.

5.3.3. If pulse oximetry oxygen saturation remains 95%, obtain a baseline blood gas (PaO_2, $PaCO_2$, pH, bicarbonate, base excess).

5.3.4. Look closely, with adequate body exposure, for respiratory movements (adequate abdominal or chest excursions) for 8–10 minutes.

5.3.5. If no respiratory drive is observed after approximately 8 minutes, measure the blood gas (PaO_2, $PaCO_2$, pH, bicarbonate, base excess) and reconnect to the ventilator.

5.3.6. If respiratory movements are absent and $PaCO_2$ is 60 mmHg (or 20 mmHg over their baseline $PaCO_2$), the apnea test result supports the clinical diagnosis of brain death.

5.3.7. If target $PaCO_2$ has not been achieved but the patient has adequate blood pressure and oxygenation can be maintained, the apnea test can be extended for a longer period of time (10-15 minutes) or an ancillary test can be considered if the result is indeterminate.

5.3.8. Connect the ventilator if, during testing, the patient becomes hypotensive or the pulse oximeter indicates significant oxygen desaturation (< 85% for > 30 seconds), or cardiac arrhythmias develop; immediately draw an arterial blood sample and analyse arterial blood gas.

5.3.8.1. If $PaCO_2$ is ≥ 60 mm Hg or $PaCO_2$ increase is ≥ 20 mm Hg over baseline normal $PaCO_2$, the apnea test result supports the diagnosis of brain death.

5.3.8.2. If $PaCO_2$ is < 60 mm Hg and $PaCO_2$ increase is < 20 mm Hg over baseline normal $PaCO_2$, the result is indeterminate.

5.3.8.3. Apnea test can be re-attempted with higher inotropic support if the test was indeterminate due to hypotension, or ancillary tests can be considered.

5.3.8.4. Apnea test can be re-attempted with T-piece, CPAP 10 cm H2O, and O_2 12 L/min if the test was indeterminate due to desaturation, or ancillary tests can be considered.

6. Ancillary Tests for Diagnosis of Brain Death

6.1. Prerequisites

6.1.1. Ancillary tests are not routinely required for determination of brain death but may be indicated to support or to supplement the clinical examination when extenuating circumstances preclude a complete brain death examination. Ancillary tests rely on demonstrating the absence of parenchymal blood flow. One ancillary test is sufficient.

6.1.2. When imaging is required, it must be preceded by undertaking those parts of the clinical examination that are possible. Testing for brain perfusion should be deferred until responsiveness, examinable brainstem reflexes and breathing effort are all absent.

6.1.3. Imaging should only be performed if the systemic blood pressure is adequate and should be performed by a specialist or above in radiology or nuclear medicine.

6.1.4. Although the absence of brain perfusion is determined by a radiologist or nuclear physician, it is the responsibility of two medical practitioners who have clinically examined the patient to determine that the patient has died.

6.1.5. When ancillary studies are used, a second clinical examination and apnea test should be performed, and components that can be completed must remain consistent with brain death. In this instance, the observation interval may be shortened, and the second neurologic examination and apnea test (or all components that are able to be completed safely) can be performed at any time thereafter. Death is declared when these above criteria are fulfilled.

6.1.6. If the ancillary study is equivocal or if there is concern about the validity of the ancillary study, the patient cannot be pronounced dead. The patient should continue to be observed until brain death can be declared on clinical examination criteria and apnea testing, or a follow-up ancillary study can be performed to assist with the determination of brain death.

6.1.7. A waiting period of 24 hours is recommended before further clinical re-evaluation or repeat ancillary study is performed. Supportive patient care should continue during this time period.

6.2. Indications for Ancillary Tests

6.2.1. Presence of confounding factors that preclude the performance of brain death clinical examination.

6.2.2. Inability to complete one or both clinical brain death examinations due to conditions like high cervical spine injury, inability to examine at least one eye and one ear, or the inability to complete an apnea test.

6.2.3. Uncertainty of motor response to pain, defined as an inability to distinguish between a spinal reflex and a true motor response to noxious stimuli.

6.3. Recommended ancillary tests

6.3.1. Ancillary studies in newborns are less sensitive than in older children.

6.3.2. No data are available to determine brain death in infants < 37 weeks estimated gestational age.

6.3.3. Ancillary tests are not recommended in infants from 37 weeks corrected gestation (post menstrual) to 30 days post term. In cases where a clinical diagnosis of death by neurological criteria is not possible (for example because of extensive faciomaxillary injuries, or high cervical cord injury), ancillary tests are not sufficiently robust to help confidently diagnose death by neurological criteria in infants.

6.3.4. Ancillary tests can be used to assist in the neurological determination of death in children more than 30 days of age, when preconditions for neurological testing cannot be met.

6.3.5. The choice of an ancillary test is dictated in large part by practical considerations, i.e., availability, advantages, and disadvantages of the tests. The ancillary tests are listed below, in alphabetical order:

6.3.5.1. Four vessels cerebral angiography

6.3.5.1.1. Intra-arterial contrast must be absent above the level of the carotid siphon in the anterior circulation and above the foramen magnum in the posterior circulation.

6.3.5.2. Multiphasic CT angiography (CTA)

6.3.5.2.1. Criteria for absent brain perfusion under the four-point scale are:

6.3.5.2.1.1. Absent enhancement of both middle cerebral artery (MCA) cortical branches (i.e. beyond the Sylvian branches).

6.3.5.2.1.2. Absent enhancement of both internal cerebral veins.

6.3.5.3. Radionuclide imaging with Tc-99m HMPAO SPECT

6.3.5.3.1. Absence of radiotracer activity upon imaging of the intracranial vault compared to the presence of the radionuclide extracranially.

III. Guidance on Filling the Form

1. It is highly recommended for the examiners to review the protocol before performing the examinations and filling the form.
2. Both examiners are required to observe the clinical findings and not to rely on his/her colleague.
3. Two sets of examinations each performed by two physicians are to be completed. If after the first set of examination an ancillary test was required and was suggestive of brain death, a second set of examination which includes apnea test should be performed to confirm the diagnosis.

4. The time of declaration of death should be after the second set of examinations. If an ancillary test is required after the second set of examination, death is declared after the ancillary test report is issued that is suggestive of brain death.

Document History and Version Control Table

The document is to be officially reviewed after 5 years from the release date. However, should there be new evidence that demands an earlier review, the committee will meet to discuss and make appropriate changes.

Document History and Version Control			
Version	**Description of Amendment**	**Author**	**Review Date**
01	Initial Release	Task Force	Nov 2027
02			
03			
04			
05			

Written by	**Reviewed by**	**Approved by**
Brain Death Task Force	Brain Death Task Force	H.E. Dr. Hilal Al Sabti Minister of Health

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Appendix 1: Methods of Ancillary Testing for the Determination of Brain Death

1. Cerebral Angiography

1.1. 4-vessel cerebral angiography to be performed

1.2. Absent filling at the points where the internal carotid and vertebral arteries enter the skull base should be demonstrated.

1.3. The external carotid circulation should be patented.

1.4. The filling of the superior longitudinal sinus may be delayed.

2. Cerebral Scintigraphy Technetium-99m HMPAO SPECT

2.1. General points to be considered: Please refer to the latest SNM and EANM guidelines for more details.

2.1.1. The isotope should be injected within 30 minutes after its reconstitution.

2.1.2. Flow images should be acquired as they help to confirm lack of brain blood flow when the brain is not visualised on delayed images using 99mTc-HMPAO.

2.1.3. Anterior and both lateral planar image counts (500,000) of the head should be obtained at several time points: immediately, between 30 and 60 minutes later, and at 2 hours.

2.1.4. SPECT images should be obtained in addition to the flow and planar images as it allows better visualisation of perfusion to the posterior fossa and brainstem structures.

2.1.5. A correct IV injection may be confirmed with additional images of the liver demonstrating uptake (optional).

2.1.6. To confirm absence of cerebral blood flow, there should be:

2.1.6.1. No radionuclide localization in the middle cerebral artery, anterior cerebral artery, or basilar artery territories of the cerebral hemispheres (hollow skull phenomenon).

2.1.6.2. No tracer in superior sagittal sinus (minimal tracer can come from the scalp).

3. Cerebral CT Angiogram

3.1. After a lateral topography, 3 similar acquisitions to be planned starting at the C1-C2 level to the convexity.

3.2. The first phase to be done without injection of contrast.

3.3. Following precontrast images, the second (early) and third (late) scans to be acquired at 20 s and 60 s after the contrast medium injection, respectively.

3.4. **The imaging analysis**

3.4.1. Opacification of branches of external carotid arteries – the superficial temporal or the facial arteries to be assessed on the second phase at 20 seconds to confirm the correct injection of contrast medium and there are no hemodynamic abnormalities causing a delay of contrast delivery to the vessels of the head and neck.

3.4.2. Late post-contrast scanning for assessing intracranial vascular opacification. This phase is to be done in 60 sec. after the beginning of injection, with a delay of 40 sec. to the early phase. The necessity of performing the late phase of CTA in the diagnosis of cerebral circulatory arrest is motivated by a possible delayed vascular opacification in intracranial hypertension.

3.4.3. 4-point CTA score based on the lack of opacification of cortical segments of the MCAs and the 2 ICVs at the third phase, at 60 seconds.

3.4.3.1. A score of 1 is to be assigned to each of the non-opacified vessel segments.

3.4.3.2. Findings are to be interpreted as cerebral circulatory arrest (i.e., positive for confirmation of BD) only when a score of 4 (i.e., non-opacification of all vessels) is achieved.

3.4.4. The stasis filling phenomenon is a common condition observed in angiographic studies in brain dead patients. It is a specific angiographic pattern of cerebral circulatory arrest, which can cause problems in interpretation of CTA results in the diagnosis of brain death. Stasis filling is defined as a delayed, weak, persistent, and progressive opacification of the **proximal segments** of intracranial arteries, **without** opacification of the cortical branches or venous outflow found between the arterial and venous acquisitions of CTA.

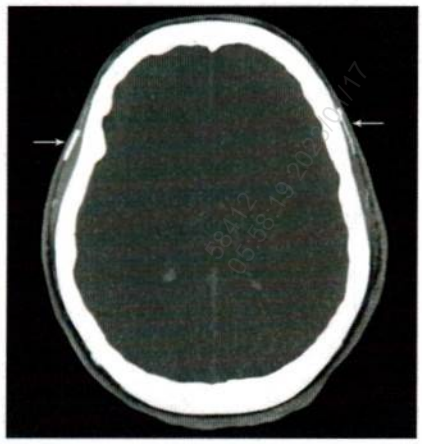

Figure 1: Arterial phase shows contrast opacification of the superficial temporal arteries indicating the adequacy of the technique. Note absence of contrast in the MCA cortical branches.

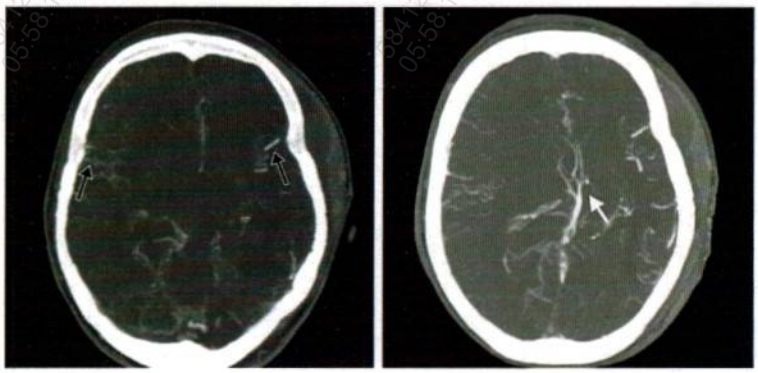

Figure 2: The venous phase axial MIP image shows the intense enhancement of the bilateral MCA-M4 segments. The white arrow indicates the opacification of ICVs on the venous phase axial MIP image. Diagnosis of brain death is not confirmed.

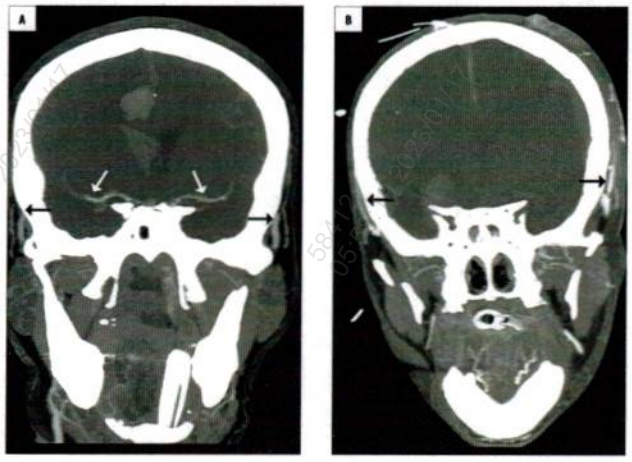

Figure 3: Positive results of CTA in the diagnosis of brain death where A coronal MIP demonstrates stasis filling with delayed opacification of proximal MCAs (white arrows). The superficial temporal arteries (black arrows) are opacified. B shows no intracranial filling. These findings confirm the diagnosis of brain death.

Patient's Sticker

National Brain Death Determination Form (Adult)

Examination Set: One □ Two□

Patient Name:	**Date of birth:**
Hospital:	**Hospital No.:**
Primary Diagnosis:	
Etiology of Irreversible and Identifiable Coma:	

Part 1. Prerequisites:	**Examiner One**	**Examiner Two**
	Date: Time:	Date: Time:
Neuroimaging explains deep coma	□ Yes □ No	□ Yes □ No
Systolic Blood Pressure ≥100 mmHg or MAP ≥60 mmHg	□ Yes □ No	□ Yes □ No
Core BodyTemperature ≥ 36^0 C	□ Yes □ No *	□ Yes □ No *
Sedative/analgesic or drug effect excluded as a contributing factor	□ Yes □ No *	□ Yes □ No *
Metabolic/electrolyte abnormalities excluded as a contributing factor	□ Yes □ No *	□ Yes □ No *
Neuromuscular blockade excluded	□ Yes □ No	□ Yes □ No
Part 2. Physical examination:		
Absent bilateral motor responses (excluding spinal reflexes)	□ Yes □ No □ NA	□ Yes □ No □ NA
Absent bilateral pupillary light reflex (Pupils ≥ 4 mm)	□ Yes □ No □ NA	□ Yes □ No □ NA
Absent bilateral corneal reflexes	□ Yes □ No □ NA	□ Yes □ No □ NA
Absent gag and cough reflexes	□ Yes □ No □ NA	□ Yes □ No □ NA
Absent bilateral oculovestibular reflex (caloric test)	□ Yes □ No □ NA	□ Yes □ No □ NA
Absent bilateral oculocephalic reflex	□ Yes □ No □ NA	□ Yes □ No □ NA
Part 3. Apnea Test: ***If high spinal cord injury or test could not be completed toproceed with the ancillary test***		
Pre-test PaCO2	_____ mm Hg	_____ mm Hg
Post-test PaCO2	_____ mm Hg	_____ mm Hg
PaCO2 ≥ 60 mmHg or ≥ 20 mmHg over pretest baseline	□ Yes □ No □ NA	□ Yes □ No □ NA

Absent Respiratory effort	□ Yes □ No □ NA	□ Yes □ No □ NA
Part 4. Ancillary Testing performed:	**□Yes** **□No**	
Reason:		
Date: Time:		
Absence of intracranial blood flow has been demonstrated by: □ Four vessels cerebral angiography □ Radionuclide imaging □ CT angiography		
Part 5. Signatures:	**Examiner one:**	**Examiner Two:**
	Date: Time:	Date: Time:
certify that my examination and/or ancillary test eport confirms unchanged and irreversible cessation of function of the brain and brainstem.	Physician : Sign:	Physician: Sign:

- * If these prerequisites can not be corrected and are judged to be potentially contributing to the loss of brain functions, complete clinical examinations and apnea test, as well as ancillary testing, should be performed to confirm brain death.
- Not assessable (NA) in the physical examination & apnea test, except for absent bilateral oculocephalic reflex, necessitates doing the ancillary test.

Patient's Sticker

Form 2: National Brain Death Determination Form (Pediatrics and Neonates)

Examination Set: One □ Two□

Patient Name:			**Date of birth:**		
Hospital Name:			**Hospital No.:**		
Primary Diagnosis:					
Etiology of Irreversible and Identifiable Coma:					
Age of patient	**Timing of first exam**		**Timing of second exam**		
Term newborn 37 weeks gestational age and < 30 days of age	□ First exam may be performed at least 48 hrs after birth OR following CPR or other severe brain injury		□ At least 24 hours from first exam		
30 days and less than 13 years of age	□ First exam may be performed 24hrs following CPR OR other severe brain injury		□ At least 6 hours from first exam		
Part 1. Prerequisites:	**Examination One**		**Examination Two**		
	Date: Time:		Date: Time:		
Neuroimaging explains deep coma	□ Yes	□ No	□ Yes	□ No	
Systolic Blood Pressure not less than 2 SD below age-appropriate norm (alternative: SBP >5th centile of age-appropriate norms)	□ Yes	□ No	□ Yes	□ No	
Core BodyTemperature ≥ 36 C°	□ Yes	□ No *	□ Yes	□ No *	
Sedative/analgesic or drug effect excluded as a contributing factor	□ Yes	□ No *	□ Yes	□ No *	
Metabolic/electrolyte abnormalities excluded as a contributing factor	□ Yes	□ No *	□ Yes	□ No *	
Neuromuscular blockade excluded	□ Yes	□ No	□ Yes	□ No	
Unresuscitated shock excluded	□ Yes	□ No	□ Yes	□ No	
Part 2. Physical examination:					
Absent bilateral motor responses (excluding spinal reflexes)	□ Yes	□ No □ NA	□ Yes	□ No	□ NA
Absent bilateral pupillary light reflex (Pupils ≥ 4 mm)	□ Yes	□ No □ NA	□ Yes	□ No	□ NA
Absent bilateral corneal reflexes	□ Yes	□ No □ NA	□ Yes	□ No	□ NA
Absent gag and cough reflexes	□ Yes	□ No □ NA	□ Yes	□ No	□ NA
Absent bilateral oculovestibular reflex	□ Yes	□ No □ NA	□ Yes	□ No	□ NA

Absent bilateral oculocephalic reflex	□ Yes □ No □ NA	□ Yes □ No □ NA
Absent sucking and rooting reflex (***only for neonates***)	□ Yes □ No □ NA	□ Yes □ No □ NA
Part 3. Apnea Test: ***If high spinal cord injury or test could not be completed, to proceed with the ancillary test***		
Pre-test $PaCO_2$	_____ mm Hg	_____ mm Hg
Post-test $PaCO_2$	_____ mm Hg	_____ mm Hg
$PaCO_2$≥ 60 mmHg or ≥ 20 mmHg over pretest baseline	□ Yes □ No □ NA	□ Yes □ No □ NA
Absent Respiratory effort	□ Yes □ No □ NA	□ Yes □ No □ NA
Part 4. Ancillary Testing performed:	**□Yes** **□No**	
Reason:		
Date: Time:		
Absence of intracranial blood flow has been demonstrated by: □ Four vessels cerebral angiography □ Radionuclide imaging □ CT angiography		
Part 5. Signatures:	**Examiner one**	**Examiner Two**
	Date: Time:	Date: Time:
I certify that my examination and/or ancillary test report confirms unchanged and irreversible cessation of function of the brain and brainstem.	Physician: Sign:	Physician: Sign:

- * If these prerequisites can not be corrected and are judged to be potentially contributing to the loss of brain functions, complete clinical examinations and apnea test, as well as ancillary testing, should be performed to confirm brain death.
- Not assessable (NA) in the physical examination &apnea test, except for absent bilateral oculocephalic reflex, necessitates doing the ancillary test.