MOH/P/PAK/578.25(HB) - e

MALAYSIAN CONSENSUS STATEMENT ON BRAIN DEATH 2024

BAHAGIAN PERKEMBANGAN PERUBATAN
KEMENTERIAN KESIHATAN MALAYSIA

Malaysian Society of Neurosciences
Persatuan Neurosains Malaysia

The Malaysian Consensus Statement on Brain Death 2024

was developed by

Malaysian Society of Neurosciences

Persatuan Neurosains Malaysia

in collaboration with

Surgical Services Unit (Transplantation Services)
Medical Services Development Section
Medical Development Division
Ministry of Health Malaysia

Electronic version is available at the following websites:

https://www.moh.gov.my/
https://www.neuro.org.my/

Published in 2025

1st edition 1993
2nd edition 2003

A catalogue of this document is available from the
Institute of Medical Research, National Institutes of Health, Ministry of Health Malaysia

MOH/P/PAK/578.25(HB) - e

And also available from the National Library of Malaysia;

ISBN 978-967-26294-5-0

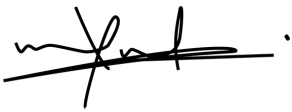
FOREWORD FROM THE DIRECTOR-GENERAL OF HEALTH, MALAYSIA

The determination of death is one of the most profound responsibilities in medicine. It is a complex clinical decision, as well as an ethical, cultural, and legal one with significant implications for patients, families, and healthcare providers. In recent years, evolving medical practice, public expectations, and advances in neuroscience have underscored the need for clarity and standards on the criteria and processes of brain death diagnosis.

The Malaysian Consensus Statement on Brain Death 2024 represents a critical step forward for our healthcare system. It is the result of extensive consultation with clinicians, ethicists, legal experts, and community voices. Its purpose is to ensure that the diagnosis of brain death is approached with the highest level of rigour, consistency, and compassion. Our guidelines must reflect the latest evidence, technological advancements, and ethical considerations to ensure accuracy, consistency, and public trust in the determination of brain death.

This document is the result of extensive deliberation, collaboration, and dedication from leading experts in neurology, intensive care, organ transplantation, and medical ethics. It builds upon previous guidelines while incorporating contemporary scientific understanding and international best practices, ensuring that Malaysia remains at the forefront of medical excellence. I extend my deepest gratitude to the Malaysian Society of Neurosciences, the Medical Development, Ministry of Health Malaysia, and all esteemed contributors who have worked tirelessly to develop this updated consensus. This collaboration affirms our shared commitment to medical integrity, ethical clarity, clinical excellence, and respect for the lives and dignity of those we serve.

I am confident that this document will serve as an invaluable resource for healthcare professionals nationwide, providing clear guidance in the determination of brain death while upholding the principles of compassion, dignity, and respect for patients and their families. May this consensus statement guide our practice, contribute to strengthening our healthcare system, enhancing clinical decision-making, and ultimately reinforce our duty to uphold the highest standards of care.



DATUK DR. MUHAMMAD RADZI BIN ABU HASSAN

Director General of Health
Ministry of Health Malaysia

FOREWORD FROM PRESIDENT MALAYSIAN SOCIETY OF NEUROSCIENCES

I am honoured to present the Malaysian Consensus Statement on Brain Death 2024. This updated consensus marks a significant milestone in the evolution of medical practice in Malaysia, addressing the critical need for clarity and alignment in brain death determination.

It has been two decades since the last consensus was established. During this time, advancements in medical science and evolving clinical practices have highlighted the importance of revisiting and refining the criteria for brain death. This updated consensus not only incorporates the latest scientific evidence and clinical guidelines but also reflects the commitment of the medical community to uphold the highest standards of care and ethical responsibility.

This monumental achievement would not have been possible without the unwavering dedication and expertise of the distinguished panellists and external reviewers who contributed their time, knowledge, and insights to this endeavour. Their collaborative spirit and commitment to excellence are the foundation of this consensus. I would also like to extend my heartfelt gratitude to Dr. Law Wan Chung, past President of the Malaysian Society of Neurosciences, whose visionary leadership and foresight initiated this critical effort.

Our sincere appreciation also goes to the Medical Development Division of the Ministry of Health Malaysia for recognizing the importance of this initiative and providing their endorsement. Their support ensures that this consensus will serve as a vital reference for clinicians across the country.

It is my hope that this updated consensus will not only guide clinical practice but also foster greater understanding and trust among healthcare providers, patients, and the public. Together, let us continue to uphold the principles of evidence-based medicine and compassionate care for the betterment of all.

DR. AHMAD SHAHIR BIN MAWARDI

President
Malaysian Society of Neurosciences

FOREWARD FROM CHAIRPERSON OF THE REVIEW COMMITTEE

It has been 20 years since there has been a review of the Brain death Consensus Guidelines by the Malaysian Society of Neurosciences, so it is timely that there is a review this year. The aims of the consensus guidelines are to provide clinicians updates on the understanding on the rationale and criteria for the certification of brain death.

The Malaysian Consensus Statement on Brain Death 2024guidelines committee comprises of different experts in the field, including adult and paediatric neurologists, neurosurgeons, anaesthesiologists and intensive care specialists, adult and paediatric neuro-radiologists. This updated document provides highlights on topics not addresses in previous document as well as current practices, internationally.

Review of the recent literature did not find any new landmark clinical studies and the diagnosis of brain death remains primarily clinical with the criteria unchanged. However, the updated guidelines have provided an improved description and rationale on the inclusion and exclusion criteria as well as pitfalls of clinical testing. In addition, there are now greater details on when to perform and how to interpret ancillary tests in brain death especially neuro-radiological tests.

Once the guidelines are reviewed and accepted by the Ministry of Health, it will be circulated to all clinicians and hospitals. I would like to thank members of the committee for their contributions and for the Malaysian Society of Neurosciences for supporting this endeavour.

PROF DATO' DR. GOH KHEAN JIN

Chairperson
Review Committee

ABBREVIATIONS

CBF	Cerebral Blood Flow
CT	Computed Tomography
CPAP	Continuous Positive Airway Pressure
EEG	Electroencephalography
ETT	Endotracheal Tube
MRI	Magnetic Resonance Imaging
$PaCO_2$	Partial Pressure of Carbon Dioxide in Arterial Blood
PEEP	Positive End-Expiratory Pressure

CONTENTS

HISTORY

The original Brain Death Committee was formed by the Ministry of Health in late 1992 to make recommendations regarding criteria and certification brain death and prepare guidelines for use in the country. Members comprised specialists in relevant fields and representatives of professional medical organisations. The committee submitted its report to the Director-General of Health and the Academy of Medicine in January 1993.

The Guidelines were then circulated to all government, private and university hospitals. Members of the committee also gave lectures nationwide to explain the guidelines on brain death.

The Brain Death Consensus Guidelines were accepted by the medical fraternity at a consensus meeting organized by the Ministry of Health and the Academy of Medicine of Malaysia on 12th December 1993. The consensus was reviewed in 2002 and published as Consensus Statement in 2003.

MEMBERS OF THE FIRST BRAIN DEATH CONSENSUS COMMITTEE (1993)

Chairperson: **Dato' Dr. Mohd Rani Jusoh**
Neurologist, representing Ministry of Health

Co-Chairperson: **Mr. A Mohandas**
Neurosurgeon, representing Academy of Medicine

Members:

Prof. Dr. Tan Chong Tin
Neurologist, representing University of Malaya

Dr. Sng Kim Hock
Physician

Mr. Chee Wee Lian
Surgeon

Assoc. Prof. Dr. Biduwiyah Long Bidin
Physician, representing Universiti Kebangsaan Malaysia

Assoc. Prof. Dr. Karis Misran
Anaesthetist

Dr. Sabri Rejab
Neurologist, representing College of Physicians

Mr. Richard Veerapen
Neurosurgeon

Dr. P Boopalan
Obstetrician & Gynaecologist

Prof. A E Delilkan
Anaesthetist

Dr. Yong Fee Mann
Physician, representing Ministry of Health

Dr. Santiago Rao
Anaesthetist

Assoc. Prof. Dr. Asma Omar
Paediatrician

Dr. S Balan
Anaesthetist representing Malaysian Medical Association

Dr. Lee Moon Keen
Neurologist, representing Malaysian Society of Neurosciences

Dr. Sylvian Das
Anaesthetist, representing College of Surgeons

THE REVIEW COMMITTEE OF CONSENSUS STATEMENT ON BRAIN DEATH 2003

Chairperson: **Dato' Dr. Mohd Rani Jusoh**
Senior Consultant Neurologist,
Ampang Puteri Specialist Hospital

Members:

Datuk Dr. Alex Delilkan
Consultant Anaesthesiologist, President Medico-Legal Society of Malaysia

Prof. Dr. Tan Chong Tin
Senior Consultant Neurologist, Pusat Perubatan Universiti Malaya

Datuk Dr. Raihanah Abdul Khalid
Consultant Neurologist, Hospital Kuala Lumpur

Prof. Dr. Raymond Azman Ali
Senior Consultant Neurologist, Hospital Universiti Kebangsaan Malaysia

Prof. Dr. Ong Lai Choo
Senior Consultant Paediatric Neurologist, Hospital Universiti Kebangsaan Malaysia

Assoc. Prof. Dr. Goh Khean Jin
Consultant Neurologist, Pusat Perubatan Universiti Malaya

Mr Johari Adnan
Consultant Neurosurgeon, Hospital Sultanah Aminah

Dr. Lim Wee Leong
Consultant Anaesthesiologist, Hospital Kuala Lumpur

Dr. Zariah Abdul Aziz
Consultant Neurologist, Hospital Kuala Terengganu

Dr. Sofiah Ali
Consultant Paediatric Neurologist, Subang Jaya Medical Centre

Dr. Santhi Datuk Puvanarajah
Consultant Neurologist, Hospital Kuala Lumpur

THE REVIEW COMMITTEE OF MALAYSIAN CONSENSUS STATEMENT ON BRAIN DEATH 2024

Chairperson: **Prof Dato Dr. Goh Khean Jin**
Senior Consultant Neurologist, Faculty of Medicine, University of Malaya, Kuala Lumpur

Panelists:

Neurology

Emeritus Prof Dato Dr. Raymond Azman Ali
Senior Consultant Neurologist Hospital Al Sultan Abdullah UiTM

Datuk Dr. Raihanah Khalid
Senior Consultant Neurologist Assunta Hospital, and former Head of Neurology Hospital Kuala Lumpur & Head of Service, KKM

Dr. Santhi Datuk Puvanarajah
Senior Consultant Neurologist, Former National Head of Neurology Services, Ministry of Health, Malaysia

Prof Dr. Tan Hui Jan
Consultant Neurologist, Faculty of Medicine, Universiti Kebangsaan Malaysia, Hospital Canselor Tuanku Muhriz, Kuala Lumpur

Dr. Irene Looi
Consultant Neurologist, Hospital Seberang Jaya, Pulau Pinang

Dr. Suganthi S Chinnasami
Consultant Neurologist, Hospital Kuala Lumpur, Kuala Lumpur

Dr. Chia Yuen Kang
Consultant Neurologist, Hospital Queen Elizabeth, Sabah

Dr. Khairul Azmi bin Ibrahim
Consultant Neurologist, Hospital Sultanah Nur Zahirah, Terengganu

Dr. Ahmad Shahir bin Mawardi
Consultant Neurologist, Hospital Kuala Lumpur, Kuala Lumpur

Neurosurgery

Dato' Dr. Nasser Abdul Wahab
Consultant Neurosurgeon, Hospital Putrajaya

Dr. Siti Azleen binti Mohamad
Neurosurgeon, Hospital Kuala Lumpur

Dr. Priya Sharda A/P Jagdish Mitter
Neurosurgeon, Hospital Kuala Lumpur

THE REVIEW COMMITTEE OF MALAYSIAN CONSENSUS STATEMENT ON BRAIN DEATH 2024

Anaesthesiology

Dr. Omar bin Sulaiman
Consultant Anaesthesiologist, Hospital Sultanah Aminah, Johor Bahru

Dr. Azmin Huda bt Abdul Rahim
Consultant Intensivist, Hospital Sultan Ismail, Johor Bahru

Dr. Premela Naidu
Consultant Intensivist, Subang Jaya Medical Center and former Head of Critical Care Service Unit, University Malaya Medical Centre.

Paediatrics

Prof Dr. Fong Choong Yi
Senior Consultant Paediatric Neurologist, Department of Paediatrics, Faculty of Medicine, University of Malaya, Kuala Lumpur

Dr. Ahmad Rithauddin bin Mohamed
Senior Consultant Paediatric Neurologist, Hospital Tunku Azizah, Kuala Lumpur

Prof Dr. Gan Chin Seng
Senior Consultant Paediatric Intensivist, Department of Paediatrics, Faculty of Medicine, University of Malaya, Kuala Lumpur

Radiology

Dr. Norzaini Rose bt Mohd Zain
Senior Consultant Neuroradiologist and National Head of Radiology Services, National Cancer Institute, Putrajaya

Dr. Noryati binti Mohammad
Senior Consultant Paediatric Radiologist, Hospital Tunku Azizah, Kuala Lumpur

Dr. Nurul Hafidzah bt Rahim
Neuroradiologist, Hospital Putrajaya, Putrajaya

INTRODUCTION

The concept of brain death has been accepted worldwide and considered ethically acceptable.

There have been significant advances in cardio-pulmonary resuscitation, vital systems support in intensive care units and organ transplantation. Therefore, the diagnosis and certification of brain death have become extremely crucial.

Brain death is a definite clinical state. Adults with brain death will eventually develop asystole, regardless of what treatments are given. Magnetic resonance imaging (MRI) of the brain shows diffuse swelling with tentorial and foraminal herniations while various angiographic studies show absent blood flow.

In well documented cases of brain death, none have survived. At post-mortem, there are widespread brain necrosis and swelling of the hemispheres and brainstem, a situation incompatible with life.

It is important to recognize this condition early for ethical, human, intellectual and utilitarian reasons.

Additionally, in our current practice, we need to consider other important factors including the expanding transplant network and current local laws.

PURPOSE AND SCOPE OF MALAYSIAN CONSENSUS STATEMENT ON BRAIN DEATH 2024

1. To provide a standard for the clinician in relation to the determination of death by neurological criteria.
2. To provide assurance that determination of death by neurological criteria is undertaken in accordance with current available medical evidence.

RECOMMENDATIONS

The Committee made the following recommendations:

1. The diagnosis of brain death is a clinical diagnosis and no confirmatory investigation is required in the usual case scenario. The exception to this when certain aspects of the clinical tests cannot be reliably performed (or evaluated). This is based on the assessing physicians' clinical judgement on an individual case-to-case basis.
2. Two specialists who are National Specialist Register (NSR) accredited, and who are experienced in diagnosing brain death, are qualified to certify brain death.
3. Doctors involved in organ transplantation are not allowed to be involved in brain death certification.
4. All hospitals, where brain death certification is carried out, shall have a committee that functions as a coordinating body and is responsible for general policies, training and accrediting staff, counselling and overseeing the facilities available.
5. The Brain Death guideline shall be reviewed every 5-10 years as necessary to accommodate new knowledge and latest clinical practice.

1. Definition

Brain death is a clinical diagnosis. It is an irreversible cessation of all functions of the entire brain, including the brain stem.

2. Diagnosis of Brain Death

2.1 Preconditions (all to be fullfiled):

- Patient is in deep coma, apnoeic and on mechanical ventilation, for at least 12 hours.
- The cause of coma is fully established and sufficient to explain the patient's condition. Brain imaging is highly recommended, at least computed tomography (CT) of the brain.
- There is irremediable brain damage.
- Patient is haemodynamically stable.

2.2 Exclusions:

- Coma due to metabolic or endocrine disturbances, drug intoxication and primary hypothermia (defined as a core temperature < 35°C).
- When certain neurological disorders, namely Guillain-Barré syndrome, locked-in syndrome, botulism, and organophosphate poisoning cannot be excluded.
- Coma of undetermined cause.
- Preterm neonates.

2.3 Diagnostic criteria (all to be fullfilled):

Brain death is a clinical diagnosis.

The standard for determination of brain death is the clinical neurologic examination performed with precision, to ascertain the irreversibility of the loss of brain function, having established the proximate cause of coma. **All clinical tests** described below are needed to declare brain death.

1. Deep coma, unresponsive and unreceptive, Glasgow Coma Score (GCS) 3/15.

- Unresponsiveness and absence of coordinated eye movements and motor activity, including decorticate or decerebrate posturing.
- Spontaneous motor activity (excluding spinal reflexes) and epileptic seizures must be absent. There is no motor response to pain.
- In the newborn, there is no sucking and rooting reflex.

2. Absent brain stem reflexes

Measures reflex pathways in the mesencephalon, pons and medulla oblongata (in a rostral-to-caudal direction).

Confirmation done by the following tests:

a. Pupillary light reflex

- Absent response to bright light in BOTH eyes.
- Pupillary size may be mid-position (4-6 mm) to fully dilated.
- Round, oval or irregularly shaped pupils are compatible with brain death.

Pitfalls:

- Many drugs can influence pupil size, but light response remains intact.
- Pre-existing anatomic abnormalities of the iris or effects of previous surgery should be excluded.
- Topical ocular installation of drugs & trauma to the cornea or eyeball may cause abnormalities in pupil size and can produce non-reactive pupils.

b. Oculo-cephalic reflex

- Testing is done ONLY when there is no fracture or instability of the cervical spine.
- In patients with head injury, the cervical spine must be imaged to exclude potential fractures or instability.
- The oculo-cephalic response is elicited by fast, vigorous turning of the head from middle position to 90° on BOTH sides.
- Any eye movement must be absent.

Pitfalls:

- After closed head injury or facial trauma, lid oedema and chemosis of the conjunctivae may restrict movement of the globe.

c. Motor response in cranial nerve distribution
- Pressure stimulus is applied to the supraorbital nerve or deep pressure on both condyles at the level of the temporo-mandibular joints.
- Absent grimace response.

d. Corneal reflex
- Both eyes to be tested with a cotton swab.
- Absent blink response.

e. Vestibulo-ocular reflex (Caloric Test)
- Prior to testing, external auditory meatus must be visualized by otoscope.
- Caloric testing to be done with head elevated to 30° during irrigation of the external auditory canal on each side with 50 ml of ice water.
- Allow 1 minute after irrigation and at least 5 minutes between testing on each side.
- Absent eye movement to cold caloric stimulus.

Pitfalls:
- Clotted blood or cerumen may diminish the caloric response. Basal fractures of the petrous bone abolish the caloric response unilaterally and may be identified by an ecchymotic mastoid process (Battle's sign).
- Certain drugs may diminish or completely abolish the caloric response.

f. Oro-pharyngeal reflex
- The gag response is tested by stimulation of the posterior pharynx bilaterally.
- Absent of gag response.

g. Tracheo-bronchial reflex
- A suction catheter is passed down through the endotracheal tube at least to the level of the carina.
- Absent of cough response to tracheo-bronchial wall stimulation.

Pitfalls:
- Severe facial and neck trauma may limit the interpretation of all brainstem reflexes.
- In the event of inability to perform any test from the list of brain stem reflexes tests (a. to g.), ancillary testing is strongly recommended
- "Lazarus sign" - Spontaneous motor responses of spinal origin may be seen.

Refer Appendix I for more details on pitfalls.

3. Apnoea test

Protocol:

- The patient must be in a stable cardiovascular and respiratory state.
- Baseline $PaCO_2$ between 35-45mmHg.
- Pre-oxygenate with 100% 0_2 for 10 minutes.
- Disconnect from ventilator.
- Deliver 100% O_2 via
  - Tracheal catheter (not for paediatrics)
  - CPAP on the mechanical ventilator
  - T-piece or via resuscitation bag with a functioning PEEP valve to ETT
- Monitor O_2 saturation with pulse oximetry.
- Measure $PaCO_2$, after 5 minutes and again after approximately 8 minutes if $PaCO_2$ has not exceeded 60 mmHg.
- Re-connect to ventilator after test.
- The disconnection of the ventilator shall not exceed 10-15 minutes at any one time provided the patient remains haemodynamically stable.

Result interpretation

- The apnoea test is positive when there is no respiratory effort at a $PaCO_2$ of $\geqslant$ 60mmHg.
- If during apnoea testing, there is significant hypotension, marked desaturation or unstable cardiac arrhythmias, immediately draw an arterial blood sample, re-connect to ventilator and analyse arterial blood gas results. Should the $PaCO_2$, not exceed 60mmHg, the result is indeterminate. It is left to the discretion of the physician to decide whether to repeat the test or to depend on an ancillary test to finalise the clinical diagnosis of brain death.
- For patients with chronic lung disease, the baseline $PaCO_2$, may already be above 40mmHg. The apnoea test is then considered positive if there is no respiratory effort at a $PaCO_2$ of 20mmg above the baseline $PaCO_2$.

2.4 Brain Dead Assessment and Certification:

- The assessment of brain death is to be carried out by two NSR-accredited specialists qualified in diagnosing brain death.
- A repeat assessment and certification must be carried out at least 6 hours and up to 24 hours after the first, not necessarily by the same pair of specialists. In paediatric patients, a minimum of 24 hours is required.
- The "**Brain Death Certification**" form is filled up by the first set of doctors (A and B) and completed by the second set of doctors (C and D); or doctors A and B if the same doctors are performing the second test.
- The time of death will then be declared by the doctors performing the second test.
- If for any reason, the second test is unable to be carried out 6 hours later the time of death shall be when the second test is completed. Should the patient develop asystole before the second test, the time of death shall be taken at the point of asystole.
- In the event an ancillary test is required (refer to appendix II), clinical tests that can be performed must be performed twice as recommended. Certification of death is after the second clinical test, taking into account both clinical and ancillary tests.

3. Other Considerations

During the period of observation, the patient shall remain deeply comatose with no respiratory effort, no abnormal posture or movements in cranial nerve distribution.

Patients who do not meet all the above criteria shall not be considered for brain death certification.

For children, no recommendations can be made for preterm infants <37 weeks of gestational age.

For term newborns or older, ancillary tests are required when component(s) of the clinical examination and apnoea test cannot be fully completed (for e.g., in cyanotic heart disease if there is uncertainty of the clinical finding(s) or if medication effects are suspected of interfering with the evaluation).

The following ancillary tests can be considered in children:

Age	Timing from unresponsive coma	Ancillary test
Term newborns (>37 weeks gestation) to 30 days of age	At least 24 hours	Electroencephalogram (EEG)
31 days – 18 years old	At least 24 hours	EEG and cerebral blood flow (CBF) radionuclide studies have equal sensitivity

Reduction of observation period between two examinations: permitted for both age groups if EEG or CBF is consistent with brain death.

Pitfalls in diagnosis may occur, especially if certain aspects of the clinical tests cannot be reliably performed (or evaluated). Ancillary laboratory tests (not usually mandatory) may be useful in these situations and in certain instances where children are involved.

4. Qualification of Doctors Certifying Brain Death

Each hospital is recommended to have a subcommittee to appoint and review doctors authorised to certify brain death in that hospital.

Two specialists are considered qualified in diagnosing brain death if they are NSR-accredited and with clinical experience in conducting brain death assessment. They should preferably be anaesthesiologists, paediatric anaesthesiologists, intensivists, paediatric intensivists, neurologists, paediatric neurologists, neurosurgeons, paediatric neurosurgeons, paediatrician or internal medicine specialists. For hospitals without qualified specialists in diagnosing brain death, they will need to liaise with a relevant clinician from another tertiary hospital for further advice and management.

5. Criteria of Hospital Performing Brain Death Certification

Brain death certification must be done in areas of the hospital with full facilities for intensive cardiopulmonary care of comatose patients which include ventilation, cardiac monitor and blood gas analysis machine.

6. Guidelines for Children/Neonates

There are some medical issues unique to children in determining brain death. It is generally assumed that the young child's brain may be more resilient to certain forms of injury, although this issue is controversial.

Newborns are difficult to evaluate after perinatal insults. This relates to many factors including difficulties of clinical examination, determination of approximate cause of coma, and certainty of the validity of laboratory tests. These problems are accentuated in the premature newborns. Hence, the guidelines are modified in two areas - the interval between two examinations is lengthened, and the timing of the 1st examination. No recommendations are made for newborns or preterm infants.

Age	Timing of first examination	Examination intervals
Term newborns (>37 weeks gestation) to 30 days of age	24 hours after birth **OR** 24 hours post CPR or severe brain injury	At least 24 hours **OR** shortened because ancillary study at first examination showed brain death
31 days – 18 years old	24 hours post CPR or severe brain injury	12 to 24 hours **OR** shortened because ancillary study at first examination showed brain death

7. Recommendations Brain Death Certification in Pregnant Women

- Same preconditions and exclusion criteria apply. (Refer above)
- Brain death testing in pregnant patient is the same as for adults. (Refer above)
- Somatic support may be continued in the presence of viable foetus (> 24 weeks gestation) in consultation with immediate family members and approval of the hospital ethics committee, with every effort made to prevent harmful effects to the foetus.

APPENDIX 1 (*PITFALLS*)

Pitfalls in the Brain Death diagnosis

1. Severe facial trauma
2. Pre-existing pupillary abnormalities
3. Toxic level of sedative drugs, aminoglycosides, tricyclic antidepressants, anticonvulsants, chemotherapeutic drugs, neuromuscular blocking agent
4. Sleep apnoea or severe pulmonary disease resulting in chronic retention of carbon dioxide.
5. Spontaneous and reflex movements in the brain death.

Spontaneous and reflex movements have been observed in patients with brain death. The most common are finger jerks. The undulating toe flexion sign (snapping the big toe leads to an undulating movement of the other toes), triple flexion response, persistent Babinski response, Lazarus sign, pronation - extension reflex, and facial myokymia can also occur. These movements are spinal in origin and generally occur during the apnoea test or are triggered during forceful flexion of the neck, rotation of the body, or by the ventilator, synchronous with pulmonary insufflation. They do not occur spontaneously. They do not preclude the diagnosis of brain death.

Drugs

Presence of certain drugs, metabolites or poisons may confound the clinical determination of brain death. Drug screens are useful, but not all drugs can be identified. Furthermore, even if a drug has been identified, the critical threshold is often not known:

A reasonable approach is:

- If screening tests reveal traces of a drug below the therapeutic range, brain death can be determined.
- When the drug or poison cannot be quantified but is certain, the recommendation is to observe the patients for at least 5 times the duration of its elimination half-life provided excretion of the drug or toxin is not affected by other drugs or organ dysfunction.
- When the drug is not known but suspicion of its presence is high, observe for 48 hours for a change in brainstem reflexes and motor response before proceeding with brain death tests.

APPENDIX 1 (*PITFALLS*)

Common drugs that may confound the neurological examination in brain death

Drugs	Elimination T ½ (hours)	Therapeutic range
Lorazepam	10-20	0.1 – 0.3 ug/ml
Midazolam	2 - 5	50-150 ng/ml
Diazepam	40	0.2 – 0.8 ug/ml
Carbamazepine	10-60	2 – 10 ug/ml
Phenobarbitone	100	20 – 40 ug/ml
Pentobarbitone**	10	1 – 5 ug/ml
Thiopentone	10	6 – 35 ug/ml
Morphine	2 - 3	70 – 450 ng/ml
Phenytoin	22	10-20mg/L
Valproic acid	4-16	50-100mcg/mL

** When high dose barbiturates are used, depressed neuronal as well as decreased cerebral blood flow may occur. A confirmatory test using angiogram may be erroneously positive for absent flow. The clinical diagnosis for brain death should only be allowed, if serum barbiturates levels have decreased to levels in which it is highly improbable that brainstem function is depressed.

APPENDIX 1 (*PITFALLS*)

Drug induced acid base abnormalities

Profound changes in acid-base balance may point to certain intoxication and may also indicate a potentially reversible medical illness or endocrine crisis. Determination of brain death should be deferred in the presence of severe acidosis or alkalosis.

Drugs that may induce acid-base abnormalities are as below:

- Metabolic acidosis:
  - Acetaminophen
  - Ethanol, methanol, ethylene glycol
  - Salicylates
  - Isoniazid
  - Cyanide, cocaine, toluene

- Respiratory acidosis:
  - Opiates
  - Ethanol, other alcohols
  - Barbiturates

APPENDIX 2 (*ANCILLARY TESTING*)

A. Ancillary Testing in Brain Death

Ancillary laboratory tests (not usually mandatory) may be useful in certain situations when clinical tests cannot be reliably performed and in certain instances where children are involved.

The main objective of the ancillary test would be to demonstrate the absence of cerebral circulation or cerebral electrical activity.

1. **Test That Can Document Cerebral Blood Circulation In The Brain On Imaging**

Tests proving absent cerebral blood circulation are appropriate for this pattern such as Computed Tomograhic Angiography (CTA), Catheter Cerebral Angiography of the Brain and Radionuclide studies.

Historically, the first technique used to demonstrate absence of intracranial circulation in brain death distal to the intracranial portions of the internal carotid and vertebral arteries was the catheter cerebral angiography. For adults, as technology has developed over the last 20 years, cerebral CTA has now become widely available and is routinely used in the diagnosis of many intracranial vascular abnormalities.

The ability to obtain high quality dynamic images of the cerebral vasculature in clinically unstable or ventilated patients in a short space of time (several seconds), and the subsequent ease of image review and lack of operator dependence, confers several practical advantages to cerebral CTA over cerebral catheter angiography, with supportive publications demonstrating its high sensitivity and specificity.

i) CT Angiography (See Table 1)
4 points scoring system to address the presence or absence of circulatory arrest.

- Time of scan: An increase in intracranial pressure (ICP), leading to cerebral circulatory arrest is a major consideration when deciding on the time to perform CTA. To avoid false negative and repetitive examinations, an interval of at least 12 hours after clinical suspicion of brain death before CTA is recommended, thus decreasing the risk of false-negative CTA study.
- False negative results can also be seen in craniotomies, children with large fontanelles or open-skull defects.

CTA is the ancillary test of choice to assess for circulatory arrest for adults and in suitable paediatric patients. If imaging findings during ancillary testing is indeterminate or negative, a repeat CTA may be sought after at least 12 hours or an EEG can be performed

APPENDIX 2 (*ANCILLARY TESTING*)

Table 1: Multi-Phase CTA Cerebral As Ancillary Test For Brain Death In Adults

3 PHASES:

- Non-contrasted CT (NCCT)
- 20 seconds post contrast (early contrast enhancement)
- 60 seconds post contrast (delayed contrast enhancement)

Phase	NCCT	20 secs post contrast	60 secs post contrast
Scan parameters	120 kV, 300 mAs, 200-mm FOV, 512 X 512 matrix		
Contrast (single bolus injection)	50 ml (300-370 mg Iodine/ml)		
Flow rate	3 ml/sec		
Coverage	Skull base to vertex		
Scan Direction	Caudo-cranial		
Scan thickness	1.0 mm		
Reconstruction thickness	5 mm slice thickness		
Image reconstruction format	Axial & Coronal & Sagittal Maximum Intensity Projection (MIP)		
Scoring	**4-points CTA Scoring in 4 vessels, tick (√) for status of vessel opacification:** Absent Present • Cortical branches of right Middle Cerebral Artery (MCA) ☐ ☐ • Cortical branches of left Middle Cerebral Artery ☐ ☐ • Right Internal Cerebral Vein (ICV) ☐ ☐ • Left Internal Cerebral Vein ☐ ☐ TOTAL SCORE: ☐ Score: 0-4 (1 point will be given to each vessel which **does not opacify** *i.e. lack of opacification' scoring).* ▪ Score of 4 (all absent) suggests cerebral circulatory arrest. ▪ Score of 0 (all present) excludes cerebral circulatory arrest. ▪ Score between 1 to 3 (1-3 absent vessels) will be deemed as inconclusive.		
Conclusion	**A Cerebral (tick √)** • **Suggests cerebral circulatory arrest** ☐ • **Excludes cerebral circulatory arrest** ☐ • **Inconclusive for cerebral circulatory arrest** ☐		

APPENDIX 2 (*ANCILLARY TESTING*)

ii) Conventional Angiography (Digital Subtraction Angiography) (See Table 2)

- If there is no flow seen beyond the skull base after the first run, this indicates absence of cerebral blood circulation.
- This finding must be confirmed by performing a second run, done 30 minutes after the first run.
- If both runs show no flow in the intracranial vessels beyond the skull base, the absence of cerebral blood circulation is confirmed.

Table 2: Digital Subtraction Cerebral Catheter Angiography As Ancillary Test For Brain Death in Adults

Phases	First run	Second run (30 minutes interval)
Imaging parameters	70 kV, 103 mAs, 512 X 512 matrix	
Contrast estimation volume and strength	50-70 ml (300-370mg Iodine/ml)	
Flow rate	Hand injection	
Coverage	Skull base to vertex	
Image projection	Towne, Lateral	
Frame rate	3 frame per second	
Scoring	**Tick (√) for imaging findings:** Absent Present • First run: Intracranial arteries opacification ☐ ☐ • Second run: Intracranial arteries opacification ☐ ☐	
Conclusion	**DSA catheter cerebral angiogram, tick (√)** • **Suggests cerebral circulatory arrest with absence of arterial opacification above the skull base in both runs.** ☐ • **Excludes cerebral circulatory arrest with presence of arterial opacification above the skull base in both runs.** ☐ • **Indeterminate i.e. presence of arteries opacification in either runs or other reason,** ☐ specify: _____	

APPENDIX 2 (*ANCILLARY TESTING*)

Pitfalls in Cerebral CT Angiography (CTA) and Digital Substraction Angiography (DSA) as the Ancillary tests:

a. An increase in intracranial pressure leading to cerebral circulation arrest is a major consideration. Certain conditions that render the intracranial pressure to be lower than Mean Arterial pressure such as presence of craniotomy will lead to inconclusive results on CTA, given its high sensitivity for vessel visualization. In such situation, if the ancillary test yields inconclusive result, further discussion with the primary team is advisable.

b. False negative results can also occur if CTA or DSA is performed too early after the clinical suspicion of Brain Death as the intracranial pressure may not have risen sufficiently. Therefore it is imperative that the delay of 12-hours before performing CTA or DSA is observed to reduce the likelihood of false negative study.

c. There is insufficient evidence to make consensus recommendation for the use of cerebral CT angiography as an ancillary investigation to support the clinical diagnosis of brain death in patients receiving extracorporeal membrane oxygenation.

iii) Nuclear Imaging

Tc-99m HMPAO (technetium 99m radiolabelled hexamethyl-propylene amine oxime) is the widely accepted study for most radionuclide CBF studies. It crosses the blood-brain barrier to be retained by parenchyma by conversion from a lipophilic to a hydrophilic form.

The classic appearance for a positive brain death indicates “hollow skull phenomenon” or “hot nose sign” due to absence brain circulation and preservation of external carotid flow.

APPENDIX 2 (*ANCILLARY TESTING*)

2. Test for Absence of Brain Electical Activity

i. ELECTROENCEPHALOGRAPHY (EEG)

- A minimum of 8 scalp electrodes should be used.
- Inter-electrode impedance should be between 100 and 10,000W.
- The integrity of the entire recording system should be tested.
- The distance between electrodes should be at least 10 cm.
- The sensitivity should be increased to at least 2mV for 30 minutes with inclusion of appropriate calibrations.
- The high-frequency filter setting should not be set below 30 Hz, and the low-frequency setting should not be above 1 Hz.
- Electroencephalography should demonstrate a lack of reactivity to intense somatosensory or audio-visual stimuli.
- No brain electrical activity during at least 30 minutes of recording.
- The EEG recording must adhere to technical specifications for brain death.

B. Ancillary Testing For Brain Death - Paediatric Radiology Section:

Generally, paediatric patients do not require ancillary studies to establish brain death and ancillary studies do not substitute neurologic examinations. However, the test may assist the clinicians in making the clinical diagnosis of brain death. Ancillary studies may be useful at 37 weeks of gestation to 30 days of life when concern exists about the validity of the clinical examinations. However, it is less sensitive in detecting brain electrical activity or cerebral circulation in this age-group when compared to older children.

Requests for ancillary studies in patients aged between 31 days of life to 18 years old may be made due to following reason(s):

- Component(s) of examination or apnoea test cannot be safely completed
- Results of the examination unable to be established
- Medication(s) interfere with evaluation and/or examination(s)
- Observation period has to be shortened

Radiology modalities that are available as ancillary studies to document cerebral circulation comprise of conventional angiography, nuclear medicine, cross-sectional studies (such as CTA and MRI) and transcranial doppler ultrasound. Note is made that Paediatric AAP 2011 guidelines has yet to recommend MR angiography and Transcranial Doppler as ancillary studies to assist determination of brain death.

APPENDIX 2 (*ANCILLARY TESTING*)

Despite some literature supporting the use of radionuclide CBF study as an ancillary study, portable radionuclide camera is not available in Malaysia and transfer of young as well as unstable children to the Department of Nuclear Medicine for such a study imposes safety issues. This modality remains an important choice but shall be reserved to the hospital where a static machine is available. Transportation of ill children out to another facility is not advocated. The mode of utilisation of radionuclide CBF study as ancillary studies in paediatric patients is described as below:

i) Radionuclide CBF Study

- Tc-99m HMPAO (technetium 99m radiolabelled hexamethyl-propylene amine oxime) is the widely accepted radionuclide for CBF studies. It crosses the blood-brain barrier and retains in parenchyma after conversion from a lipophilic to a hydrophilic form.
- The classic appearance of “hollow skull phenomenon” or “hot nose sign” signify absence of cerebral perfusion in the preservation of external carotid flow.

APPENDIX 3 (*BRAIN DEATH CERTIFICATION CHECKLIST*)

Brain death Certification Checklist

Name:		Age:	
NRIC:		Sex:	
DOB:		Race:	

Date of admission: _____ Time: _____
Date of ventilation: _____ Time: _____
Cause of irreversible brain damage (Full Diagnosis): _____
_____
CT/MRI brain result (if available): Date _____ Result: _____
_____

	First Assessment Date: _____ Time: _____		Second Assessment Date: _____ Time: _____	
	Assessor 1 Name: Designation:	**Assessor 2** Name: Designation:	**Assessor 1** Name: Designation:	**Assessor 2** Name: Designation:

1. Precondition	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Patient in deep coma, apnoeic and on ventilation, for at least 12 hours	☐	☐	☐	☐	☐	☐	☐	☐
Drugs excluded	☐	☐	☐	☐	☐	☐	☐	☐
Hypothermia excluded	☐	☐	☐	☐	☐	☐	☐	☐
Metabolic causes excluded	☐	☐	☐	☐	☐	☐	☐	☐
Endocrine causes excluded	☐	☐	☐	☐	☐	☐	☐	☐
Haemodynamic stability	☐	☐	☐	☐	☐	☐	☐	☐

APPENDIX 3 (*BRAIN DEATH CERTIFICATION CHECKLIST*)

2. Brain Stem function tests	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Pupillary light reflex	☐	☐	☐	☐	☐	☐	☐	☐
Oculo-cephalic reflex	☐	☐	☐	☐	☐	☐	☐	☐
Motor response in cranial nerve distribution	☐	☐	☐	☐	☐	☐	☐	☐
Corneal reflex	☐	☐	☐	☐	☐	☐	☐	☐
Vestibulo-ocular reflex (Caloric test)	☐	☐	☐	☐	☐	☐	☐	☐
Oro-pharyngeal reflex	☐	☐	☐	☐	☐	☐	☐	☐
Tracheo-bronchial reflex	☐	☐	☐	☐	☐	☐	☐	☐
3. Apnoea test								
PaCO2 • Pre-test • Post-test	_____mm Hg _____mm Hg				_____mm Hg _____mm Hg			
Apnoea confirmed 1. Yes 2. No	☐ ☐				☐ ☐			
Any need for ancillary test?	Yes		No		Yes		No	
	Type of test: _____ Result: _____							
	Signature: **Stamp:**		**Signature:** **Stamp:**		**Signature:** **Stamp:**		**Signature:** **Stamp:**	

APPENDIX 3 (*BRAIN DEATH CERTIFICATION CHECKLIST*)

4. Confirmation of Brain death

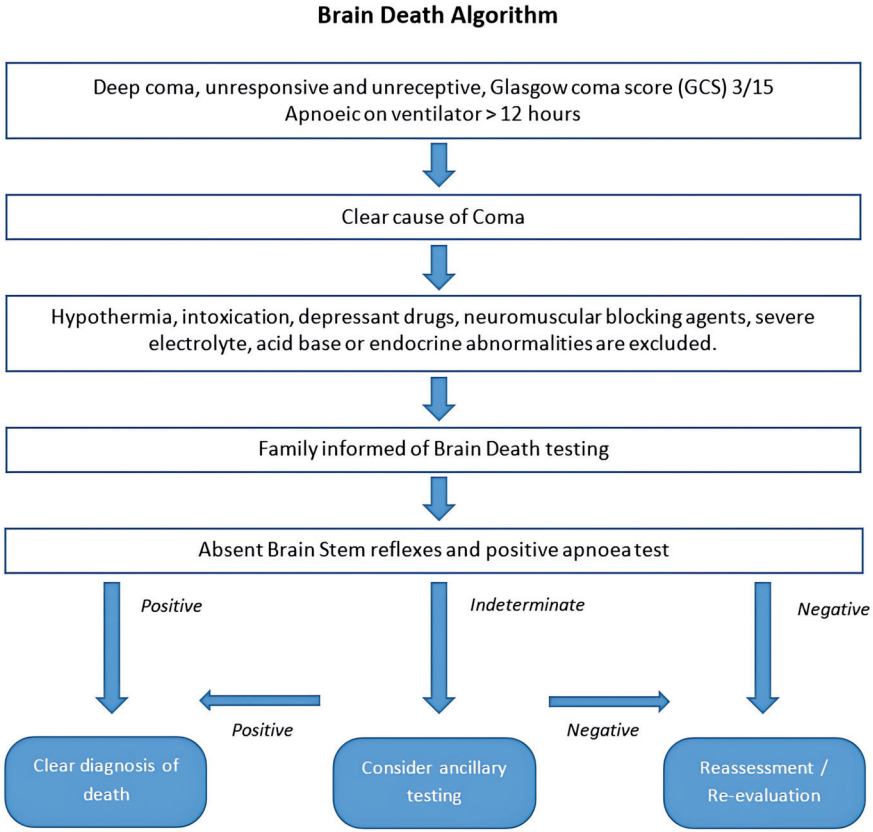
Do the above tests confirm brain death? Yes No

Date of death: _____ Time of Death: _____

Name: _____ Signature and stamp: _____

Name: _____ Signature and stamp: _____

APPENDIX 4 (*BRAIN DEATH ALGORITHM*)



ACKNOWLEDGEMENT

External Reviewers

Panels:

Dato' Dr. Mohd Ridhwan bin Mohd Noor
Senior Consultant Anaesthesiologist (Intensive Care)
Department of Anaesthesiology and Intensive Care
Hospital Sultanah Nur Zahirah

Dr. Sapiah binti Sapuan
Senior Consultant Neurology & National Head of Neurology
Department of General Medicine
Hospital Sungai Buloh

Dr. Cheah Wee Kooi
Senior Consultant Geriatrician & National Head of Internal Medicine
Department of General Medicine
Hospital Taiping

Dr. Ahmad Fareed bin A. Rahman
Public Health Physician
Medico Legal section
Medical Practice Division

ACKNOWLEDGEMENT

Medical Development Division

Advisor: **Dato' Dr. Mohd Azman bin Yacob**
Director
Medical Development Division
Ministry of Health, Malaysia

Facilitators: **Dr. Adilah binti A. Bakar**
Senior Principal Assistant Director & Head
Surgical Services Unit
Medical Development Division

Dr. Shahanizan binti Mohd Zin
Senior Principal Assistant Director & Head
Medical Services Unit
Medical Development Division

Dr. Murnilina binti Abdul Malek
Senior Principal Assistant Director
Surgical Services Unit
Medical Development Division

Dr. Nur Shaheera binti Shaharuddin
Senior Principal Assistant Director
Medical Services Unit
Medical Development Division

REFERENCES

1. Malaysia Consensus Statement of Brain death 2003
2. Lewis A et al. Determination of Brain Death Death by Neurologic Criteria in Countries in Asia and the Pacific, J Clin Neurol 2020;16(3):480-490
3. Ostermann ME, Young B, Sibbald WJ, Nicolle MW. Coma mimicking brain death following baclofen overdose. Intensive Care Med 2000;26:1144 –1146.
4. Richard IH, LaPointe M, Wax P, Risher W. Nonbarbiturate, drug-induced reversible loss of brainstem reflexes. Neurology 1998;51:639–640.
5. Waters CE, French G, Burt M. Difficulty in brainstem death testing in the presence of high spinal cord injury. Br J Anaesth 2004;92:760 –764.
6. Peter JV, Prabhakar AT, Pichamuthu K. In-laws, insecticide and mimic of brain death. Lancet 2008;371:622.
7. Stojkovic T, Verdin M, Hurtevent JF, Laureau E,Krivosic-Horber R, Vermersch P. Guillain-Barre´ syndrome resembling brainstem death in a patient with brain injury. J Neurol 2001;248:430–432.
8. Rivas S, Douds GL, Ostdahl RH, Harbaugh KS. Fulminant Guillain-Barre´ syndrome after closed head injury: a potentially reversible cause of an ominous examination. J Neurosurg 2008;108:595– 600.
9. Friedman Y, Lee L, Wherrett JR, Ashby P, Carpenter S. Simulation of brain death from fulminant differentiation. Can J Neurol Sci 2003;30:397– 404.
10. Joshi MC, Azim A, Gupta GL, Poddar BP, Baronia AK, Singh RK. Guillain-Barre´ syndrome with absent brainstem reflexes: a report of two cases. Anaesth Intensive Care 2008;36:867–869.
11. Kainuma M, Miyake T, Kanno T. Extremely prolonged vecuronium clearance in a brain death case. Anaesthesiology 2001;95:1023–1024.
12. Volakli E. A., Mantzafleri P-E., Kalamitsou S., Violaki A., Chochliourou E., Svirkos M., Kasimis A., Sdougka M., Brain death in Children,chapter 6 ,http://dx.doi.org/10.5772/intechopen.68468
13. Thomas A.N., Ashwal S., Mathur M., Mysore M., and the society of critical care medicine, section on critical care and section on neurology of America academy of paediatrics, and the child neurology society. Clinical report-Guidelines for the determination of brain death in infants and children: An update of the 1987 Task Force recommendations. Pediatrics. 2011:128:e720-e740
14. The Australian and New Zealand Intensive Care Society (ANZICS), The ANZICS Statement on Death and Organ Donation, Edition 3.2 2013, ACN 057 619 986
15. Marikar D., The diagnosis of death by neurological criteria in infant less than 2 months old: RCPCH guideline 2015. Archive of Disease in Childhood Education and Practice Edition. 2016;101(4):186. DOI: 10.1136/archdischild-2015-309706. Epub 2016 March 9th
16. Rosenklint A. & Jorgensen, P.B. Evaluation of angiography methods in the diagnosis of brain death. Correlation with local and systemic arterial pressure and intracranial pressure. Neuroradiology 1074; 7:215-19

REFERENCES

17. Laurin NR., Driedger AA., Hurwitz GA., Mattar AG., Powel JE., Chamberlain MJ., Zabel PL.,Pavlovsky WF. Cerebral Perfusion Imaging with Technitium-99m HMPAO in Brain Death and Severe Central Nervous System Injury, Journal Nuclear Medicine 1989; 30:1627-35
18. Spieth ME, Ansari AN., Kawada TK., Kimura RL., Siegel MF., Direct Comparison of Tc-99m DTPA and Tc-99m HMPAO for Evaluating Brain Death, Clinical Nuclear Medicine 1994; 19:867-97
19. Koszer S., Moshe L.S., Kao A., Riviello J.J., Determination of Brain Death in Children. http://www.emedicine.medscape.com/article/1177999-updated Oct 5th 2016
20. Ad Hoc Committee of Havard Medical School. A definition of Irreversible Coma. Report of Ad Hoc Committee of Havard Medical School to examine the definition of brain death. The Journal of the American Medical Association. 1968;205(6):337-340
21. Monteiro LM, Bollen CW, van Huffelen AC, et al. Transcranial Doppler ultrasonography to confirm brain death: a meta-analysis. Intensive Care Med 2006;32:1937–44
22. Li Y, Liu S, Xun F, Liu Z, Huang X., Use of Transcranial Doppler Ultrasound for Diagnosis of Brain Death in Patients with Severe Cerebral Injury, Medical Science Monitor, 2016; 22: 1910-hyj9u78901915
23. S. Palmer, M. K. Bader. Brain Tissue Oxygenation in Brain Death. Neurocritical Care 2005. ISSN 1541-6933/05/2:17–22
24. C Machado, J Perez, C Scherle, J Korein. When Are Ancillary Tests Recommended In Brain Death Confirmation? The Internet Journal of Neurology 2009 Volume 12 Number 2
25. M. Savard, A. F. Turgeon, J. Gariépy, F. Trottier, S. Langevin. Selective 4 Vessels Angiography in Brain Death: A Retrospective Study. Can. J. Neurol. Sci. 2010; 37: 492-497
26. Taylor T, Dineen RA, Gardiner DC, Buss CH, Howatson A, Pace NL. Computed tomography (CT) angiography for confirmation of the clinical diagnosis of brain death. Cochrane Database of Systematic Reviews 2014, Issue 3. Art. No.: CD009694. DOI: 10.1002/14651858.CD009694.pub2.
27. B. Dupas, M. Gayet-Delacroix, D. Villers, D. Antonioli, M. F. Veccherini, J. P Soulillou. Diagnosis of Brain Death Using Two-Phase Spiral CT. AJNR Am J Neuroradiol 19:641–647, April 1998
28. E. Frampas, M. Videcoq, E. de Kerviler, F. Ricolfi, V. Kuoch, F. Mourey, A. Tenaillon, B. Dupas. CT Angiography for Brain Death Diagnosis. AJNR 30, Sept 2009. DOI 10.3174/ajnr.A1614.
29. Braun M, Ducrocq X, Huot JC, et al. Intravenous angiography in brain death: report of 140 patients. Neuroradiology 1997;39: 400 – 05
30. M. Sawicki, R. Bohatyrewicz, A. Walecka, J. Sołek-Pastuszka, O. Rowiński, J. Walecki. CT Angiography in the Diagnosis of Brain Death. Pol J Radiol, 2014; 79: 417-421

REFERENCES

31. Shankar and R. Vandorpe. CT Perfusion for Confirmation of Brain Death. J.J.S. AJNR Am J Neuroradiol 34:1175–79 Jun 2013
32. J. J. Chang, G. Tsivgoulis, A. H. Katsanos, M. D. Malkoff, A. V. Alexandrov. Diagnostic Accuracy of Transcranial Doppler for Brain Death Confirmation: Systematic Review and Meta-Analysis. American Journal of Neuroradiology March 2016, 37 (3) 408-414; DOI: https://doi.org/10.3174/ajnr.A4548
33. Kerhuel, Srairi et al. The optimal time between clinical brain death diagnosis and confirmation using CT angiography: a retrospective study. Minerva Anestesiologica 2016 November, 82(11) 1180-8
34. Bohatyrewicz, Pastuzska et al. Implementation of Computed Tomography Angiography (CTA) and Computed Tomography Perfusion (CTP) in Polish Guidelines for Determination of Cerebral Circulatory Arrest (CCA) during Brain Death/Death by Neurological Criteria (BD/DNC) Diagnosis Procedure. J. Clin. Med. 2021; 10: 4237; DOI: https://doi.org/10.3390/jcm10184237

BAHAGIAN PERKEMBANGAN PERUBATAN
KEMENTERIAN KESIHATAN MALAYSIA

ISBN 978-967-26294-5-0