Brain stem death

Richard Cowan

Barbara Miles

Abstract

The concept of brain and brain stem death developed from the observation of apnoeic comatose patients. In the UK, the diagnosis of brain stem death is made by clinically testing brain stem function once specific preconditions have been met. The exact definition of brain death and some details regarding the tests required to make this diagnosis vary across the globe. However, the majority of tests carried out are similar to those in the UK. In this review we define brain stem death and the clinical tests used to confirm it. The use of ancillary testing can have a role in patients where clinical tests are not possible and this is also discussed.

Keywords Apnoeic coma; brain death; brain stem death; brain stem death testing

Royal College of Anaesthetists CPD Matrix: 1AO1, 2CO1, 2CO6

Learning objectives

After reading this article, you should be able to:

- describe the anatomy of the brain stem and the physiological changes associated with brain stem death
- identify the preconditions required and the clinical tests then used to confirm brain stem death
- discuss when ancillary testing may be required and describe such tests

Anatomy

The brain stem is the inferior part of the brain, adjoining and structurally continuous with the spinal cord. It is divided in to three distinct areas: the medulla, the pons and the midbrain (Figure 1). The pons and midbrain contain the nuclei of the reticular activating system which are vital for cortical arousal and conscious awareness, whereas the medulla contains the control centres of cardio-respiratory homoeostasis. The nuclei and origins of cranial nerves III to XII are also contained within the brainstem.

History of diagnosing death

Prior to the development of mechanical ventilation, the diagnosis of death was relatively straightforward: death occurred at the cessation of respiration, which inevitably led to the cessation of circulation. The advent of long-term ventilation techniques in the 1950s meant inadequate ventilation no longer immediately led to circulatory death. With the regular use of these techniques and the emergence of intensive care units, case series of patients with profound irreversible apnoeic coma began to be described.

These patients had no angiographic evidence of blood flow to the brain, although no mechanical obstruction to flow was demonstrated at autopsy. They had no spontaneous respiratory effort, an absence of all electroencephalogram (EEG) activity and were areflexic and polyuric with vasopressor dependent hypotension. These patients proceeded to circulatory death if artificial ventilation or vasopressors were discontinued. These findings were characteristically described in 1959 as 'coma dépassé', i.e. 'beyond coma'. The autolytic neuropathological findings in such patients was also discussed and described in the literature as 'respirator brain'.

The formalization of criteria to diagnose brain death occurred in 1968 with the publication in JAMA of *'A definition of irreversible coma, the Report of the Ad Hoc Committee of the Harvard Medical School to Examine the Definition of Brain Death'*. On the same day, the World Medical Assembly issued a statement discussing some key philosophical issues surrounding the definition of death. This included the concept that a definition of death should regard the fate of a person rather than the preservation of isolated cells. The development of these standards for the diagnosis of brain stem death allowed appropriate treatment limitations to be put in place for patients who were irreversibly comatose. Although the concept of brain death evolved relatively contemporaneously with the first allogenic organ transplants, it developed independently.

The statements have been refined over time and different countries have produced their own guidelines. The current UK definition of death is that described by The Academy of Medical Royal Colleges (UK):

> 'Death entails the irreversible loss of those essential characteristics which are necessary to the existence of a living human person and, thus, the definition of death should be regarded as the irreversible loss of the capacity for consciousness, combined with irreversible loss of the capacity to breathe.'

Geographical differences in brain death definitions

There remain global differences in nomenclature regarding brain death. In some countries (e.g. Australia, New Zealand, USA), demonstration of whole brain death is required to determine death. In the majority of cases of brain stem death, acute whole brain injury is evident radiologically. However, in cases of isolated brain stem injury, whole brain injury is not evident and blood flow to the rest of the brain remains. Such patients therefore cannot be defined as brain dead in some countries.

Confirming brain stem death is the basis of determining death in patients in apnoeic coma in the UK. The cessation of brain stem function does not necessarily entail cessation of neurological activity in the whole brain. Any potentially remaining function in brain other than the brainstem is not seen to

Richard Cowan *MBChB (Hons) MRCP(UK) FRCA FFICM is a Specialist Trainee Registrar in Anaesthesia and Intensive Care at Glasgow Royal Infirmary, Glasgow, UK. Conflict of Interest: none declared.*

Barbara Miles *MBChB FRCA FFICM is a Consultant in Anaesthesia and Intensive Care at Glasgow Royal Infirmary, Glasgow, UK. Conflict of Interest: none declared.*

Please cite this article in press as: Cowan R, Miles B, Brain stem death, Anaesthesia and intensive care medicine (2018), https://doi.org/10.1016/j.mpaic.2018.08.010

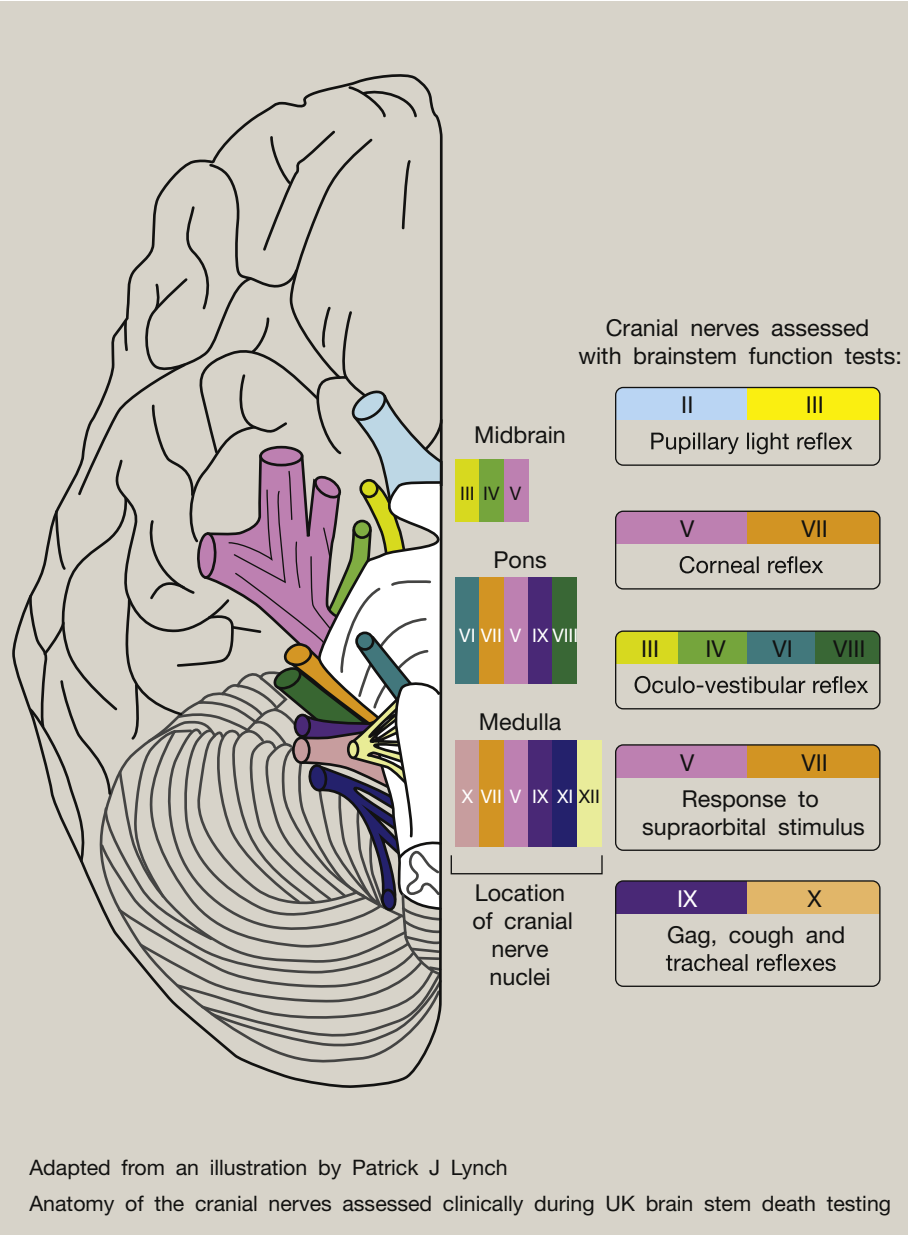

Figure 1

constitute the essential characteristics necessary for a living human existence and so in the UK these patients can be defined as dead.

Physiological changes associated with brain stem death

Cardiovascular

With initial brain stem compromise there is a massive sympathetic discharge, resulting in tachycardia and hypertension. With further brain swelling, in an attempt to maintain cerebral perfusion, Cushing's reflex (hypertension with bradycardia) occurs in one-third of patients. The sympathetic surge subsequently dissipates and in the majority of patients is followed by vasodilatation induced hypotension. Arrhythmias can also occur. Any hypotension may be worsened by concomitant hypovolaemia.

Endocrine

Pituitary failure causes a reduction in anti-diuretic hormone (ADH) production. This results in an inappropriate diuresis (neurogenic diabetes insipidus) with resulting hypovolaemia and hypernatraemia. There is reduced thyroid hormone synthesis and secretion as well as reduced cortisol production. These hormonal changes can adversely affect the cardiovascular state. Hypothalamic failure leads to loss of thermoregulation. The patient may need active control of body temperature.

Diagnosis of brain stem death

Clinical assessment of brain stem function alone can determine brain stem death in the UK. However, clinical testing can only be undertaken when specific preconditions are met.

Please cite this article in press as: Cowan R, Miles B, Brain stem death, Anaesthesia and intensive care medicine (2018), https://doi.org/10.1016/j.mpaic.2018.08.010