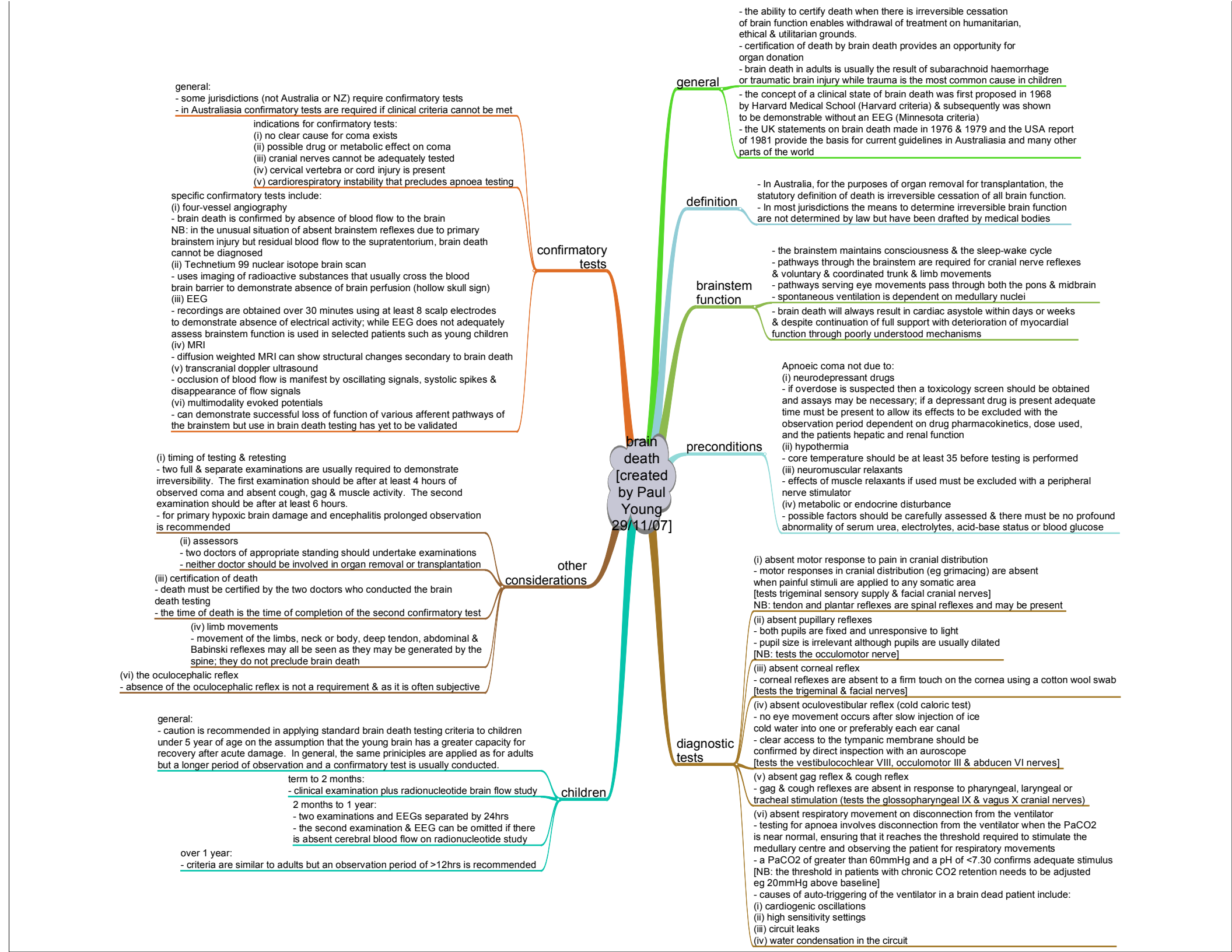
brain death [created by Paul Young 29/11/07]
general
- the ability to certify death when there is irreversible cessation of brain function enables withdrawal of treatment on humanitarian, ethical & utilitarian grounds.
- certification of death by brain death provides an opportunity for organ donation
- brain death in adults is usually the result of subarachnoid haemorrhage or traumatic brain injury while trauma is the most common cause in children
- the concept of a clinical state of brain death was first proposed in 1968 by Harvard Medical School (Harvard criteria) & subsequently was shown to be demonstrable without an EEG (Minnesota criteria)
- the UK statements on brain death made in 1976 & 1979 and the USA report of 1981 provide the basis for current guidelines in Australiasia and many other parts of the world
definition
- In Australia, for the purposes of organ removal for transplantation, the statutory definition of death is irreversible cessation of all brain function.
- In most jurisdictions the means to determine irreversible brain function are not determined by law but have been drafted by medical bodies
brainstem function
- the brainstem maintains consciousness & the sleep-wake cycle
- pathways through the brainstem are required for cranial nerve reflexes & voluntary & coordinated trunk & limb movements
- pathways serving eye movements pass through both the pons & midbrain
- spontaneous ventilation is dependent on medullary nuclei
- brain death will always result in cardiac asystole within days or weeks & despite continuation of full support with deterioration of myocardial function through poorly understood mechanisms
preconditions
Apnoeic coma not due to:
(i) neurodepressant drugs
- if overdose is suspected then a toxicology screen should be obtained and assays may be necessary; if a depressant drug is present adequate time must be present to allow its effects to be excluded with the observation period dependent on drug pharmacokinetics, dose used, and the patients hepatic and renal function
(ii) hypothermia
- core temperature should be at least 35 before testing is performed
(iii) neuromuscular relaxants
- effects of muscle relaxants if used must be excluded with a peripheral nerve stimulator
(iv) metabolic or endocrine disturbance
- possible factors should be carefully assessed & there must be no profound abnormality of serum urea, electrolytes, acid-base status or blood glucose
diagnostic tests
(i) absent motor response to pain in cranial distribution
- motor responses in cranial distribution (eg grimacing) are absent when painful stimuli are applied to any somatic area
[tests trigeminal sensory supply & facial cranial nerves]
NB: tendon and plantar reflexes are spinal reflexes and may be present
(ii) absent pupillary reflexes
- both pupils are fixed and unresponsive to light
- pupil size is irrelevant although pupils are usually dilated
[NB: tests the occulomotor nerve]
(iii) absent corneal reflex
- corneal reflexes are absent to a firm touch on the cornea using a cotton wool swab
[tests the trigeminal & facial nerves]
(iv) absent oculovestibular reflex (cold caloric test)
- no eye movement occurs after slow injection of ice cold water into one or preferably each ear canal
- clear access to the tympanic membrane should be confirmed by direct inspection with an auroscope
[tests the vestibulocochlear VIII, occulomotor III & abducen VI nerves]
(v) absent gag reflex & cough reflex
- gag & cough reflexes are absent in response to pharyngeal, laryngeal or tracheal stimulation (tests the glossopharyngeal IX & vagus X cranial nerves)
(vi) absent respiratory movement on disconnection from the ventilator
- testing for apnoea involves disconnection from the ventilator when the PaCO2 is near normal, ensuring that it reaches the threshold required to stimulate the medullary centre and observing the patient for respiratory movements
- a PaCO2 of greater than 60mmHg and a pH of <7.30 confirms adequate stimulus
[NB: the threshold in patients with chronic CO2 retention needs to be adjusted eg 20mmHg above baseline]
- causes of auto-triggering of the ventilator in a brain dead patient include:
(i) cardiogenic oscillations
(ii) high sensitivity settings
(iii) circuit leaks
(iv) water condensation in the circuit
confirmatory tests
general:
- some jurisdictions (not Australia or NZ) require confirmatory tests
- in Australiasia confirmatory tests are required if clinical criteria cannot be met
indications for confirmatory tests:
(i) no clear cause for coma exists
(ii) possible drug or metabolic effect on coma
(iii) cranial nerves cannot be adequately tested
(iv) cervical vertebra or cord injury is present
(v) cardiorespiratory instability that precludes apnoea testing
specific confirmatory tests include:
(i) four-vessel angiography
- brain death is confirmed by absence of blood flow to the brain
NB: in the unusual situation of absent brainstem reflexes due to primary brainstem injury but residual blood flow to the supratentorium, brain death cannot be diagnosed
(ii) Technetium 99 nuclear isotope brain scan
- uses imaging of radioactive substances that usually cross the blood brain barrier to demonstrate absence of brain perfusion (hollow skull sign)
(iii) EEG
- recordings are obtained over 30 minutes using at least 8 scalp electrodes to demonstrate absence of electrical activity; while EEG does not adequately assess brainstem function is used in selected patients such as young children
(iv) MRI
- diffusion weighted MRI can show structural changes secondary to brain death
(v) transcranial doppler ultrasound
- occlusion of blood flow is manifest by oscillating signals, systolic spikes & disappearance of flow signals
(vi) multimodality evoked potentials
- can demonstrate successful loss of function of various afferent pathways of the brainstem but use in brain death testing has yet to be validated
other considerations
(i) timing of testing & retesting
- two full & separate examinations are usually required to demonstrate irreversibility. The first examination should be after at least 4 hours of observed coma and absent cough, gag & muscle activity. The second examination should be after at least 6 hours.
- for primary hypoxic brain damage and encephalitis prolonged observation is recommended
(ii) assessors
- two doctors of appropriate standing should undertake examinations
- neither doctor should be involved in organ removal or transplantation
(iii) certification of death
- death must be certified by the two doctors who conducted the brain death testing
- the time of death is the time of completion of the second confirmatory test
(iv) limb movements
- movement of the limbs, neck or body, deep tendon, abdominal & Babinski reflexes may all be seen as they may be generated by the spine; they do not preclude brain death
(vi) the oculocephalic reflex
- absence of the oculocephalic reflex is not a requirement & as it is often subjective
children
general:
- caution is recommended in applying standard brain death testing criteria to children under 5 year of age on the assumption that the young brain has a greater capacity for recovery after acute damage. In general, the same priniciples are applied as for adults but a longer period of observation and a confirmatory test is usually conducted.
term to 2 months:
- clinical examination plus radionucleotide brain flow study
2 months to 1 year:
- two examinations and EEGs separated by 24hrs
- the second examination & EEG can be omitted if there is absent cerebral blood flow on radionucleotide study
over 1 year:
- criteria are similar to adults but an observation period of >12hrs is recommended