Coma and brainstem death

Robin S Howard

Abstract

The diagnosis and management of the patient in coma demands rigorous clinical assessment that encompasses a meticulous approach to history-taking and systemic and neurological examination. Following immediate resuscitation and acute management, the level of consciousness must be assessed and evidence of meningism, brainstem or lateralizing neurological signs sought. The prognosis depends on the underlying cause and the appropriateness of acute management. The diagnosis of brain death depends on establishing the aetiology of irreversible brain damage, excluding reversible causes and establishing the absence of any brainstem reflexes.

Keywords Brain death; coma; neuro-critical care

Key points

- Normal consciousness depends on two critical components — arousal and the cognitive content of mental functions
- Coma can be caused by a variety of neurological and general medical disorders
- It is essential to obtain as detailed and accurate a history as possible, and a full general medical examination must be undertaken immediately after resuscitation
- The Glasgow Coma Scale is helpful when assessing any change in the level of consciousness, but it should not replace detailed and careful neurological examination of the pattern of responsiveness
- The approach to the patient in coma involves resuscitation and emergency treatment, medical assessment, establishing the level of consciousness, identifying brainstem activity and assessing motor function
- The diagnosis of brain death involves three stages: establishing that the patient has suffered an event of known aetiology resulting in irreversible brain damage, excluding a reversible cause and performing a set of bedside clinical tests of brainstem function to confirm the absence of any brainstem reflexes

Introduction

Different patterns of arousal and awareness are complex and variable, but characteristic features allow the recognition and classification of a spectrum of states of conscious level. These range from full consciousness to coma. Although a number of terms have been applied to these intermediate states, overlap inevitably occurs.[1–4]

Normal consciousness

Consciousness is a state of awareness of self and environment that gives significance to stimuli from the internal and external environment. It depends on two critical components:

- **arousal or alertness,** which reflects the integrity of the brainstem's reticular activating system
- **cognitive content of mental functions,** which allows awareness of self and the environment, and the expression of the psychological functions of sensation, emotion and thought.

Coma can be caused by either bilateral hemispheric damage or a structural or metabolic lesion in the brainstem reticular activating system. Unilateral dysfunction of the cerebral hemispheres does not, by itself, cause stupor or coma. Coma can be defined as a state of unrousable unresponsiveness in which the subject lies with their eyes closed. There is no understandable response to external stimuli or inner need, and the patient cannot localize noxious stimuli. Thus, there is a total absence of awareness of self and environment even when the subject is externally stimulated. There is no spontaneous eye opening, response to voice, localization to painful stimuli or verbal output.

Coma can be caused by a variety of neurological and general medical disorders. The most important considerations in the initial assessment are listed in Table 1 and can be divided into the:

- presence of lateralizing signs
- presence of meningism
- pattern of brainstem reflexes.

The emergency management of coma is summarized in Table 2.

Assessment of the patient in coma (Table 3)[5]

History: it is essential to obtain as detailed and accurate a history as possible.

Examination: an urgent and detailed general medical examination must be undertaken immediately after resuscitation.

Fundal examination may show:

- retinopathy caused by diabetes mellitus or hypertension
- papilloedema, which suggests raised intracranial pressure, hypertensive retinopathy or carbon dioxide retention
- subhyaloid haemorrhage, which indicates subarachnoid haemorrhage.

Otoscopic examination may reveal otorrhoea or haemotympanum from a basal skull fracture.

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Causes of coma

Coma with intact brainstem function, no meningism and no lateralizing motor signs

- Hypoxia — ischaemic brain injury
- Toxins — carbon monoxide, methanol, lead, cyanide, thallium
- Alcohol
- Drug toxicity — sedatives, barbiturates, tranquillizers, opioids, psychotropics, amphetamines
- Extrapyramidal causes — acute movement disorders (status dystonicus), neuroleptic malignant syndrome, serotonin syndrome
- Seizures
- Psychiatric causes — catatonia, conversion reaction
- Respiratory causes — hypoxia, hypercapnia
- Electrolytes — hyponatraemia, hypernatraemia, hypercalcaemia, hypocalcaemia, hypermagnesaemia
- Diabetes mellitus — hypoglycaemia, ketoacidosis, lactic acidosis, hyperosmolar non-ketotic diabetic coma
- Renal causes — uraemia
- Hepatic causes — hepatic encephalopathy
- Endocrine causes — hypopituitarism, hypothyroidism, hyperthyroidism, hypoadrenalism, Hashimoto's encephalopathy
- Temperature — hypothermia, hyperpyrexia
- Nutrition — Wernicke's encephalopathy
- Inborn errors of metabolism
- Others — porphyria, Reye's syndrome (hepatic), idiopathic recurrent stupor

Coma with meningism (± intact brainstem function and lateralizing signs)

- Infective — meningitis, encephalitis
- Vascular — subarachnoid haemorrhage

Coma with intact brainstem function and lateralizing signs

Asymmetrical lateralizing signs

- Vascular causes
- Infarction — ischaemia, embolic; hypoperfusion/hypotension; haemorrhage — extradural, subdural, subarachnoid, intracerebral (primary or secondary); vasculitis, venous thrombosis, eclamptic toxaemia, endocarditis
- Infection — abscess, subdural empyema
- Neoplasm
- White matter disease — multiple sclerosis, acute disseminated encephalomyelitis, posterior reversible leucoencephalopathy, toxic leucoencephalopathy

Symmetrical lateralizing signs

- Diffuse axonal brain injury
- Bilateral subdural haematoma/empyema
- Vascular causes

Coma with signs of focal brainstem dysfunction

- Herniation syndrome
- Intrinsic brainstem disease
- Central pontine myelinolysis
- Vascular — vertebrobasilar occlusion, dissection, haemorrhage
- Tumour — posterior fossa

Table 1

Emergency management of the patient in a coma

- Cardiopulmonary resuscitation should be given to ensure adequate oxygenation and airway protection; this involves tracheal intubation and mechanical ventilation when indicated
- Intravenous access and maintenance of an appropriate arterial blood pressure should be provided by the use of intravenous fluids and/or inotropic drugs
- During resuscitation, urgent determination of blood glucose concentration, electrolytes, renal and hepatic function and full blood count should be made
- Following this, in cases where the cause of coma is not apparent, 25 ml of 50% glucose should be given intravenously
- If alcoholism or malnutrition is suspected, thiamine should be administered to prevent the development of Wernicke's encephalopathy
- Naloxone or flumazenil should be administered if narcotic or benzodiazepine overdose is suspected
- Further acute management of the unconscious patient includes adequate treatment of seizures, correction of electrolyte and acid–base disturbances and supportive treatment including adequate nutrition, nursing and physiotherapy

Table 2

Glasgow Coma Scale: this is the most widely used (and reproducible) scale to assess the level of consciousness. It requires regular and serial observations. Full assessment cannot be undertaken in intubated patients or when soft tissue swelling prevents eye-opening.

Eyelids: in the patient in coma, opening of the eyelids by an examiner is followed by slow spontaneous re-closure, whereas in psychogenic coma there is usually forceful resistance to eyelid opening and active closure.

Pupillary responses: pre-existing ocular or neurological injury, or topical or systemic medication, can cause pupillary asymmetry or even a fixed dilated pupil. The presence of equal, light-reactive pupils indicates that the reflex pathway is intact, and a normal pupillary reaction to light in a comatose patient suggests a metabolic rather than structural cause of the coma.

- Unilateral or bilaterally small pupils with normal reactions to light can be caused by Horner's syndrome.
- Bilateral pinpoint pupils with preserved light reflexes also occur with pontine lesions in the tegmentum that interrupt the descending sympathetic pathways.
- Mid-position pupils, which do not respond to light but in which the accommodation reflex is spared, are associated with dorsal tectal, pretectal or tegmental lesions.
- In progressive compressive IIIrd cranial nerve lesions, the initial sign is a sluggish pupillary response, which is followed by the development of fixed dilatation.
- Irregular oval, unequal pupils follow brainstem transtentorial herniation leading to midbrain infarction.