Review article

Monitoring an unconscious patient in the Intensive Care Unit

Nisha Sara M. Jacob, Jacob Paul

Email: nishasara@gmail.com

Abstract

Monitoring an unconscious patient is complex and involves continuous clinical, haemodynamic and neurological assessment aided by various tools. This article discusses the various methods of monitoring a patient with and without a primary neurological insult. Regardless of the tools employed, monitoring, in itself, does not change the outcome. Processing the information obtained along with sound clinical judgment can, however, have a significant impact.

Keywords: Intensive care unit, monitoring, neurological, unconsciousness

Introduction

An unconscious patient is one who is unaware of one's surroundings and unable to notice and respond to stimuli in the environment. Unconsciousness usually indicates an insult to the brain, the causes for which may be structural damage, metabolic derangement, endocrine abnormality, physiological dysfunction or toxins.[1]

Initial assessment is often complex and many of the tools may continue to be used to monitor these patients, either continuously or intermittently.

General monitoring of the unconscious patient

Unconscious patients should be monitored in a high dependency or an intensive care unit (ICU), with adequate facilities. Components of monitoring in such a patient are discussed below *(Figure 1)*.

Clinical monitoring: Clinical monitoring of the unconscious patient involves continuous assessment of the 'ABC's', *i.e.*, airway, breathing and circulation. Ability of the patient to maintain a patent airway should be monitored closely in an obtunded patient and measures taken to secure the airway, if the need arises. It should be ensured that patients are breathing adequately and are not hypoxic.[1] Clinical monitoring is aided by monitoring tools such as pulse oximeter, waveform capnography and arterial blood gas (ABG) analysis. In mechanically ventilated patients, detection of patient-ventilator dysynchrony, dynamic hyperinflation, increase in resistance, and appropriateness of ventilator mode and settings should be reassessed at regular intervals.[2] Along with the ABCs, level of consciousness must be continually assessed. The importance of regular, detailed clinical examination cannot be over-emphasised.

Haemodynamic monitoring: The basic haemodynamic monitors used include noninvasive blood pressure (NIBP) monitoring and continuous electrocardiogram monitoring of heart rate and rhythm. However, in certain conditions, invasive arterial blood pressure (ABP), central venous pressure, cardiac output and echocardiogram monitoring may be required. Numerous types of monitors, with varying degrees of reliability, sensitivity and limitations are available and the choice depends on the patient's condition and available expertise.[3] Additionally, serum lactate levels may be

Nisha Sara M. Jacob, MD
Department of Anesthesia, Kasturba Medical College, Manipal

Jacob Paul, MD
Department of Anesthesia And Intensive Care, Ibra Regional Hospital, Sultanate of Oman.

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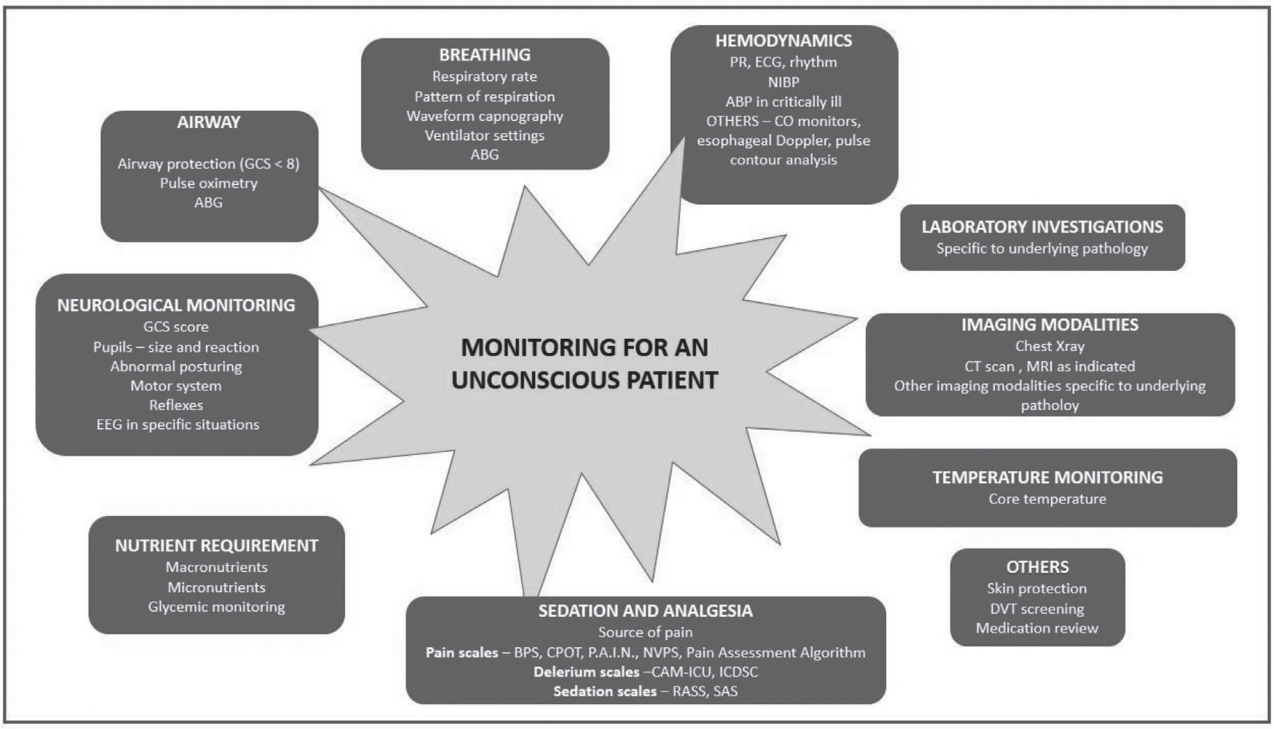

Figure 1: Monitoring of an unconscious patient

Abbreviations: *GCS- Glasgow Coma Scale, ABG – arterial blood gas, PR – pulse rate, ECG – electrocardiogram, NIBP – non-invasive blood pressure, , ABP arterial blood pressure, CO – cardiac output, CT – computed tomography, MRI – magnetic resonance imaging, DVT – deep vein thrombosis, BPS - Behavioral Pain Scale, CPOT - Critical Care Pain Observation Tool, P.A.I.N. - Pain Assessment and Intervention Notation, NVPS - Nonverbal Adult Pain Assessment Scale, CAM-ICU - Confusion Assessment Method for Intensive Care Unit, ICDSC - Intensive Care Delirium Screening Checklist, RASS - Richmond Agitation-Sedation Scale, SAS - Sedation Agitation Score, EEG electroencephalogram.*

used to monitor haemodynamic response to therapy. Urine output, too, serves as an indicator of adequate perfusion. In recent years, the use of ultrasound to monitor hypovolaemia has become increasingly popular.

While the above monitor the macrocirculation, other tools such as gastric tonometry, sublingual capnography and tissue oximetry using near infra-red spectroscopy (NIRS) provide useful information about the microcirculation.[2]

Neurological monitoring: Neurological monitoring involves frequent assessment of the level of consciousness. Scoring systems have been developed for rapid bedside clinical assessment and enable consistent inter-physician communication. Although many exist, the most widely used one is the Glasgow Coma Scale (GCS). The score ranges from three to 15, with categories of eye opening (scores 1 to 4), best verbal response (scores 1 to 5) and best motor response (scores 1 to 6). Factors such as endotracheal intubation and drugs (sedatives, neuromuscular blocking agents and opioid analgesics) can confound the interpretation. Often a 'pseudoscore' is assigned to the component unable to be tested (*e.g.*, V_T for patients unable to vocalise). Assessment with the GCS is a challenge in children aged <3 years.[4]

Other parameters that are monitored include the size, shape, symmetry and reaction of the pupils to light, examination of the motor system for paucity of movements, abnormal posturing, reflexes and abnormal breathing patterns.[5]

Pain, sedation and delirium: Pain is grossly undetected and untreated in unconscious patients, since they are incapable of self-report. Identification of intermittent and continuous painful stimuli

need to be monitored and treated. Pain assessment scoring systems based on behavioural patterns such as facial and body movements, ventilator compliance, muscle tension and physiological signs have been developed; some of them are the Behavioral Pain Scale (BPS), Critical Care Pain Observation Tool (CPOT), Nonverbal Adult Pain Assessment Scale (NVPS), Pain Assessment and Intervention Notation (P.A.I.N) and Pain Assessment Algorithm, each with varying degrees of reliability and feasibility.[6]

Delirium and sedation often confound the assessment of pain. It is desirable to monitor depth of sedation since minimising depth and duration results in shorter ICU stay and mechanical ventilation. Sedation scales such as the Riker Sedation Agitation Score (SAS) and Richmond Agitation-Sedation Scale (RASS) should be used with daily sedation interruption and assessment.[3]

Scales such as Confusion Assessment Method for ICU (CAM-ICU) and the Intensive Care Delirium Screening Checklist (ICDSC) should be implemented for early detection, prevention and treatment of delirium.[3]

Laboratory investigations: Laboratory investigations which should be monitored in the unconscious patient include complete blood counts, coagulation parameters, biochemistry including blood glucose, renal function tests, liver function tests and thyroid profile, appropriate cultures with sensitivity studies, toxicology panel and inflammatory markers. Certain investigations indicative of the cause for unconsciousness may be used to monitor improvement (*e.g.*, serum sodium levels in hyponatraemic patients).

Imaging modalities: Common imaging modalities used include the chest X-ray, ultrasound, computerised tomography (CT) scan and magnetic resonance imaging (MRI). Choice of imaging tool used will vary depending on the underlying pathology.

Temperature: Monitoring the core temperature is preferred as maintenance of normal body temperature reflects adequacy of perfusion and serves as an indicator of infection.

Monitoring nutrition and glycaemic control: Monitoring nutrition involves ensuring adequate supply of macronutrients and micronutrients, and ensuring glycaemic control.[2] Enteral feeding is preferred, but may be supplemented with parenteral nutrition where indicated. Detection of overfeeding and its complications is as important as detection of inadequate feeding. Computer assisted systems and a dedicated dietician will allow for accurate monitoring and optimisation of caloric needs.

Miscellaneous concerns: Of importance in an unconscious patient is the care of the skin and pressure points, and prevention of pressure sores. Screening for and prophylaxis against deep vein thrombosis (DVT) should be instituted.[1] Medications should be reviewed on a regular basis for necessity, adequacy and overdosage.

Monitoring the patient with primary neurological insult

When monitoring a patient with a primary neurological insult, besides the routine tools employed, specific monitors are used which provide information pertaining to the underlying pathology, resulting in improved morbidity and mortality. The aim of monitoring in these patients is to identify, treat and prevent secondary injury to the brain. It allows for individualisation of patient care and management, and enables development of protocols through better understanding of pathophysiology of the disease process, ultimately resulting in improved outcome and quality of life among survivors. Some of the tools used to monitor and the common concerns while monitoring the neurocritical patient are discussed below *(Table 1)*.

Table 1: Monitoring in a patient with primary neurological insult

Clinical assesssment – serial clinical assessment	Airway, breathing, circulation GCS Pupils Motor system Reflexes Abnormal posturing
Haemodynamics	PR, NIBP, ECG with rhythm ABP CO monitor Pulse contour analysis Echocardiography

Ventilation	Pattern of respiration Pulse oximeter Waveform capnography Arterial blood gas Ventilator – Dysynchrony, respiratory mechanics
Imaging	CT scan, MRI, CT angiogram, MRA Serial studies may be required
ICP monitoring	INVASIVE Intraparenchymal Intraventricular NON-INVASIVE Optic Nerve Sheath Diameter Fundoscopic examination Transcranial Doppler Automated pupillometer Tympanic membrane displacement
Electrophysiology monitoring	Quantitative EEG Continuous EEG
Cerebral metabolism	Microdialysis catheter – lactate, pyruvate, glutamante, glucose Lactate/pyruvate ratio
Brain oxygen monitoring	Jugular venous oximetry Parenchymal brain oxygen Near Infra-red Spectroscopy
Miscellaneous concerns	Pain and sedation Temperature monitoring Position Glycaemic control

Abbreviations: *GCS- Glasgow Coma Scale, PR – pulse rate, NIBP – noninvasive blood pressure, ECG - electrocardiogram, ABP arterial blood pressure, CO – cardiac output, CT – computed tomography, MRI – magnetic resonance imaging, MRA magnetic resonance angiography, ICP intracranial pressure, EEG electroencephalogram.*

Clinical assessment: As detailed above, clinical re-evaluation is the cornerstone of neurocritical monitoring. Symptoms of raised intracranial pressure (ICP) are subjective and unreliable. Scoring systems help in rapid, objective, bedside clinical assessment. The GCS, initially developed to prognosticate patients with severe traumatic brain injury (TBI), is now used to predict outcomes in other pathologies such as intracranial and subarachnoid haemorrhage, poisoning, posterior circulation stroke, cardiac arrest, neurodegenerative disorders and tuberculous meningitis.[4] It stratifies head injury as mild (scores 14-15), moderate (scores 9 to 13) and severe (scores less than 9).[5] The 'AVPU' score is an abridged version of the GCS where the patients' sensorium in terms of alertness, response to verbal or painful stimuli or unresponsiveness is assessed. Although it has limited clinical use, this score is used by first responders for rapid assessment of the unconscious patient.

The Full Outline of UnResponsiveness (FOUR) scale assesses the following 4 components, each of which is scored from 0 to 4: eye response, motor response, brainstem reflexes and respiration.[7] Advantages of this scale include assessment of brainstem reflexes enabling detection of vegetative and locked-in states, and incorporation of hand gestures which negates the need for a verbal response.

Haemodynamic monitoring: Haemodynamic disturbances are common among patients with acute brain injury, one of the reasons being sympathetic stimulation following the insult. All patients require basic noninvasive monitoring. Additional invasive monitoring may be instituted depending on the degree of haemodynamic instability, underlying cardiac condition and primary intracranial injury, which may warrant close monitoring of the cerebral perfusion pressure (CPP).[3]

Monitoring ventilation: Unconscious patients may require airway protection with endotracheal intubation at any juncture. Abnormal patterns of respiration such as Cheyne-Stokes respiration, apneustic breathing, Biot breathing and tachypnoea due to central neurogenic hyperventilation are premonitory signals. Both hypercapnia and hypocapnia (especially arterial carbon dioxide < 25 mmHg) have deleterious effects on the cerebral blood flow (CBF) by increasing intracranial pressure (ICP) and worsening ischaemia respectively. In patients who require a higher positive end-expiratory pressure (PEEP), the benefits need to be weighed against the risk of raised ICP. These patients will benefit from concurrent ICP monitoring. In patients with adult respiratory distress syndrome, high frequency ventilation may be advantageous over conventional methods due to reduction in peak inspiratory pressures and ICP.[8]

Imaging: Serial imaging studies are vital to detect worsening intracranial pathology. These include computerized tomography (CT) scan, magnetic resonance imaging (MRI), CT angiography and magnetic resonance angiography (MRA). Features

such as magnitude of midline shift, effacement of basal cisterns and ventricles, presence of mass lesion or subarachnoid blood, and loss of grey and white matter differentiation are some of the findings to detect raised ICP, and are used in the Marshall CT classification and the Rotterdam scoring system. However, real-time, bedside ICP monitoring is not feasible with the above.

Intracranial pressure monitoring: Elevated ICP (>20 mmHg) is associated with significantly worse outcomes. In current clinical practice, the intraparenchymal and intraventricular methods of ICP monitoring are widely accepted.[3] Other methods such as epidural, subdural and lumbar subarachnoid cerebrospinal fluid pressure monitoring are almost obsolete.

Noninvasive modalities to monitor ICP have varying sensitivity and specificity. Pulsatility Index (PI) and the direction of flow index (DFI), derived from the Transcranial Doppler (TCD) are insensitive tools while fundoscopic examination for papilloedema cannot detect acute rise in ICP and is operator-dependent. Tympanic membrane displacement (TMD) following stimulation of the stapedial reflex has a negative association with invasively measured ICP, but lacks sensitivity and specificity. Optic Nerve Sheath Diameter (ONSD) measured using a transocular ultrasound is sensitive to detect raised ICP. The automated pupillometer is a device that analyses pupillary reaction to light and computes the neurological pupillary index, which drops when ICP rises.[9]

Despite these modalities, Chestnut *et al* found no difference in mortality among severe TBI patients who received treatment based on ICP monitoring compared to clinical evaluations and imaging, thus further iterating the need for clinical examination.[10]

Electrophysiology monitoring: Electroencephalography (EEG) provides vital information about the electrical activity of the brain through waveform analysis, measured *via* electrodes placed on the patient's scalp. A fall in the cerebral blood flow (CBF) results in a change in electrical activity as a result of ischaemia, which is identified on the EEG. Continuous (cEEG) is more useful when patients have refractory status epilepticus, unexplained neurological deficits and altered mental status secondary to non-conclusive seizure activity. cEEG is also used to titrate dose of antiepileptic agents and barbiturates. Displacement of electrodes due to patient movement, availability of round-the-clock technical and interpreting staff, and presence of external noise confound the results.[11]

Cerebral metabolism: Decreased oxygen supply below critical threshold, due to cerebral ischaemia, results in accumulation of metabolites such as lactate, pyruvate, glutamate and glucose. Measurement of these metabolites is performed through a microdialysis catheter introduced at the vulnerable site. The lactate/pyruvate ratio is a sensitive indicator of impending cerebral ischaemia.[3] It is a one-time rather than a real-time measurement and reflects the metabolism in a focal area. Interpretation must be based on position of the catheter in the CT scan.

Brain oxygen monitoring: It is performed using one of three methods: jugular venous oximetry (SjO_2), parenchymal brain oxygen monitoring ($PbtO_2$) and near infrared spectroscopy (NIRS).[3,12] SjO_2 is invasive and reflects global hemispheric balance between the oxygen supply and demand. It is especially useful when hyperventilation is required. Complications such as malposition and vessel injury may occur. It is insensitive in monitoring infratentorial pathology. $PbtO_2$, an invasive and regional tool, measures oxygen tension in the brain interstitium. Therefore, in patients with severe neurocritical illness, monitoring $PbtO_2$ (<15 mmHg suggesting ischaemia) may be beneficial as cellular hypoxia is a precursor to raised ICP. NIRS is based on the principle that oxyhaemoglobin and deoxyhaemoglobin absorb near infrared light to differing extents. By measuring the changes in the light reflectance at differing wavelengths, NIRS enables estimation of changes in the concentration of oxy- and deoxyhaemoglobin through spectroscopy, which reflects variations in oxygen saturation and ultimately the cerebral blood volume. Rather than a standalone tool, the NIRS may find application along with other monitoring tools in the neurocritical patient, as it gives useful information about the regional brain oxygenation in

a real-time, noninvasive bedside manner. However, deeper structures cannot be monitored, and factors such as scalp oedema may confound results.

Transcranial Doppler (TCD): The TCD uses ultrasound to measure the linear cerebral blood flow velocity, which is inversely related to the arterial cross-section. Pulsatility index and resistance index, derived from the TCD, reflect resistance in the distal cerebral blood vessels and hence the ICP.[9] TCD is also used to detect cerebral vasospasm and real-time micro-emboli. The angle of insonation can affect the data obtained.

Pain monitoring: The reaction to pain among patients with head trauma may differ from other patients in the absence of frowning and brow lowering; a higher proportion of these patients may present with closed eyes and weeping eyes.[6]

Temperature monitoring: The presence of fever alone cannot be used to detect an infectious cause since neurological cause for increased temperature will need to be considered. Therapeutic hypothermia may be instituted in select patients, especially following a cardiac arrest or subarachnoid haemorrhage; core temperature monitoring should be instituted in these patients. Shivering during the maintenance phase increases cerebral oxygen consumption and must be avoided. Rebound cerebral edema and raised ICP may occur during rewarming; ICP monitoring is desirable in these patients.[13]

Miscellaneous considerations: Changes in position can significantly impact the ICP. Neurocritical patients should be nursed in the 30^0 head elevated position, which helps alleviate the raised ICP and decreases the risk of pulmonary aspiration. Hyperglycaemia is associated with poor outcomes and strict glycaemic control results in inadequate substrate to the cerebral tissue. Targeting levels between 140-180mg/dl is desirable.

In summary, monitoring of the unconscious patient is complex, regardless of the presence of a primary neurological insult. Monitoring needs to be tailored for each patient, depending on the underlying pathology and illness. A holistic approach is required. Although a variety of monitoring tools are available, the information garnered from these need to be interpreted with sound clinical judgment and decisions regarding further management made judiciously.

Bibliography

1. Nozari A, Fehnel CR, Schwamm LH. Coma. In: Parsons PE, Wiener-Kronish JP, editors. Critical Care Secrets. 5th ed. Philadelphia, PA: Elsevier/ Mosby; 2013. pg. 423–7.
2. Kipnis E, Ramsingh D, Bhargava M, Dincer E, Cannesson M, Broccard A, *et al.* Monitoring in the Intensive Care. *Crit Care Res Pract.* 2012:**27**;e473507.
3. Le Roux P, Menon DK, Citerio G, Vespa P, Bader MK, Brophy GM, *et al.* Consensus summary statement of the International Multidisciplinary Consensus Conference on Multimodality Monitoring in Neurocritical Care: a statement for healthcare professionals from the Neurocritical Care Society and the European Society of Intensive Care Medicine. *Neurocrit Care.* 2014;**21**:S1-26.
4. Kornbluth J, Bhardwaj A. Evaluation of coma: a critical appraisal of popular scoring systems. *Neurocrit Care.* 2011;**14**:134–43.
5. Hayward LJ, Drachman DA. Evaluating the Patient with Altered Consciousness in the Intensive Care Unit.In: Irwin RS, Rippe JM, editors. Irwin and Rippe's Intensive Care Medicine. 6th Ed. Philadelphia: Lippincott Williams and Williams, 2008. pg. 1959-66.
6. Pudas-Tähkä S-M, Axelin A, Aantaa R, Lund V, Salanterä S. Pain assessment tools for unconscious or sedated intensive care patients: a systematic review. *J Adv Nurs.* 2009;**65**:946–56.
7. Iyer VN, Mandrekar JN, Danielson RD, Zubkov AY, Elmer JL, Wijdicks EFM. Validity of the FOUR Score Coma Scale in the Medical Intensive Care Unit. *Mayo Clin Proc.* 2009 ;**84**:694–701.
8. Chang W-TW, Nyquist PA. Strategies for the use of mechanical ventilation in the neurologic intensive care unit. *Neurosurg Clin N Am.* 2013;**24**:407–16.

9. Nair S. Clinical review of non-invasive intracranial pressure measurement in medical cases. *J Neuroanaesthesiol Crit Care* 2016;**3**:9-14
10. Chesnut RM, Temkin N, Carney N, Dikmen S, Rondina C, Videtta W, *et al.* A Trial of Intracranial-Pressure Monitoring in Traumatic Brain Injury. *N Engl J Med.* 2012;**367**:2471–81.
11. Kennedy JD, Gerard EE. Continuous EEG monitoring in the intensive care unit. *Curr Neurol Neurosci Rep.* 2012;**12**:419–28.
12. Nortje J, Gupta AK. The role of tissue oxygen monitoring in patients with acute brain injury. *Br J Anaesth.* 2006;**97**:95–106.
13. Badjatia N. Hypothermia in neurocritical care. *Neurosurg Clin N Am.* 2013;**24**:457–67.