INTRODUCTION

Emergence from anaesthesia by definition is the process of return to baseline physiological function of all organ systems after cessation of administration of general anaesthesia.

It is the stage from general anaesthesia that includes a return to spontaneous breathing, voluntary swallowing and normal consciousness.

It is a time of great physiological stress for many patients and ideally should happen smoothly, free of coughing, straining or arterial hypertension in a short time in a controlled environment ***(Morgan and Mikhail, 2005).***

Ideally on completion of surgery and anaesthesia, the patient should be awake or easily arousable, protecting the airway, maintaining adequate ventilation with his pain under control.

Delayed emergence from anaesthesia is failure of the patient to regain the expected level of concioussness within 20 to 30 minutes from the end of anaesthetic administration, it remains a cause of concern for both anaesthesiologist and surgeon.

Time to emerge from anaesthesia is very variable and depends on many factors related to the patient, the type of anaesthetic given and the length of surgery ***(Radhakrishnan et al., 2001).***

Factors related to the patient include: extremes of age, genetic variation, metabolic factors, cognitive dysfunction. Patients with preexisting cardiac, pulmonary, hepatic and renal disease require anaesthetic dose adjustment ***(Frost, 2014).***

Delayed recovery from anaesthesia is often multifactorial, the principal factor is assumed to be the medications and anaesthetic agents used in the perioperative period ***(Deuri et al., 2010).***

Although delayed emergence from general anaesthesia is not uncommon, recognizing the cause and instituting timely treatment is imperative in condition where delayed therapy can increase morbidity and mortality ***(Shaikh and Lakshmi, 2014).***

AIM OF THE ESSAY

The main purpose is to discuss adequate diagnosis and early management of the causes of delayed emergence from general anaesthesia.

GENERAL ANAESTHESIA

General anaesthesia (GA) is the state produced when a patient receives medications for amnesia, analgesia, muscle paralysis, and sedation. An anaesthetized patient can be thought of as being in a controlled, reversible state of unconsciousness. Anaesthesia enables a patient to tolerate surgical procedures that would otherwise inflict unbearable pain, potentiate extreme physiologic exacerbations, and result in unpleasant memories ***(Evers and Crowder, 2006).***

The combination of anaesthetic agents used for general anaesthesia often leaves a patient with the following clinical constellation:

- Unarousable even secondary to painful stimuli.
- Unable to remember what happened (amnesia).
- Unable to maintain adequate airway protection and/or spontaneous ventilation as a result of muscle paralysis.
- Cardiovascular changes secondary to stimulant/depressant effects of anaesthetic agents

It uses intravenous and inhaled agents to allow adequate surgical access to the operative site. A point worth noting is that general anaesthesia may not always be the best choice; depending on a patient’s clinical presentation, local or regional anaesthesia may be more appropriate ***(Abou-Chebl et al., 2015; Zhang et al., 2015; Nash et al., 2015).***

Preparation for General Anaesthesia

Safe and efficient anaesthetic practices require certified personnel, appropriate medications and equipment, and an optimized patient.

Minimum infrastructure requirements for general anaesthesia include a well-lit space of adequate size; a source of pressurized oxygen (most commonly piped in); an effective suction device; standard ASA (American Society of Anaesthesiologists) monitors, including heart rate, blood pressure, ECG, pulse oximetry, capnography, temperature; and inspired and exhaled concentrations of oxygen and applicable anaesthetic agents ***(Shah and Shelley, 2013).*** An array of routine and emergency drugs, including dantrolene sodium (the specific treatment for malignant hyperthermia), airway management equipment and a cardiac defibrillator. A recovery room staffed by properly trained individuals completes the picture ***(Bergek et al., 2013).***

Table (1): ASA physical status classification system:

Classification	Definition	Examples
ASA I	A normal healthy patient	Healthy, non-smoking, no or minimal alcohol use
ASA II	A patient with mild systemic disease	Mild diseases only without substantive functional limitations. Examples include (but not limited to): current smoker, social alcohol drinker, pregnancy, obesity (30 < BMI < 40), well-controlled DM/HTN, mild lung disease
ASA III	A patient with severe systemic disease	Substantive functional limitations; One or more moderate to severe diseases. Examples include (but not limited to): poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, premature infant PCA < 60 weeks, history (>3 months) of MI, CVA, TIA, or CAD/stents.
ASA IV	A patient with severe systemic disease that is a constant threat to life	Examples include (but not limited to): recent (< 3 months) MI, CVA, TIA, or CAD/stents, ongoing cardiac ischemia or severe valve dysfunction, severe reduction of ejection fraction, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis
ASA V	A moribund patient who is not expected to survive without the operation	Examples include (but not limited to): ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction
ASA VI	A declared brain-dead patient whose organs are being removed for donor purposes	

The addition of “E” denotes Emergency surgery: (An emergency is defined as existing when delay in treatment of the patient would lead to a significant increase in the threat to life or body part ***(Sankar et al., 2014).***

Monitoring during General anaesthesia:

Clinical monitoring:

Despite the advance in technology, clinical monitoring plays a vital role because the machines used to provide information can fail at any stage. Information provided from the machines should be confirmed by clinical means. The best and main monitor in the operating room is always the anaesthesiologist.

It includes monitoring of the anaesthetic machine and equipment, close observation of the patient and the events in the operating theatre. Depth of anaesthesia may be monitored by clinical parameters such as movements, lacrimation, sweating, increase in heart rate and blood pressure. Cardiovascular parameters may be monitored by feeling peripheral pulses, capillary refill and auscultating the heart sounds. Respiratory parameters are monitored by observing chest movements, movement and feel of reservoir bag, auscultating lung fields and by observing the colour of lips and nail beds for cyanosis ***(Niutanen, 2014).***

Monitoring with special equipment:

1. **Electrocardiography (ECG):** The placement of electrodes that monitor heart rate and rhythm. This may also help the anaesthetist to identify arrythmias and early signs of heart ischaemia.

2. **Pulse oximetry (SpO_2):** The placement of this device (usually on one of the fingers) allows for early detection of a fall in a patient's haemoglobin saturation with oxygen (hypoxaemia) ***(Niutanen, 2014).***

3. **Blood pressure monitoring (NIBP or IBP):** There are two methods of measuring the patient's blood pressure. The first, and most common, is called non-invasive blood pressure (NIBP) monitoring. This involves placing a blood pressure cuff around the patient's arm, forearm or leg. A blood pressure machine takes blood pressure readings at regular, preset intervals throughout the surgery.

The second method is called invasive blood pressure (IBP) monitoring. This method is reserved for patients with significant heart or lung disease, the critically ill, major surgery such as cardiac or transplant surgery, or when large blood losses are expected. The invasive blood pressure monitoring technique involves placing a special type of plastic cannula in the patient's artery usually at the wrist or in the groin ***(Niutanen, 2014).***

4. **Agent concentration measurement:** Common anaesthetic machines have monitors to measure the percent of inhalational anaesthetic agents used. Some monitors usually measure nitrous oxide and oxygen percentages and could give a MAC level ***(Niutanen, 2014).***

5. **Low oxygen alarm:** Almost all circuits have a backup alarm in case the oxygen delivery to the patient becomes compromised. This warns if the fraction of inspired oxygen drops lower than minimum alarm setting and allows the anaesthetist to take immediate action.

6. **Circuit disconnect alarm or low pressure alarm:** indicates failure of circuit to achieve a given pressure during mechanical ventilation ***(Niutanen, 2014).***

7. **Capnography:** measures the amount of carbon dioxide expired by the patient's lungs in mmHg. It allows the anaesthetist to assess the adequacy of ventilation.

8. **Temperature monitoring:** is standard for patients undergoing general anaesthesia, both core and peripheral temperature should be measured to discern hypothermia or fever, and to aid early detection of malignant hyperthermia ***(Niutanen, 2014).***

9. **Depth of anaesthesia:** is assessed by EEG to verify depth of anaesthesia may also be used. This reduces the likelihood that a patient will be mentally awake, although unable to move because of the paralytic agents ***(Bruhn et al., 2006).***

10. **Monitoring of the neuromuscular system:** Nerve stimulation, single twitch, train of four, tetanic, post-tetanic count, double burst stimulation ***(Murphy and Szokol, 2004).***

Clinical stages of general anaesthesia:

The Process of Anaesthesia:

Premedication:

Premedication is the administration of medication before anaesthesia. It is used to prepare the patient for anaesthesia and to provide optimal conditions for surgery. it is usually conducted in the surgical ward or in a preoperative holding area. The goal of premedication is to have the patient arrive in the operating room in a calm, relaxed frame of mind. The most commonly used premedication is midazolam, a short-acting benzodiazepine ***(Steeds and Orme, 2006).***

A. Induction

The patient is now ready for induction of general anaesthesia, a critical part of the anaesthesia process. One should remember to check (drugs, airway equipment, machine, monitors, suction). The induction of anaesthesia refers to the transition from an awake to an anaesthetized state. It is a time of physiological disruption with multi-system effects ***(Kumar et al., 2012).***

Intravenous induction:

This stage can be achieved by intravenous injection of induction agents (drugs that work rapidly, such as propofol) and the effects reviewed before further titration of the drug.

Delays in inducing anaesthesia may represent slow arm–brain circulation time (e.g. elderly, cardiovascular disease), patient anxiety, or extravasation. An opioid is often given to reduce the dose of induction agent needed and to smooth the induction process helping to ease the undesirable effects of intubation. A muscle relaxant is usually given if intubation is required.

Inhalational induction:

An alternative method of inducing anaesthesia is with a volatile agent, e.g. sevoflurane (well-tolerated anaesthetic vapor). The concentration of volatile delivered is gradually increased with the patient spontaneously breathing. Common uses include paediatric practice, cases of difficult airway or difficult venous access where maintaining spontaneous ventilation is preferable. Intubation of the trachea can be achieved under deep inhalational induction without muscle relaxation ***(McClelland and Hardman, 2007).***

The next step of the induction process is securing the airway. This may be a simple matter of manually holding the patient's jaw such that his or her natural breathing is unimpeded by the tongue, or it may demand the insertion of a prosthetic airway device such as oropharyngeal airway, laryngeal mask or endotracheal tube ***(Kumar et al., 2012).***

Potential indications for endotracheal intubation under general anaesthesia may include the following ***(Lundstrøm, 2012):***

- Potential for airway contamination (full stomach, gastroesophageal reflux, gastrointestinal or pharyngeal bleeding).
- Surgical need for muscle relaxation.
- Surgery of the mouth or face.
- Prolonged surgical procedure.

If intubation is required, it may be necessary to paralyse the patient using: depolarizing muscle relaxants (e.g. suxamethonium) or non-depolarizing muscle relaxants (e.g atracurium, rocuronium). Not all surgeries requires muscle relaxation, if surgery is taking place in the abdomen or thorax, a muscle relaxant drug is administered in addition to the induction agent and opioid ***(King and Hunter, 2002).***

RSI is used most commonly when the patient is considered to be at high risk for aspiration. The technique involves IV administration of rapidly acting anaesthetic agents and muscle relaxants. Sellick's maneuver pressure is then applied to the cricoid cartilage to occlude the oesophagus in order to prevent the regurgitation of stomach contents until the trachea is intubated and endotracheal tube cuff is inflated ***(Nathan and Odin, 2007).***

B. Maintenance phase:

At this point, the drugs used to initiate anaesthesia are about to wear off, and the patient must be anaesthetized with a maintenance agent which can be achieved using combination of intravenous anaesthetic agents, inhalational agents, opioids, muscle relaxants and sedatives along with ventilatory support. Volatile agents are most commonly used, delivered via vaporisers found on the 'back bar' of the anaesthetic machine which feed into the breathing circuit.

The concentrations of the inhaled agents are measured and displayed. Expired end tidal concentration is equivalent to the alveolar concentration which in turn represents the concentration at the site of action (CNS). This gives the anaesthetist an idea of the amount of anaesthetic agent reaching the patient and the likely depth of anaesthesia ***(Yentis et al., 2009).***

The minimal alveolar concentration **(MAC)** is the alveolar concentration of a volatile agent which when given alone prevents movement in 50% of healthy volunteers to a standard surgical stimulus e.g. skin incision.

Intravenous maintenance of anaesthesia can be achieved with infusions of propofol with or without an opioid delivered via a pump. The choice of maintenance technique may be determined by surgical and patient factors and the experience of the anaesthetist ***(Yuill and Simpson, 2002).***

If muscle relaxants have not been used the patient may move, cough, or obstruct his airway if the anaesthesia is too light for the stimulus being given. If muscle relaxants have been used, the patient is unable to demonstrate any of these phenomena. In these patients, the anaesthetists must rely on observation of autonomic phenomena such as hypertension, tachycardia, sweating, and capillary dilation to decide whether the patient requires a deeper anaesthesia.

As the surgical procedure draws to a close, the patient's emergence from anaesthesia is planned. In advance of that time, anaesthetic vapors have to be decreased or even switched off entirely to allow time for them to be exhaled by the lungs.

If a ventilator has been used, the patient is allowed to restore spontaneous breathing and as anaesthetic drugs dissipate, the patient emerges to consciousness. Emergence is not synonymous with removal of the endotracheal tube or other artificial airway device. This is only performed when the patient has regained sufficient control of his or her airway reflexes ***(Ropcke and Wartenberg, 2000).***

C. Emergence Phase:

Emergence from general anaesthesia is a passive process that depends on the amounts of drugs administered; their sites of action, potency, and pharmacokinetics; the patient's physiological characteristics; and the type and duration of the surgery. Recovery from general anaesthesia is generally assessed by monitoring physiological and behavioral signs. The return of spontaneous respirations is typically one of the first clinical signs observed once peripheral neuromuscular blockade is decreased ***(Brown et al., 2010).***

The heart rate and blood pressure typically increase. Salivation and tearing begin, followed by nonlocalizing responses to painful stimuli. As skeletal-muscle tone returns, the patient begins to grimace, swallow, gag, and cough and make defensive movements, such as reaching for the endotracheal or naso-gastric tube. At this point the anaesthesiologist will perform oropharyngeal suction followed by extubation ***(Giacino et al., 2002).***

Intravenous Agents used during general anaesthesia:

1) Intravenous hypnotics:

a. Benzodiazepines:

They are the most popular drugs for anxiolysis, amnesia and sedation. They act by binding to GABA receptor resulting in CNS depression ***(Horn and Nesbit, 2004).***

- ***Midazolam:***

It has the advantage that it has quick onset 1-3 min and short duration of action 20-30 min. Due to quick onset and rapid clearance, it is often the most satisfactory benzodiazepine