Patient Monitoring And Invasive Monitors

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The procedure for anesthesia has evolved gradually over the past century, and various safety measures and monitoring devices have been introduced to assist the anesthesia provider and to reduce the possibility of human error. Despite all these advances, the anesthesia provider continues to be the best monitor of the patient in the operating room. Patient monitoring can be classified as clinical, non-invasive and invasive monitoring. In high-risk patients, and for those requiring an intensive level of care during and after surgery, invasive monitoring is de rigueur.

Clinical Monitoring

Clinical patient monitoring during any type of anesthesia includes assessment and recording of the **arterial pulse**, **blood pressure**, **ventilation,** and **oxygen saturation** (by observing the color of the patient's skin and mucous membranes and correlating with pulse oximetry values) at regular intervals. A vigilant provider continuously observes the patient, anticipates problems and corrects them promptly.

Non-invasive monitoring

Monitors, or devices which can record patient's parameters without having to be placed inside the body, include **blood pressure cuff**, **pulse oximeter**, **electrocardiogram**, **temperature probe**, **oxygen analyzer,** and **carbon dioxide analyzer** (capnograph).

Invasive Monitoring

Invasive monitoring is useful to observe and maintain adequate **hemodynamic status** in an anesthetized patient. This helps to ensure adequate tissue perfusion, prevents organ dysfunction and death. It is especially important in high-risk patients, patients undergoing cardiac, neurosurgical or lengthy surgical procedures, or when major blood loss during surgery is anticipated.

Monitors required for high-risk patients include:

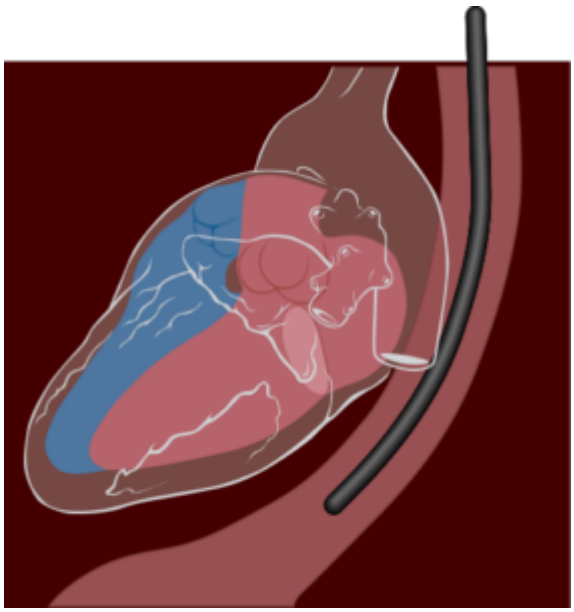

Image: "Diagram of transesophageal echocardiography ultrasound," by Patrick J. Lynch, the medical illustrator. License: CC BY 2.5

- Invasive blood monitors: for blood pressure, central venous pressure and pulmonary arterial pressure
- Intracranial pressure monitor
- Trans-esophageal echocardiography (TEEC);
- Sensory and motor potentials
- EEG
- Fetal heart monitor
- Uterine contraction monitor
- Cerebral monitors (BIS, cerebral oximetry) – transcranial cerebral oximetry is a non-invasive technique of detecting cerebral oxygenation.

Invasive Blood Pressure Monitors

Hemodynamic monitoring involves measuring the systemic and pulmonary arterial and venous pressures and cardiac output. To facilitate this, either a central line or an arterial line has to be introduced in the patient's body.

The central line is introduced through the internal or external jugular veins or through the femoral and subclavian veins. It can be difficult to insert a central line in morbidly obese patients, in patients with thyromegaly or anatomical abnormalities.

Arterial line: invasive blood pressure measurement is conducted by placing a cannula in

any peripheral artery, e.g., radial, brachial, dorsalis pedis or the femoral artery. The cannula is flushed with normal saline–heparin to prevent clotting. It is connected to a transducer device which converts the mechanical energy of diaphragmatic movement with arterial pulsation to electrical energy and displays it as a blood pressure reading on the monitor.

Disadvantages of invasive blood pressure monitoring are:

- Thrombus or hematoma formation
- Bleeding
- Infection
- Accidentally injecting drugs through the arterial line.

Central Venous Pressure

The central venous pressure (CVP) measures the **right atrial and vena cava blood pressure** directly. It helps to assess the **fluid status** and **right ventricular function** of the patient.

A **multi-lumen catheter** is introduced through the internal or external jugular vein or the subclavian vein. The tip of the catheter is located in the lower one-third of the superior vena cava, while the proximal end is connected to a pressure monitoring device.

The catheter is also used for **transfusion** of fluids, drugs which cause thrombophlebitis, parenteral nutrition and venous blood tests.

Pulmonary Arterial Pressure

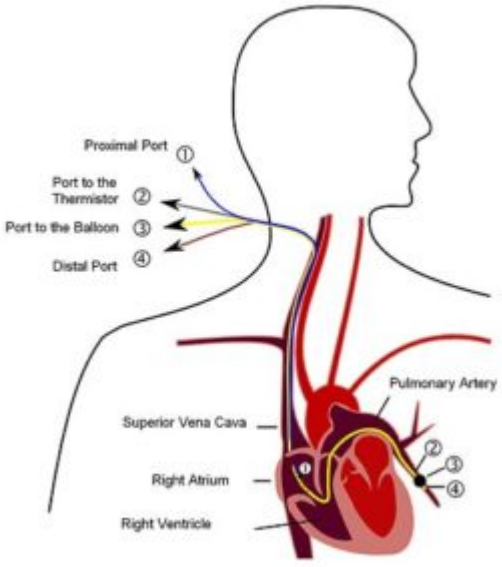

Image: "A simple figure descripting pulmonary artery catheter." Derivative work: Tariq Abdullah. License: CC BY-SA 3.0

A **balloon-tipped Swan-Ganz catheter** is used to measure the pulmonary arterial, right atrial and left ventricular pressures. It helps to assess left ventricular and cardiac function.

Intracranial pressure monitor

It is important to measure intracranial pressure in patients with a **head injury**, **hydrocephalus**, **intracranial tumors**, **cerebral edema,** and **encephalopathies**.

Monitoring intracranial pressure helps to detect and intervene early in case of elevated pressure, thereby maintaining the ideal cerebral perfusion pressure. If the intracranial pressure is maintained within the normal range for 48 to 72 hours, or if the patient shows signs of neurological improvement, then the intracranial pressure monitoring can be withdrawn.

Trans-esophageal Echocardiography (TEEC)

TEEC is an **endoscope-guided ultrasound transducer** which is threaded through the esophagus to obtain dynamic images of the chambers of the heart and the valves as well as cardiac function. It is useful to assess the intra-operative as well as immediate post-operative cardiac status in high-risk patients.

Sensory and Motor Potentials

Intraoperative monitoring of sensory and motor potentials is used to assess the **neural pathways**. The sensory potentials assess the ascending sensory tracts for integrity, while the motor potentials assess the integrity of the descending motor pathways. Intraoperative monitoring helps to **prevent iatrogenic nervous system injury**. Constant levels of the anesthetic drugs have to be maintained while recording these potentials.

Electroencephalography (EEG)

EEG is a sensitive indicator of **changes in the cerebral perfusion**. It is used for intraoperative monitoring during **carotid endarterectomy and aneurysmectomy** as it can detect changes in cerebral perfusion when the carotid artery is clamped. EEG is also useful to monitor cerebral perfusion in patients with **hypothermic circulatory arrest** during cardiac surgery.

Bispectral index (BIS)

BIS is an **algorithmic index based on EEG parameters, and it measures the depth of general anesthesia**. The BIS monitor provides a single number between 0 to 100. The appropriate level of anesthesia is indicated by a BIS value ranging between 40 and 60.

Electrocorticography (ECoG)

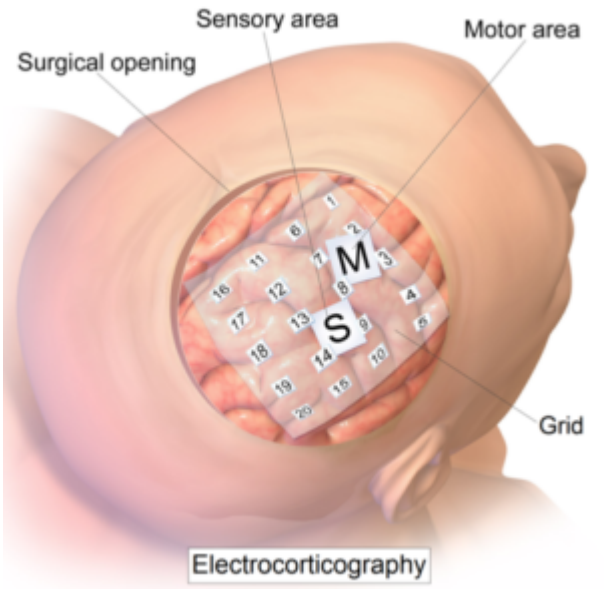

Image: “Intracranial electrode grid for electrocorticography,” by Blausen.com staff. “Blausen gallery 2014”. Wikiversity Journal of Medicine. DOI:10.15347/wjm/2014.010. ISSN 20018762. – Own work. License: CC BY 3.0

ECoG is used during surgeries for the **treatment of seizures**. During these surgeries, entire regions of the cortex responsible for causing the seizures have to be resected. ECoG provides a **map for the resection** by indicating lesion margins which are occasionally undetectable with inspection or neuroimaging.

It is important for the anesthesia provider to adjust doses of the anesthesia drugs during deep anesthesia as most anesthesia agents suppress the seizure spikes and may interfere with the monitoring ability of the ECoG.

Fetal Heart Monitor and Uterine Contraction Monitor

Fetal heart monitoring is indicated for **non-obstetric surgeries during pregnancy**. Intraoperative fetal heart monitoring helps to identify any factors (anesthesia agents, oxygenation, etc.) adversely influencing the well-being of the fetus and to position the patient and assess oxygen requirements.

In pre-viable fetuses, **ultrasound monitoring of the fetal heart rate** before and after the surgery is advisable. Simultaneous electronic fetal heart rate and uterine contraction monitoring before and after completion of the procedure is essential in a fetus considered viable.

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Notes