TEAM ANESTHESIA

435

Monitoring during anaesthesia

{Color index: Important★| Notes | Extra | Editing File}

Objectives:

- Definition
- Where, when, what to monitor
- The rules and regulations that govern modern monitoring
- The basic monitors and the advanced monitors
- Arterial Oxygen Saturation- SpO_2
- Expired CO_2 - $ETCO_2$
- Awareness under anesthesia
- Means to monitor the wakeful state of the brain
- Other somatosensory and motor monitoring
- The neuro muscular junction relaxation monitoring
- Brief introduction about invasive hemodynamic monitoring and oxygenation of the brain

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Special thanks to Sarah Almutawa for her great effort

Patient Monitoring and Management:

★ What is Monitoring[1] ?

observe and check the progress or quality of (something) over a period of time; keep under systematic review.

Anything you monitor there is a goal to achieve so if something happened wrong, I have to interfere

★ What do you Monitor in a patient?

Vitals, Color/skin, Wakefulness.

★ How and by which means do you Monitor in a patient?

- Physical exam
- Equipments (advances in technology) [2]

★ What are the Standards to follow for monitoring a patient Responsibilities?

These standard were produced by some society that conducted studies on such patients with medico legal issues who had morbidity and mortality and investigated the causes e.g. blood pressure wasn't measuring regularly, then they put the legislation لازم يكون فيه معايير لأن إذا مافيه معايير كل شخص بيتحاسب بطريقة مختلفة عن الآخر وبمعرفة معايير مراقبة المريض كل شخص يعرف مسؤوليته

★ What determines the Standards of care for monitoring a patient?

- Basic monitoring
- Advanced monitoring
- Patient/illness
- Equipments/technology
- Rules/legislation
- Anesthesia type: (General, Regional/neuraxial)
- Monitored Anesthesia Care/Sedation

★ What is Anesthesia?

- Hypnosis
- Analgesia
- Paralysis

★ What would happen for the body during anesthesia? Our body monitor itself but during anesthesia the feedback mechanism may be not effective to restore the normal status of the body

- Neurodepression/respiratory
  Cardiodepression / BP CO
- Vasodilation
- Low BP affects perfusion to vital organs.
- Low Oxygen affects metabolism of organs

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[1] Where can you monitor? Maybe in clinic or in the street also suppose you found someone with asthmatic attack so you monitor HR, RR, Pulse, BP, chest expansion, if you have oximeter check the oxygen saturation
Can you help him if he collapses? Yes of course that's why everybody has to learn BLS and ACLS, and before that don't forget to (call for help!)

[2] means long time ago there wasn't some devices like oximeter so of course it wasn't a must for them to use it but now it is a must for as to use it

Standards for Anesthetic Monitoring:

- Apply to all anesthesia care although, in emergency circumstances, appropriate life support measures take precedence.
- may be exceeded at any time based on the judgment of the responsible anesthesiologist.
- They are intended to encourage quality patient care, but observing them cannot guarantee any specific patient outcome.
- They are subject to revision from time to time, as warranted by the evolution of technology and practice. Practice means evidence, evidence is related to whatever we have in literature and if u see something interesting report it to attribute to literature.
- **They apply to all general anesthetics, regional anesthetics and monitored anesthesia care.**
- This set of standards addresses only the issue of basic anesthetic monitoring, which is one component of anesthesia care. So **basic** anesthesia monitoring should be applied to **every patien**t whether the patient is healthy or sick whether the procedure is simple or invasive.

- in certain rare or unusual circumstances,

1) some of these methods of monitoring may be clinically impractical

2) appropriate use of the described monitoring methods may fail to detect untoward clinical developments.

Even if you put all the monitors you might be missing something or you might doing something that is not benefiting the patient this is why they say that we have to use our judgement.

- Brief interruptions of continual monitoring may be **unavoidable**.

- **continual** is defined as repeated regularly and frequently in steady rapid succession
- **continuous**[3] means prolonged without any interruption at any time.

We record the values continually over frequent regular intervals 3-4 ms
but we should be there around the patient continuously all the time!

Standard basic monitoring guidelines form the American Society of Anesthesiologists (ASA):

Standard | "1" (How we are going to manage our monitoring)

Qualified anesthesia personnel should be presented in the room throughout the conduct of all general anesthetics, regional anesthetics and monitored anesthesia care due to the rapidity of occurrence of physiologic derangement during surgical interference Bc patient may need intubation and if you don't act immediately he might die

- In the event there is a direct known hazard, e.g., radiation, to the anesthesia personnel which might require intermittent remote observation of the patient, some provision for monitoring the patient must be made.[4]
- In the event that an emergency requires the temporary absence of the person primarily responsible for the anesthetic, the best judgment of the anesthesiologist will be exercised in comparing the emergency with the anesthetized patient's condition and in the selection of the person left responsible for the anesthetic during the temporary absence.

[3] Anaesthesia monitoring cannot be continues (witch means that we have to monitor the patient without any interruption) because we need to talk to surgeon, fill in a chart and so on Continual monitoring means that we monitor frequently (we cannot leave for one hour) by the rules we can stop monitoring for five minutes or less, but it could defer based on the surgery and the patient and whether it's general or local anaesthesia.

[4] If the patient is taking radiotherapy, to protect the anaesthesiologist he must monitor from a distance (like outside the room and he looks through a window or a camera) in case of events like hypotension or so they will stop the radiation and the anaesthesiologist can then enter the room.

Standard || " 2 " (what to monitor)

- During all anesthetics, the patient's oxygenation, ventilation, circulation and temperature should be continually evaluated.
- Frequency of mandatory monitoring varies between each category, but never exceeds five minutes, If not used, a reason should be recorded on the patient record.

The following are all specifically mandated:

1. **Oxygen analyzer:**
   - Most modern anesthesia machines monitor, both inspired and expired concentrations of O2
   - This is essential during anesthesia because it is possible to deliver a hypoxic gas mixture with a low inspired concentration limit alarm during general anesthesia when mixing O2, air, nitrous oxide, and/or volatile anesthetic agents.

2. **Quantitative assessment of blood oxygenation** Quantitative 3 things:
   1- Expired O2: if inspired O2 =100 and expired O2 =100 it means no consumption so this is bad
   If inspired O2 = 100 and expired O2 =10 also bad bc indicates too much use of O2 so there are tissue go unperfused
   2- Tidal volume: to know if I give enough
   3- CO2: it can give us idea about metabolism, is there change during anesthesia course
   (don't go into details)

3. **Ensuring adequate ventilation** during all anesthetic care including verification of expired oxygen (when possible), quantitative measurement of tidal volume, and capnography in all general anesthetics**.**

4. **Qualitative evaluation of ventilation** is required during all other care. The patient is breathing well not tachypneic and the color is pink "although pink color not always means normal"

5. **Ensure correct placement of endotracheal tube or laryngeal mask airway via expired carbon dioxide (CO2).**

6. **Alarms** for disconnects when a mechanical ventilator is used.

7. **Continuous display of ECG** became mandatory.

8. **Determination of arterial BP and heart rate at least every 5 minutes.**

9. **Adequacy of circulation** is to be determined by quality of pulse either electronically, through palpation, or auscultation

10. **The means to determine temperature** must be available and should be employed when changes in temperature are anticipated or intended.[5]

[5] it's from vitals, especially if the pt is 1 day old and room temp is 20 degree I should monitor pt bc he has risk of hypothermia > acidosis > arrest.

Pulse oximetry:

- Is one of the most commonly employed monitoring modalities in anesthesia that non-invasively monitor and provides quantitative analysis about the oxygenation of a patient's hemoglobin.
- A sensor with both red and infrared wavelengths is placed on the patient:
  - Red (660 nm absorbed by unoxygenated hemoglobin)
  - Infrared (940 nm absorbed by oxygenated hemoglobin)
- The ratio of Absorption of these wavelengths by the blood is measured and oxygen saturation (Sp02) can be calculated. This ratio was made from studies of healthy volunteers.[6]

  Oxygenated Hg absorb infrared light and reflect the red so we see it, De-oxygenated Hg absorb the red light and reflects the infrared. Sensors in the oximeter detect the amount of red and infrared light absorbed by the blood

➔ Two main types of oximetry. IMP

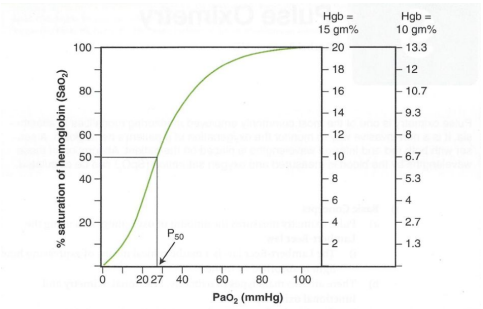
Fractional oximetry:	**Functional oximetry:**
Can only be measured by an arterial blood sample. **Measures**: oxyhemoglobin + deoxyhemoglobin + methemoglobin + carboxyhemoglobin and **arterial** oxygen saturation (SaO2)[7].	**Can be measured noninvasively by a standard pulse oximeter.** (oxyhemoglobin + deoxyhemoglobin) = (SpO2)[8] إذا أقدر من البلس ليش أسوي الارتريال؟ لأنه لو لاحظنا يقيس فقط نوعين هيموقلوبين وبتبقى نوعين هيموقلوبين زيادة

➔ Accuracy of the pulse oximeter:

- If the SpO2 is between 70% and 100%, the pulse oximeter is accurate to within 5%
- It is not accurate below 70% because calibration of the pulse oximeter involved healthy volunteers whose SpO2 did **not** routinely reach levels <70%.
- Best thing about the pulse oximeter is that it is **fast**, **non-invasive,** and **accurate**, unlike the fraction where we have to draw blood and check if it works or not

➔ Relationship between SaO2 and PaO2:

- Pulse oximetry is not as accurate in <u>low amplitude states</u>
- **Low perfusion** makes it difficult for the pulse oximeter to distinguish a true signal from background noise
  - State of low amplitude: hypovolemia , - hypothermia , - cardiac arrest , - arrhythmias, - Cardiac bypass , - vasoconstriction, - tourniquet, - BP cuff inflation..
- When we have hypoxia it's better to use fractional oximeter.



The oxygen dissociation curve showing the relationship between SpO_2 and PaO_2. P_{50} is the PaO_2 at which hemoglobin is 50% saturated with oxygen. The normal value is 27 mmHg. Adapted from Martin L. *All you really need to know to interpret arterial blood gases*. 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 1999.

The graph: paO2 must be 80 to be safe, paO2 of 27 is very bad, Saturation of haemoglobin must not be below 90%, If the patient's haemoglobin saturation was 100% initially then started to drop we don't wait for it to reach 90%,we have to act immediately.

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[6] Nail polish will affect the reading of the saturation monitor, that's way we must remove it.

[7] A blood-oxygen saturation reading indicates the percentage of hemoglobin molecules in the arterial blood which are saturated with oxygen. The reading may be referred to as SaO2

[8] The term SpO2 means the SaO2 measurement determined by pulse oximetry.

★ Dyshemoglobinemias:

- Pulse oximetry only accurately measures oxyhemoglobin and deoxyhemoglobin—all other forms of hemoglobin are not accurately measured
- Patients with sickle cell anemia presenting in a vaso-occlusive crisis can have an inaccurate SpO2 reading
- High levels of bilirubin do not alter SpO2 readings

➔ Carboxyhemoglobin

- Measured as: **90% oxyhemoglobin** and **10% deoxyhemoglobin**
- Thus, when there are high amounts of carboxyhemoglobin it will overestimate the SpO2 (false result of high O2)
- This is an important consideration in patients exposed to smoke or fire.

➔ Methemoglobin

- Absorbs **equal amounts** of red and infrared light so the **SpO2 will read 85%.**
- Methemoglobin is formed when iron goes from it's +2 ferrous form to the +3 ferric state. The ferric state of iron displays a left shift on the oxygen dissociation curve and releases oxygen less easily
- **Causes of Methemoglobin:**Nitrates, local anesthetic (benzocaine, hurricaine), chlorates, antimalarials, Antineoplastic, sulfonamides, dapsone, metoclopramide.

Capnography and Carbon dioxide (CO2):

Both Inspired and expired CO2 should be monitored:

Inspired CO2:	Expired CO2:
- Monitored to ensure that the CO2 absorber of the anesthesia machine is adequately removing all CO2 from the circuit. - If inspired CO2 is greater than zero, changing of the absorbent should be considered. The color of absorbent turns blue when its capacity is exhausted.	- Expired CO2 is frequently displayed through **capnography** with a displayed value correlating to the peak expired CO2 of each breath - Capnography Provides qualitative and quantitative information regarding expired CO2. **Quantitatively**, this is useful to ensure the endotracheal tube is within the respiratory tract as well as to ensure adequate cardiac output.[9]

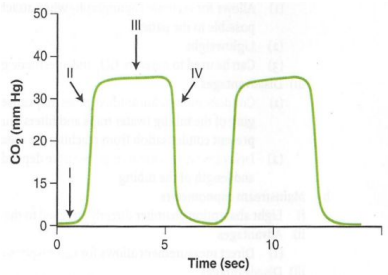
➔ Multiple expired gas analysis:

Allows determination of the percent inspired and expired of the volatile agents and nitrous oxide. This allows the ability to better determine the delivery of an adequate anesthetic without over or under dose.

[9]Expired CO2 will tell us about Cardiac Output, because cardiac muscle will output everything and circulate it in the blood, then the blood will come back to the lungs and exchange CO2 that was produced by the body tissue, if blood doesn't circulate, there will be no CO2 go out, so it will remain in the body IMP

➔ Capnography:

★ Normal Capnography:



a) Phase I: Initiation of expiration CO_2 free gas from anatomic dead space from trachea without any O_2

b) Phase II: Expiration of mixture of dead space and alveolar gas

c) Phase III: IMP phase! Alveolar plateau , CO_2-rich gas from alveoli

End tidal CO_2 confirm that intubation is inside the trachea

d)Phase IV or o: Inspiration.

★ Clinical uses of capnography

- Confirmation of endotracheal intubation
- Monitoring of adequacy of ventilation in controlled or spontaneously ventilating patients
- Noninvasive estimation of $PaCO_2$:
  - Assumes the normal 2 to 5 mm Hg difference between expired ($PETCO_2$) and arterial (in the awake state is present) if $PaCO_2$ is 37 then $PETCO_2$ will be less by 2 to 5 mm =(35-32) and vice versa.
  - The gradient between $PETCO_2$ and $PaCO_2$ may be increased with age,pulmonary disease, pulmonary embolus, low cardiac output, and hypovolemia because of decreased $PETCO_2$.[10]

★ Interpretation of abnormal capnograms

➔ Causes of decreased $PETCO_2$ "partial pressure of end-tidal carbon dioxide":

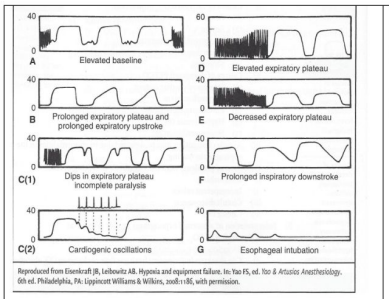
Decreased cardiac output, Hypovolemia, Pulmonary embolism, Hypothermia, Hyperventilation, so airway obstruction may be detected due to abnormalities in the capnography tracing

➢ **Interpretation** decreased CO_2 production: Decreased plateau height, may indicated decreased CO_2 production state or increased minute ventilation.

➔ Causes of increased CO_2 production:

Fever, Sepsis, Malignant hyperthermia, Hyperthyroidism, Shivering

➢ **Interpretation:** Elevated plateau height, indicates increased CO_2 production states other source of CO_2 (as in laparoscopic surgery), or inadequate minute ventilation.



If there is airway obstruction, the third phase will have an upstroke
in COPD the upstroke is always present.

In acute airway obstruction , the upstroke appear when the obstruction happens

➔ **Other Interpretations:**

➢ **Incompetent inspiratory valve:** Prolonged Phase III with elevation of baseline COz and plateau height

➢ **Esophageal intubation:** Initial presence of CO_2 followed by no CO_2

➢ **Rebreathing of CO_2:** Elevation in baseline CO_2 and Phase I

➢ **Obstruction to expiratory gas flow:** Prolonged Phase II +steeper Phase III slope.

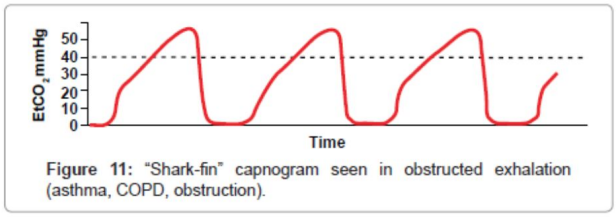


Figure 11: "Shark-fin" capnogram seen in obstructed exhalation (asthma, COPD, obstruction).

[10] يعني ببساطة لو قسنا ثاني اوكسيد الكربون من الدم يمكن نلقى نسبته في الحدود الطبيعية واذا قسناه من التنفس مفروض يكون أقل بشكل بسيط 2-5 مم بس بعض الحالات مثل المذكورة فوق يكون أقل بكثير ليش؟ لأن عنده مشاكل منعت ثاني اوكسيد الكربون يوصل من الدم إلى الرئة بالتالي نسبته بالدم طبيعية بس بالتنفس قليلة

Arterial blood pressure:

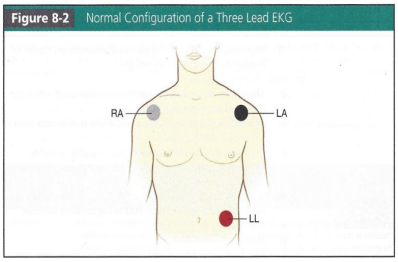
BP can be monitored invasively or non-invasively:

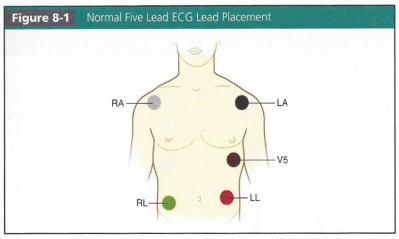
- The invasive methods is not a basic standard
- The standard one is Non-invasive methods which Include oscillometric cuff and rarely palpation, ausculatation and Doppler probe.

Temperature:

- Any general anesthetic requires temperature measurement, and the availability of temperature monitoring should be recorded.[11]
  - ➔ Very brief procedures may be an exception, but the availability of temperature monitoring should be recorded. The brief procedure is an exception which takes 10 ms and the patient is healthy you may not measure the temp unless the patient is 1 day old as we mentioned bc of the high risk of hypothermia and arrest.
- Measurement locations: skin, nasopharynx, esophageal, bladder, rectal, or a pulmonary arterial catheter.
  - ➔ Best way to monitor brain temperature is a nasopharynx tube, but we should be careful about nasal bleeding and it's contraindicated in trauma because of basal skull fracture.
- Core temperatures obtained from a pulmonary catheter, esophageal stethoscope, or rectal probe are preferable sources.
  - ➔ we usually measure core temp not the skin temp bc maybe the core temp is high but skin temp low bc of the vasoconstriction.

ECG (Electrocardiogram):





The minimum of three leads is to be used, although five leads are used for most adults. ECG 3 leads gives you 2 graphs from 2 angles, but ECG 5 leads is important bc it's more accurate and gives you more details so if something happens to the patient definitely you'll know.

- **The lead placement should be standard**
  - For 3 leads ECG: Left arm / Right Arm / Left Leg
    can be used to display leads I, II,and/or Ill
  - For 5 leads ECG: Left arm / Right Arm / Left Leg / Right leg / Chest
    can be used to display I, II, III, aVR, aVL, aVF, and/or V
- Lead placement is commonly altered for cases involving the chest, shoulders, back, and neck. Consideration must be taken for the surgical field and patient positioning: if surgery is in the chest like breast surgery, put it on the back and If the surgery is in the Abdomen, put it in leg.
  - There is a trick If you don't have 5 leads ECG and you only have 3 leads ECG and you want to know the chest lead (V5 lead) you can just move the LA lead from shoulder to the V5 position in the chest the fifth intercostal space at the anterior axillary line.
- The most commonly monitored leads and the most important 2 leads:
  - Lead II: best used to monitor **rhythm** because it provides the best visibility of the P wave
  - Lead V5: monitors for anterior and lateral ischemic events. Best chest lead to use is V5
- If an arrhythmia or ischemic event appears to be present, the ability to viewing all leads simultaneously may be helpful for diagnostic purposes.
- The new way to **read ECG read 1st ST segment** to know if there is any changes in the heart then check the rest of ECG

[11] In Some operations like aortic arch replacement we decrease body temp to 18 degree and stop completely the circulation BUT shouldn't exceeds certain time

Processed EEG and Awareness Monitoring:

Intraoperative awareness with recall is defined as a patient having an unexpected and undesirable recall of wakefulness and it involves explicit recall of sensory perceptions during general anesthesia including aspects of their surgical environment, procedure, and pain related to the intervention.
Processed EEG analysis has been developed as a method to monitor depth of anesthesia intraoperatively and can be used as an effect-site monitor to aid in titration of anesthetic drugs and may be useful in reducing the incidence of intraoperative awareness with recall.

- It's not acceptable nowadays to have intraoperative awareness, so it's imp to know if the patient awake or not, 1 MAC used to know if we give enough "inhalation" anesthesia or no, but if we give IV we can't know if it's enough or no, that's why we use EEG, but it needs high skills to analyze it while monitoring the patient so we need easier way with less time, and it is not a standard monitor, the probe is expensive, and it's not count with the OR budget, however doctor think that it is important and should be one of the standard monitors in future.

➔ Symptoms of Intraoperative awareness:

- The **most common** symptoms reported by patients suggesting awareness with recall are auditory perceptions such as voices or noises, followed by loss of motor function (inability to move, sensation of weakness, or paralysis), pain (last thing), and feelings of helplessness, anxiety, panic, impending death, or catastrophe.
- **Awareness with recall** can lead to anxiety, sleep difficulties, insomnia, irritability, nightmares, and posttraumatic stress disorder.
- Awareness occurs in approximately **1.14% to 1.5% of cardiac surgery cases**, **0.4% of obstetric cases**, and **11% to 43% of trauma surgeries**.[12]

➔ Risk factors of Intraoperative awareness:

- **light anesthesia** (e.g., delivering a low level of inhaled anesthetic minimum alveolar concentration)
- **History** of intra-operative awareness[13]
- **Chronic use of central nervous system depressants,** younger age, obesity
- **Inadequate** or misused anesthesia delivery systems.

➔ Detecting episodes of intraoperative awareness

Often it is **difficult** to know for sure that intraoperative awareness with recall occurred. If the patient is not asked specifically about it they may not report it voluntarily. Or, the patient may recollect hearing sounds during surgery, when in fact they are remembering something that occurred in the recovery room.

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[12] obstetric bc there are factors associated with hemodynamic and safety to the baby
لو عطيت تخدير ونزل الضغط وصار البيبي هايبوكسيك ما ينفع بالتالي نضطر نعطي تخدير اقل.
Trauma: the same in trauma they are hemodynamically unstable, I should give less anesthesia in order not to lower their BP furthermore
[13] maybe they are less sensitive to anesthesthetic drugs, as we said 1MAC is for 50% of population, the other 50% could have some kind of less responsive

➔ Prevention or vigilance for detecting intraoperative awareness:

a) Monitor delivered volatile anesthetic levels:

The unintended inadequate delivery of volatile anesthetic agents (light anesthesia) during maintenance of anesthesia may be avoided by the addition of a low alarm limit to end-tidal gas monitoring settings, as well as use of a "near empty" alarm in anesthetic vaporizers

إذا قرب يخلص الدواء يطلع تنبيه بالتالي يقدرون يعبونه مو إذا خلص ينبه

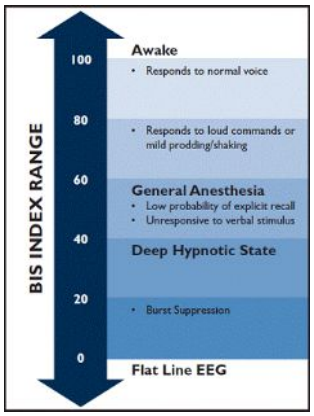
b) Monitor processed EEG signals:

➢ **Depth of anesthesia monitoring**, via the processed EEG, has proved useful in reducing the amount of anesthetic drugs, optimizing extubation times, and in some studies reducing awareness with recall. Although most anesthesiologists in the UK, USA, and Australia accept that clinical signs are unreliable indicators of awareness, few believe that monitors of anesthetic depths should be used for all routine cases

➢ Several brain-function monitors based on the processed electroencephalogram (EEG) or evoked potentials have been developed to **assess anesthetic depth:**

1- BIS (bispectral index) Aspect Medical Systems: "this name is the most imp thing to know here"

- The most widely used monitor is the BIS monitor. This device integrates several parameters of an EEG into a calculated, dimensionless variable (0 to 100).
- It is important to note that bispectral index (BIS) is a probability distribution where a measure of 40 does not provide a 100% guarantee of no awareness.
- The term bispectral applies because it incorporates both power and phase spectrums of an EEG into the calculated 0 to 100 value.
- BIS values between 40 and 60 purportedly indicate adequate general anesthesia for surgery, and values below 40 indicate a deep hypnotic state



- Targeting a range of BIS values between 40 and 60 is marketed to help prevent anesthesia awareness while allowing for minimization the anesthetic dose.

2. M-Entropy Module (GE-Healthcare).

A mathematical approach that quantifies EEG using non-linear dynamics. This mode measures spectral entropy and applies it to the power spectrum of EEGs. Two variables, state and response entropy, which measure EEG and combined EEG/EMG activity respectively, are displayed on the awareness monitor as a dimensionless unit (0 to 100)

3. Mid-latency auditory evoked potentials (MLAEP)s:

This method is thought to be an alternative to the use of EEG monitoring. MLAEP are electroencephalographic responses to auditory stimuli.

(the dr. read only the black points)

Neurophysiologic monitoring or neuromonitoring allows early detection of events that may increase postoperative neurological morbidity. The aim of monitoring is **to identify changes** in brain, spinal cord, and peripheral nerve function prior to irreversible damage. Neuromonitoring is also useful in identifying anatomical structures.

- **Electromyography (EMG)**

EMG is the recording of electrical activity of muscle and therefore an indirect indicator of function of the innervating peripheral nerve.
This technique is also used to identify and verify the integrity of a peripheral nerve, including cranial nerves as well as pedicle screw testing during spine surgery.
EMG is only sensitive to neuromuscular blocking agents.

- **Somatosensory evoked potentials (SSEP)**

SSEP are the recording, usually at the cerebral cortex, of responses from electrically stimulated peripheral afferent nerves.
The most commonly used peripheral nerves are median, ulnar, posterior tibial, and common peroneal nerves.

- **Brainstem auditory evoked potentials (BAEP)**

BAEP are the recording of brainstem responses to auditory stimuli.
BAEP monitors the function of the entire auditory pathway along the acoustic nerve, through the brainstem to the cerebral cortex.

- **Motor evoked potentials (MEP)**

MEP is the recording obtained from electrical stimulation of the motor cortex, which elicits potentials in the spinal cord or (myogenic) potentials from the innervated muscle.
Monitors motor pathway function.

- **Electroencephalography (EEG)**

- EEG monitoring can be a useful supplement to surgery when: Seizure foci need to be identified, The general state of cerebral metabolism needs monitoring, and Cerebral ischemia can occur
- EEG is a standard of care in many institutions for carotid endarterectomy.
- EEG is the recording of brain electrical activity and is highly dependent on anesthetic depth.
  - ➢ Alpha waves are rhythmically regular waves of 8 to 12 Hz seen in a lightly anesthesized patient
  - ➢ A faster, disorganized beta (>12 Hz) rhythm is seen upon awakening.
  - ➢ Slower theta waves (4 to 8 Hz) are seen with deep inhalation or moderate dose narcotic anesthesia.
  - ➢ Slow delta waves (<4 Hz) indicate deep anesthesia, or ischemia if the amplitude is low.

Cerebral Oximetry: the same principle of oximeter but for the brain, Usually we use it if the patient is elderly or has history of stroke

Cerebral oximetry uses Near InfraRed Spectroscopy (NIRS).
Using reflectance spectroscopy near infrared light is emitted by a probe on the scalp
Receptors are likewise positioned to detect the reflected light from both deep and superficial structures.
As with pulse oximetry, oxygenated and deoxygenated hemoglobin absorb light at different frequencies.
Likewise, cytochrome absorbs infrared light in the mitochondria.

- The NIRS saturation largely reflects the absorption of venous hemoglobin, as it does not have the ability to identify the pulsatile arterial component.
- Regional saturations of less than 40% on NIRS measures, or changes of greater than 25% of baseline measures, may herald neurological events secondary to decreased cerebral oxygenation.

Invasive pressure monitoring:

➔ Arterial: When we need to monitor the BP more frequently in patient who is prone to hypotension. allows for continuous beat to beat monitoring of arterial blood pressure displayed as a waveform and provides access for arterial sampling

- Arterial pressure is important bc it gives you faster result than the usual measure which takes 2-3 ms.
- Arterial blood pressure also provide you with a blood sample so you can do fractional analysis gases at the same time.

➔ Central Venous Pressure (CVP): US monitor the needle where to go exactly to be inserted in the correct place. It involves placement of a **sterile catheter** into one of the large central veins usually we use the **right internal jugular vein** and allows for multiple modalities of intervention along with the option of monitoring central venous pressure.

- CVP monitoring can be a useful tool for **evaluating intravascular volume and preload** in the absence of left ventricular (LV) dysfunction (ejection fraction <40%), severe mitral valve disease, pulmonary hypertension, or significant reduction in LV compliance (ischemia/ diastolic dysfunction).
- In normal heart: if body's hydration is adequate > left heart pressure will be high > reflects on CVP
- In heart failure or mitral regurgitation: patient even if he has volume depleted > left heart pressure will still be high > reflects on CVP "false value" (know it but don't go into details It's complicated)

➔ Pulmonary artery Pressure:

Pulmonary artery pressure: it measures both Right heart pressure as well as Left heart pressure so you will know everything about the heart that's why it's a better estimate, and it's usually done for cardiac patients

- The pulmonary artery (PA) catheter is a controversial but potentially powerful tool, offering information about **cardiac filling pressures**, **cardiac output (CO)**, derived parameters of **cardiac performance**, and **mixed venous oxygen saturation (Sv02).**
- ASA consensus opinion is that PA catheter monitoring may reduce perioperative complications if critical hemodynamic data obtained are accurately interpreted and appropriate treatment is instituted.
- Contraindicated in: complete LBBB and severe arrhythmia.

TransEsophageal Echocardiography (TEE):

- Is a monitoring modality gaining popularity in the field of anesthesiology due to its versatility, reliability, and safety.
- It was initially used as a **diagnostic tool primarily by cardiologists** (Cardiac output, valve problems and regional wall abnormalities) but has become a mainstay in intraoperative cardiac anesthesia and its utility is extending into other areas as well.

Central Nervous System Monitoring: (the dr. didn't read the grey points)

Peripheral Nerve Stimulation: it becomes a standard!

➔ Indications:

- Because of the variation in patient sensitivity to neuromuscular blocking agents, the neuromuscular function of all patients receiving intermediate- or long-acting neuromuscular blocking agents should be monitored.
- In addition, peripheral nerve stimulation is helpful in assessing paralysis during rapid-sequence inductions or during continuous infusions of short-acting agents.
- Furthermore, peripheral nerve stimulators can help locate nerves to be blocked by regional anesthesia.

➔ Contraindications:

- There are no contraindications to neuromuscular monitoring, although certain sites may be precluded by the surgical procedure.
- Additionally,atrophied muscles in areas of hemiplegia or nerve damage may appear refractory to neuromuscular blockade secondary to the proliferation of receptors.[14].
- Determining the degree of neuromuscular blockade using such an extremity could lead to potential overdosing of competitive neuromuscular blocking agents

➔ Techniques & Complications:

- Neuromuscular blockade is monitored during surgery to guide repeated doses of muscle relaxants
- The evoked mechanical or electrical response of the innervated muscle is observed.

- **Picture:** most commonly monitored.
  - ➢ Ulnar nerve stimulation of the adductor pollicis muscle and
  - ➢ Facial nerve stimulation of the orbicularis oculi

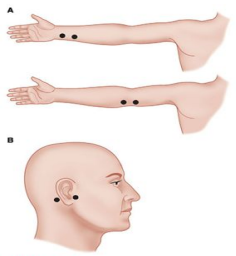
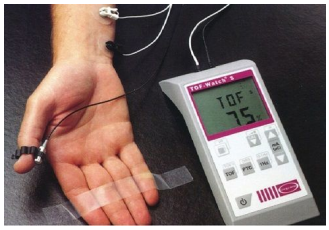


FIGURE 6–13 A: Stimulation of the ulnar nerve causes contraction of the adductor pollicis muscle. B: Stimulation of the facial nerve leads to orbicularis oculi contraction. The orbicularis oculi recovers from neuromuscular blockade before the adductor pollicis. (Reproduced, with permission, from Dorsch JA, Dorsch SE: *Understanding Anesthesia Equipment*, 4th ed. Williams & Wilkins, 1999.)

[14] ACh nicotinic receptors in the end motor plate muscle causes Action Potential that let the K goes out and Na goes in, In denervated muscle "atrophied": there are many ACh receptors, If we gave succinylcholine they will stimulate the release of K from every receptor and bc there are too many receptors there will be a massive K release from the cells to the blood "hyperkalemia" that may lead to arrest, important !

➔ Clinical Considerations:

- **Train-of-four stimulation** denotes four successive 200-µs stimuli in 2 sec (2 Hz).
  At induction we give muscle relaxant like NMJ blocker e.g. rocuronium and at the end we want to awake the patient but how to know when to do that? We do peripheral nerve stimuli to NMJ and get the response:
  - ➢ 1st twitch: very strong
  - ➢ 2nd twitch: weaker
  - ➢ 3rd twitch: much weaker
  - ➢ 4th twitch: the weakest
- The twitches in a train-of-four pattern progressively fade as nondepolarizing muscle relaxant block increases. The ratio of the responses to the first and fourth twitches is a sensitive indicator of nondepolarizing muscle paralysis. Ratio of fourth twitch over the first twitch should be greater than or equal to 90% to give the reversal (neostigmine and glycopyrrolate)
- The four twitches will not be the equal intensity in non-depolarizing muscle relaxant but it will be equal intensity with succinylcholine.
- Because it is difficult to estimate the train-of-four ratio, it is more convenient to visually observe the sequential disappearance of the twitches, as this also correlates with the extent of blockade. Disappearance of the fourth twitch represents a 75% block, the third twitch an 80% block, and the second twitch a 90% block. Clinical relaxation usually requires 75% to 95% neuromuscular blockade.
- Tetany at 50 or 100 Hz is a sensitive test of neuromuscular function. Sustained contraction for 5 sec indicates adequate but not necessarily complete reversal from neuromuscular blockade.
- Double-burst stimulation (DBS) represents two variations of tetany that are less painful to the patient, DBS is more sensitive than train-of-four stimulation for the clinical (ie, visual) evaluation of fade.
  - ➔ Single Twitch
  - ➔ Train of four
  - ➔ Double Burst Stimulation
  - ➔ Post Tetanic Count
- Because muscle groups differ in their sensitivity to neuromuscular blocking agents, use of the peripheral nerve stimulator cannot replace direct observation of the muscles (eg, the diaphragm) that need to be relaxed for a specific surgical procedure, Furthermore, recovery of adductor pollicis function does not exactly parallel recovery of muscles required to maintain an airway.
- The diaphragm, rectus abdominis, laryngeal adductors, and orbicularis oculi muscles recover from neuromuscular blockade sooner than do the adductor pollicis.
- Other indicators of adequate recovery include sustained (≥5 s) head lift, the ability to generate an inspiratory pressure of at least –25 cm H 2 O, and a forceful hand grip.
- Twitch tension is reduced by hypothermia of the monitored muscle group (6%/°C).
- Decisions regarding adequacy of reversal of neuromuscular blockade, as well as timing of extubation, should be made only by considering both the patient's clinical presentation and assessments determined by peripheral nerve stimulation.
- Postoperative residual curarization remains a problem in post-anesthesia care, producing potentially injurious airway and respiratory function compromise.
- Reversal of neuromuscular blocking agents is warranted, as is the use of intermediate acting neuromuscular blocking agents instead of longer acting drugs.



TEAM MCQs

435

1- which one of the following is the most sensitive to confirm the position of the endotracheal tube?

a) Chest x-ray
b) Continuous tracing of capnography
c) Use of esophageal detector device
d) Presence of mist in the tube

Answer: b

2- which one of the following considered ASA1 standard monitors?

a) Pulse oximetry
b) Capnography
c) Anesthesiologist presence
d) Blood pressure monitoring

Answer: C

3- Which one of the following is an indication of Bispectral index monitor?

a) Blood pressure
b) Oxygenation
c) Ventilation
d) Depth of anesthesia

Answer: D

4- Which one of the following is the indication of using capnography?

a) Ventilator disconnection
b) Oxygen consumption
c) Depth of anesthesia
d) Temperature

Answer: A