Reviewed By
RAAOUM M. JABOR

5- Monitoring During Anesthesia

Objectives

At the end of the lecture you will be able to know the basics of anesthetic monitoring as follows:

- Definition
- What, When, How to monitor
- The policies that govern modern monitoring (Standards I and Standards II)
- The basic monitors and the advanced monitors
- Arterial Oxygen Saturation- SpO2
- Expired CO2- ETCO2
- Awareness under anesthesia
- Means to monitor the wakeful state of the brain
- Other somatosensory and motor monitoring
- Brief introduction about invasive hemodynamic monitoring and oxygenation of the brain
- The neuromuscular junction relaxation monitoring

Color Index:

- Main Text
- 41 Doctor's notes
- 39 Doctor's notes
- Reference
- Important
- Golden notes
- Extra

Editing file

Case discussion

What Is Anesthetic Monitoring?

Definition

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

What do you Monitor in a patient?

- Vitals: blood pressure, heart rate, respiratory rate and temperature
  Q: What vital sign had nowadays been measured very frequently ?
  A: temperature in public areas during the pandemic which was neglected in the past.
- Color/skin Especially if you are resuscitating where you don't have a pulse oximeter present
- Wakefulness state By communicating with the pt & see if he's responding or not .

How & By Which Means Do You Monitor In A Patient?

- Physical exam.
- Equipments (advances in technology).

Where do you monitor a patient?

- Hospital vs Out-of-Hospital setting.
- Safe vs Dangerous place (biologic, electric, chemical hazards, radioactive, infectious areas etc...).

What determines the Standards of Care for monitoring a patient (What are you responsible for?)

Depends on:

- Equipments/technology Now a days we can use ECG and SpO2 regularly for all patients not only for critical patients.
- Patient/illness
- Place: In-hospital Vs Out-of hospitals In hospital you're responsible for monitoring everything but if you're Out of hospital you won't be responsible for monitoring pulse oximeter or BP because you won't have the necessary equipment.
- Rules/legislation: every institution or hospital may have its own policies that are based on evidence. Or adopted other national and international policies.

Standards For Anesthetic Monitoring

Theses Standards:

Apply to all anesthesia care although, in emergency circumstances, appropriate life support measures take precedence So for example you may skip the temperature monitoring during the initial phases of ACLS or PALS. We'll give priority to chest compression & ventilation over temperature for example.	Brief interruptions of continual monitoring may be unavoidable anesthesia care - So you may not be able to monitor and document "continuously at every second interval". Hence the term "Continual" instead of "Continuous" "continual" is defined as "repeated regularly and frequently in steady rapid succession Every 1 or 2 hrs in ICU and every 8 hrs in the ward. "continuous" means "prolonged without any interruption at any time." **in anesthesia the frequency of monitoring never exceed 5 minutes (imp)**
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
They apply to all general anesthetics, regional anesthetics and monitored anesthesia care (like sedation).	May be exceeded at any time based on the judgment of the responsible anesthesiologist

Standard I: **Why the frequency of anesthetic monitoring shouldn't exceed 5 mins?**

01

Qualified anesthesia personnel shall be present 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:

- Bleeding
- Brain ischemia Difficult to detect it immediately.
- Hypothermia
- Anaphylaxis
- Hypoperfusion to vital organs Difficult to detect it immediately.
- Neuro Depression / respiratory depression
- Cardiac Depression / alteration in BP, CO
- Acid and blood gases, fluid and electrolyte imbalance
- Myocardial infarction, acute heart failure and arrhythmias
- Vasodilation: low BP affects perfusion to vital organs, low oxygen affect metabolism of organs

02

If 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, via tele monitoring (cameras to the patient and monitor or satellite monitor out of the radiation area).

03

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 If the pt in the OR is stable you can go and make a resident monitor but if the pt is unstable let the resident go and you stay to monitor and resuscitate the pt.

Standards For Anesthetic Monitoring

Standard II:

During all anesthetics, the patient's oxygenation, ventilation, circulation and temperature shall be continually evaluated.

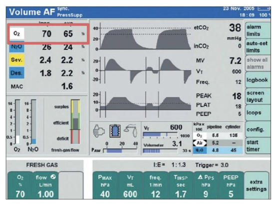
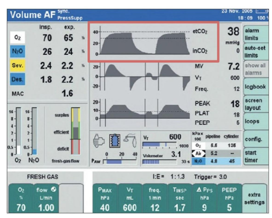
Q: Brief interruptions of monitoring may be unavoidable. So how frequent should it be? (as stated in Standard II)
A:

- On the **general ward**, documenting vitals routinely would be **every 8 hours** or every nursing team shift.
- In closed observation units (**intensive care unit**) documenting patient's status would be at least every **one hour** or more frequently as per patient's condition.

- **during surgical anesthesia** Frequency of mandatory monitoring varies between each category, but **never exceeds five minutes**. Otherwise, a reason should be documented on the patient's record (for medico-legal purposes).

The following are all specifically mandated[1]:

Standard ASA monitors: Heart rate, blood pressure, ECG, pulse oximetry, capnography, temperature; and inspired and exhaled concentrations of oxygen

First	**Oxygen analyzer** with a low inspired concentration limit alarm during general anesthesia. **Most modern anesthesia machines monitor both inspired and expired concentrations of O_2.** This is essential during anesthesia because it is possible to deliver a hypoxic gas mixture when mixing O_2, air, nitrous oxide, and/or volatile anesthetic agents.	
Second	**Quantitative assessment of blood oxygenation.** **Pulse Oximetry**: Provides quantitative analysis of the patient's saturation of hemoglobin with O_2.	
Third[2]	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.	
Fourth	**Quantitative evaluation of ventilation** is required during all other care. • Inspired and expired CO_2 should be monitored. • Expired CO_2 is frequently displayed through capnography with a displayed value correlating to the peak expired CO_2 of each breath.	Capnography 
Fifth[3]	Ensure **correct placement** of endotracheal tube or laryngeal mask airway **via expired carbon dioxide (CO_2). Observation of bilateral chest movement** and **air entry**, as well as **auscultation** of the chest is also necessary[4]. Do not Rely only on the equipment, you have to observe chest movement.	

1- Basic monitors.
2- End tidal volume is the most accurate and important value of CO2, it can determine many things including cardiac output.
3- If tube is in the airway, the CO2 will come out but if it's in the esophagus there will be no CO2 coming out, there will be residual CO2 coming in the primary basis first two cycles then it will stop so it's important to monitor the CO2 for a while after you intubate.
4- Because end tidal CO2 might not detect that we are in one lung or two lungs ventilation.

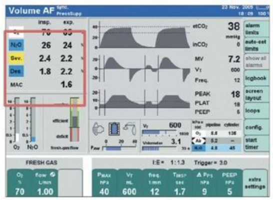
Standards For Anesthetic Monitoring

Sixth	**Alarms** for breathing circuit disconnection or leak when a mechanical ventilator is used. Also we use alarms for BP.
Seventh	Continuous display of **ECG**.
Eighth	Determination of **arterial BP** and **heart rate** at least every 5 minutes.
Ninth[1]	**Adequacy of circulation** is to be determined by quality of pulse either electronically, through palpation, or auscultation.
Tenth[2 3]	The means to determine **temperature** must be available and should be employed when changes in temperature are anticipated or intended.

Modalities for Anesthetic Monitoring

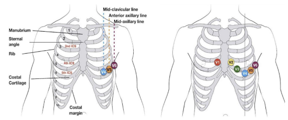
Multiple Expired Gas Analysis

- 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[4].



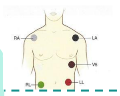
ECG

- Minimum of three leads is to be used, although five leads are used for most adults.
- Consideration must be taken for the surgical field and patient positioning.
- Lead placement is commonly altered for cases involving the chest, shoulders, back, and neck.



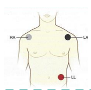
External chest landmark for the V leads

More useful



Five Lead ECG[5]

right arm (RA), left arm (LA), right leg (RL), left leg (LL), and V display I, II, III, aVR, aVL, aVF, and/or V.



Three lead ECG

Includes the RA, LA, and LL leads and can be used to display leads I, II, and/or III, Can be modified to display V5 by moving the LA lead to the V5 , position in the fifth intercostal space at the anterior axillary line.

1- For example if the pt is having hypotension you check if there is problem with the machine or if it's true situation but be careful not to press to hard in the carotids.
2- In cardiac surgeries or in ACLS when the pt doesn't recover well you induce hypothermia up to 32 C to protect organs.
3- In cardiac surgery we stop the blood circulation completely and there is no blood flow so we keep temperature at 18c before let blood recirculate again to prevent tissue damage.
4- If it's decreased it will cause awareness during anesthesia / if increased the pt may not wake up as it supposed to be because there is still anesthetics in his system. So it can tell you when the pt will waking up
5- You can detect any ischemic event by 100%, very important in any suspected MI patients.

Numbers not important just understand it.

Sensitivity of Various Lead Combinations for Detecting Ischemia

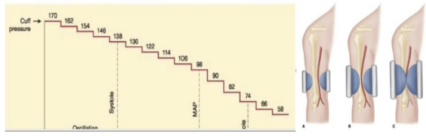
London et al.		Landesberg et al.	
$II + V_2 + V_3 + V_4 + V_5$	100%		
$V_4 + V_5$	90%	$V_3 + V_5$	97%
$II + V_5$	80%	$V_4 + V_5$	92%
$II + V_4 + V_5$	96%	$V_3 + V_4$	100%
Single leads V_5, V_4, and V_3	75%, 61%, and 24%, respectively	Single leads V_5, V_4, and V_3	75%, 83%, and 75%, respectively

Modalities for Anesthetic Monitoring

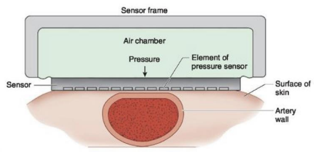
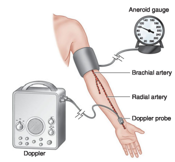
ECG

- The most commonly monitored leads are **II and V5**
- **Lead II** is best used to monitor rhythm because it provides the best visibility of the P wave **(lead II best is the for detecting arrhythmia)**
- **V5 monitors for anterior and lateral ischemic events**
- If an arrhythmia or ischemic event appears to be present, the ability to view all leads simultaneously may be helpful for diagnostic purposes.

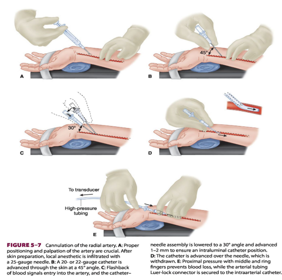
Arterial blood pressure



- BP can be monitored non-invasively or invasively
- Non-invasive methods include oscillometric cuff, and rarely palpation, auscultation, Doppler probe.
- **Automatic oscillometric:**

The cuff (Skipped by Dr)	Placement (Skipped by Dr)	Patient positioning (Skipped by Dr)
is able to sense oscillations in cuff pressure which correlate with arterial pulsation.  FIGURE 5–5 Tonometry is a method of continuous (beat-to-beat) arterial blood pressure determination. The sensors must be positioned directly over the artery.	1. Each cuf is labeled with an arrow pointing to where arterial pulsation is felt best. 2. The cuff is then placed on the arm over the brachial artery, forearm over the radial artery, or thigh/calf over the popliteal artery.	When monitoring non-invasive pressure, consideration must be taken of patient position.  FIGURE 5–3 A Doppler probe secured over the radial artery will sense red blood cell movement as long as the blood pressure cuff is below systolic pressure. (Reproduced, with permission, from Parks Medical Electronics.)

- **Invasive pressure monitoring:**
  - Arterial : allows for continuous beat to beat monitoring of arterial blood pressure displayed as a waveform and provides access for arterial sampling. Important in critical pts it can detect immediate changes before the pt become ischemic.
  - **Radial is the most preferred artery to use**

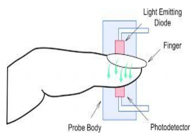


Temperature

- Temperature changes should be anticipated and expected under any general anesthetic and therefore any general anesthetic requires temperature measurement.
- **Very brief procedures** may be an exception, but the availability of temperature monitoring should be recorded.
- **Temperature may be measured from many locations including:**
  - skin, nasopharynx, esophageal, bladder, rectal, pulmonary arterial catheter.
- **Core temperatures obtained preferably from:**
  - pulmonary catheter, esophageal probe, or rectal probe.
- It's mandatory monitor in neonates and infants it can detect neonatal arrest and acidosis.
- It's important especially in neonates and elderly.

Modalities for Anesthetic Monitoring

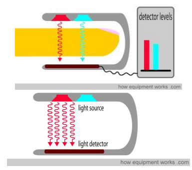
Pulse oximetry (SpO_2)



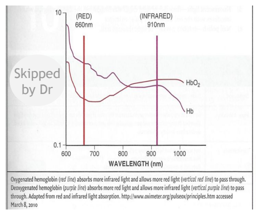
- Is one of the most commonly employed monitoring modalities in anesthesia.
- It is a non-invasive way to monitor the oxygenation of a patient's hemoglobin.
- A sensor with both red and infrared wavelengths is placed on the patient.
- Absorption of these wavelengths by the blood is measured and oxygen saturation (SpO_2) can be calculated.
- ***There are two main types of oximetry :***

Fractional oximetry SaO_2	Functional oximetry SpO_2
Oxyhemoglobin/(oxyhemoglobin + deoxyhemoglobin + methemoglobin + carboxyhemoglobin).	Oxyhemoglobin/(oxyhemoglobin + deoxyhemoglobin).
Can only be measured by an **arterial blood sampling.**	Can be measured noninvasively by a standard **pulse oximeter.**
	

How pulse oximetry works?



- A pulse oximeter emits two wavelengths of light: red (660 nm) and infrared (940 nm).
- Deoxyhemoglobin absorbs more light in the red and reflect less **red**, so it's color is **darker red**.
- Oxyhemoglobin absorbs more light in the infrared and reflect more red, so it's color is red.
- Do not shine any light to the oximetry detector, it will falsify the reading.



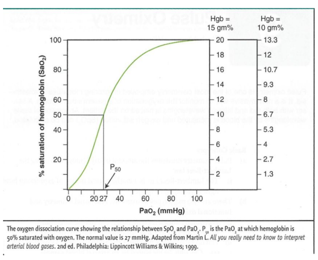
Accuracy of the pulse oximeter

The calibration to deliver SpO_2 from $(AC/DC)_{940}$ ratio was made from studies of healthy volunteers

- **If the SpO_2 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 SpO_2 did not routinely reach levels <70%.
- If it's low value you can't rely on oximetry result, you have to do arterial blood gases.
- when Spo2 is (90%) start to intubate the patient, don't wait to be (85%) because it danger to the pt.
- Spo2 (< 85%) is alarming value.

For the relationship between SaO_2 and PaO_2

- The absorption spectrum of deoxygenated hemoglobin is very steep at 600 nm in the red range so small changes in the amount of deoxyhemoglobin can cause very wide variances in SpO_2



SaO2 %	PaO2 mmHg
99	175
95	80
94	70
90	60
85	50
80	45
75	40
70	37
65	34
60	31
55	29
50	27
45	25
40	23

TABLE 1. Values for standard human blood O_2 dissociation curve at 37°C, pH = 74, extrapolated between data in [7].

PO_2	%Sat	PO_2	%Sat	PO_2	%Sat
1	0.60	34	65.16	80	95.84
2	1.19	36	68.63	85	96.42
4	2.56	38	71.94	90	96.88
6	4.37	40	74.69	95	97.25
8	6.68	42	77.29	100	97.49
10	9.58	44	79.55	110	97.91
12	12.96	46	81.71	120	98.21
14	16.89	48	83.52	130	98.44
16	21.40	50	85.08	140	98.62
18	26.50	52	86.59	150	98.77
20	32.12	54	87.70	175	99.03
22	37.60	56	88.93	200	99.20
24	43.14	58	89.95	225	99.32
26	48.27	60	90.85	250	99.41
28	53.16	65	92.73	300	99.53
30	57.54	70	94.06	400	99.65
32	61.69	75	95.10	500	99.72

Which of the following IV drugs makes the measurement of pulse oximetry unreliable?
Methylene blue

Modalities for Anesthetic Monitoring

Accuracy of the pulse oximeter

- Pulse oximetry is affected by: low amplitude state and dyshemoglobinemia.
- Patients with **sickle cell anemia** presenting in a vaso occlusive crisis can have an inaccurate SpO_2 reading.
- Pulse oximetry is not as accurate in low amplitude states (low BP).
- Low perfusion makes it difficult for the pulse oximeter to distinguish a true signal from background noise.

- Arrhythmias
- Vasoconstriction
- BP cuff inflation
  Occlude the artery for a while when used. So, a problem will be shown in the oximetry
- Cardiac Bypass
- Hypovolemia
- Cardiac arrest
- Hypothermia
- Tourniquet

Dyshemoglobinemia

- Pulse oximetry only accurately measures oxyhemoglobin and deoxyhemoglobin -**all other forms of hemoglobin are <u>not</u> accurately measured.**

- Carboxyhemoglobin is measured as 90% oxyhemoglobin and 10% deoxyhemoglobin. Thus, when there are high amounts of carboxyhemoglobin it will overestimate the SpO_2. This is an important consideration in patients exposed to **smoke or fires.**

- Methemoglobin absorbs equal amounts of red and infrared light **so the SpO_2 will read 85%.**
- **The pulse oximetry will give higher percentage of oxygen saturation in carbon monoxide poisoning**

- Methemoglobin is formed when iron goes from it's +2 ferrous form to the +3 ferric state.

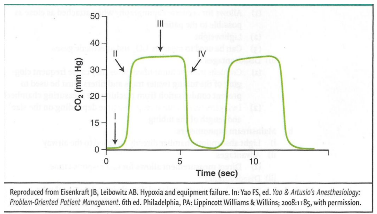
- The ferric state of iron displays a left shift on the oxygen dissociation curve and releases oxygen less easily.

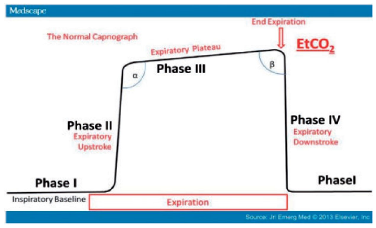
Methemoglobinemia can be caused by many drugs:

- Nitrates/ Nitrites
- Local anesthetics (eg. Benzocaine)
- Chlorates
- Antimalarials
- Antineoplastics
- Sulfonamide & Dapsone (antibiotic)
- Metoclopramide (antiemetic)

Modalities for Anesthetic Monitoring

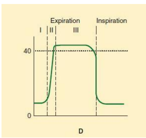
Capnography (measures how CO2 is changing)





- **Phase I**: Initiation of expiration, CO_2 free gas from anatomic dead space (trachea)
- **Phase II**: Expiration of mixture of dead space and alveolar gas
- **Phase III:** Alveolar plateau, CO_2-rich gas from alveoli (plateau phase)
- **Phase IV or 0:** Inspiration (no more CO2)

Clinical Uses of Capnography:

inspired CO_2 it provides:	Expired CO_2 it provides:	
Quantitative information	Qualitative information	Quantitative information
Ensure that the patient is not breathing back any CO_2 from the anesthesia ventilator, that would be a cause of respiratory acidosis. Otherwise CO_2 absorber of the anesthesia machine should be exchanged[1]. 	• **Ensure the endotracheal tube is within the respiratory tract** • Indicates adequacy of breathing in spontaneously ventilating non-intubated patients[2].	• **Ensure adequate cardiac output information**[3]. • **Indicate adequacy of ventilating** intubated patients[4]. • Non-invasive estimate of $PaCO_2$: assumes the 2-5 mmHg difference between expired (PETCO2) and arterial

The gradient between PETCO2 and $PaCO_2$ may be increased with age, pulmonary disease, pulmonary embolism, low cardiac output, and hypovolemia.
Detection of Patient Disease:

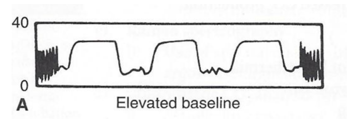
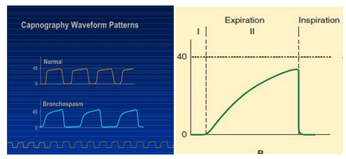
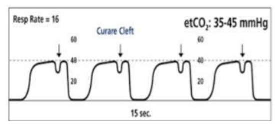
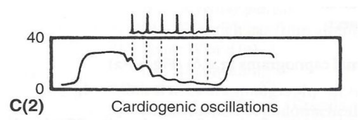
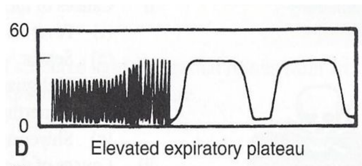
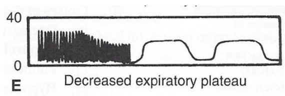
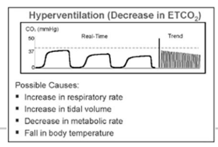
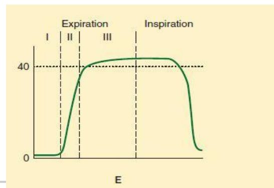
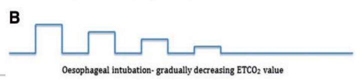
Causes increased CO_2 production	Causes of decreased PETCO2
Fever, sepsis, **malignant hyperthermia**[6], hypoventilation (CO_2 accumulation), hyperthyroidism (increase metabolism)shivering.	↓ cardiac output (↓ metabolism), hypovolemia, **pulmonary embolism sudden ↓ in saturation,** hypothermia and **hyperventilation**.
 Typical $ETCO_2$ trace in hypoventilation or rarely malignant hyperpyrexia	 Sudden drop in $ETCO_2$- represents reduction in pulmonary blood flow i.e. drop in cardiac output, pulmonary embolus

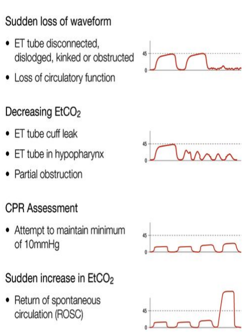
- **Detection of problems with the anesthetic breathing system:** Rebreathing of CO_2, Incompetent valves, **Circuit disconnect** and Circuit leak.

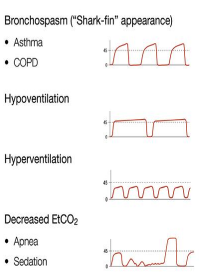
1- As it might be malfunctioning or exhausted causing the pt to rebreath CO2.
2- You want to make sure that your intubation is not too deep to the point that the patient stops breathing spontaneously.
3- CO2 is the end product of metabolism, so if there is adequate CO2 = adequate metabolism = adequate cardiac output.
4- If the value of CO2 is too high it means we're hypoventilating the pt but if it's too low then we're washing too much CO2 and hyperventilating the pt.
5- For example if the PETCO2 is 32 then PaCO2 will be between 34-37.
6- CO2 will start to increase and never drop we have to manage the pt immediately by cooling the pt & giving muscle relaxants or he will suffocate & die.

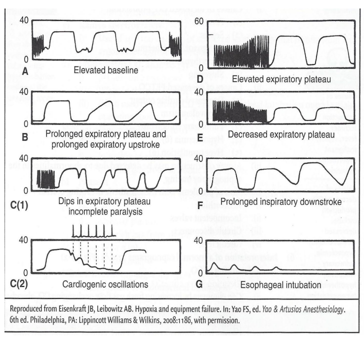
Modalities for Anesthetic Monitoring

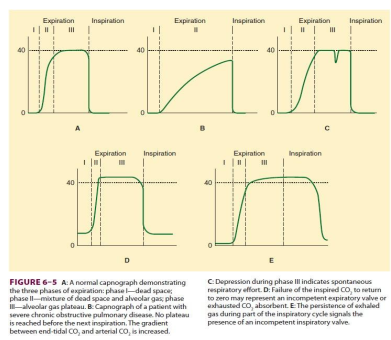
Interpretation of abnormal capnograms

Rebreathing of CO_2	• Elevation in baseline CO2 and Phase I. • Can be eliminated by increasing fresh gas low or changing CO_2 absorber.	
Obstruction to expiratory gas low	• Prolonged Phase II and steeper Phase III slope[1]. • Occurs with bronchospasm, COPD, kinked endotracheal tube.	
Curare Cleft	• Dip in Phase III. • Indicates return of spontaneous respiratory efforts.	
Cardiogenic oscillations	• Oscillations of small gas movements during phase III and IV (or 0). • Produced by aortic and cardiac pulsations.	
Increased CO_2	• Elevated plateau height. • Indicates increased CO_2 production states • Other sources of CO_2 (as in laparoscopic surgery[2]), or inadequate minute ventilation.	
Decreased measured CO_2	• Decreased plateau height. • May indicates decreased CO_2 production states or increased minute ventilation.	
Incompetent inspiratory valve	• Prolonged Phase III with elevation of baseline CO_2 and plateau height. • Results in rebreathing. • May be difficult to detect without simultaneous analysis of low waveforms.	
Esophageal intubation:	• Initial presence of CO_2 followed by no CO_2[3].	
Dr Note	1- Phase III is not flat it rising up. 2- CO2 inside the abdomen→ dissolve into blood→ go to the lung → rise in CO2. 3- Because there's no source of CO2 in the stomach, you have to manage the patient and re-intubate the patient adequately. 4- When you're resuscitating someone with ACLS you get sudden increase which means the heart took over and returned to spontaneous circulation→ adequate cardiac output→ adequate CO2.	









Intraoperative Awareness With Recall

- **Intraoperative awareness with recall is defined as** a patient having an unexpected and undesirable recall of wakefulness.

- **Intraoperative awareness with recall involves** explicit recall of sensory perceptions during general anesthesia including aspects of their surgical environment, procedure, and even pain related to the intervention.

- **Processed EEG analysis** has been developed as a method to monitor depth of anesthesia intraoperatively in titration of anesthetic drugs and may be useful in reducing the incidence of intraoperative awareness with recall.

Symptoms

- Auditory perceptions such as voices or noises (most common) Voices & noises should be controlled as much as possible so that if the pt had intraoperative awareness he will suffer less.
- loss of motor function (inability to move, most common sensation of weakness, or paralysis)
- pain
- anxiety & panic
- catastrophe
- feelings of helplessness
- impending death

Awareness with recall can lead to

anxiety, sleep difficulties culties, insomnia, irritability, nightmares, and posttraumatic stress disorder.

Incidence of awareness

- The incidence of awareness with recall varies among studies, countries, anesthetic techniques, patient characteristics, and types of surgery.

- The most commonly cited rate of intra-operative awareness is 0.2%. This figure is thought to reflect the incidence in routine cases but not including cardiac or obstetric surgeries.

Routine surgeries	0.2%
Cardiac surgeries	1.14-1.5%
Obstetric surgeries	0.4%
Awareness with recall associated with pain	0.01-0.03%
Trauma surgeries Because traumatic patient they already Hypotensive due to bleeding, so we avoid to give them too much medication (to avoid severe hypotension & ischemia) and this can lead to awareness.	11-43%

Intraoperative Awareness With Recall

Factors associated with increased risk of awareness with recall

1. younger age
2. history of intra-operative awareness
3. chronic use of central nervous system depressants
4. obesity
5. inadequate or misused anesthesia delivery systems
6. "light" anesthesia[1] e.g., delivering a low level of inhaled anesthetic minimum alveolar concentration[2]

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.**
One accepted method to assess intraoperative awareness with recall is to conduct three structured interviews with open ended questions at intervals of 24 hours, between 24 and 72 hours, and at 30 days after surgery[3] (awareness may not arise until days to weeks postoperatively).

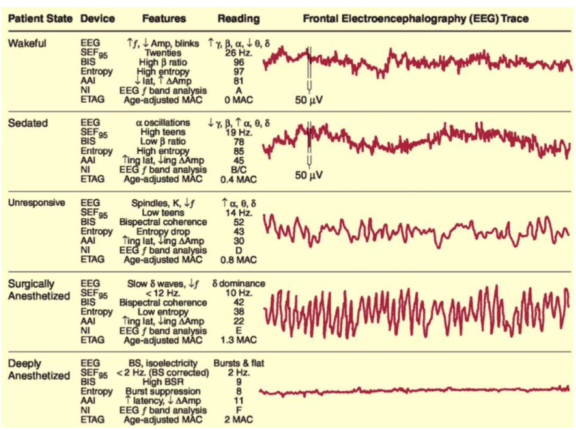
Prevention or vigilance for detecting intraoperative awareness

- **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.

- **Monitor processed EEG signals** It is expensive so we use it only for high-risk patients.

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.



Patient State	Device	Features	Reading	Frontal Electroencephalography (EEG) Trace
Wakeful	EEG	↑f, ↓ Amp, blinks	↑ γ, β, α, ↓ θ, δ	
	SEF_{95}	Twenties	26 Hz.	
	BIS	High β ratio	96	
	Entropy	High entropy	97	
	AAI	↓ lat, ↑ ΔAmp	81	
	NI	EEG f band analysis	A	
	ETAG	Age-adjusted MAC	0 MAC	50 μV
Sedated	EEG	α oscillations	↓ γ, β, ↑ α, θ, δ	
	SEF_{95}	High teens	19 Hz.	
	BIS	Low β ratio	78	
	Entropy	High entropy	85	
	AAI	↑ing lat, ↓ing ΔAmp	45	
	NI	EEG f band analysis	B/C	
	ETAG	Age-adjusted MAC	0.4 MAC	50 μV
Unresponsive	EEG	Spindles, K, ↓f	↑ α, θ, δ	
	SEF_{95}	Low teens	14 Hz.	
	BIS	Bispectral coherence	52	
	Entropy	Entropy drop	43	
	AAI	↑ing lat, ↓ing ΔAmp	30	
	NI	EEG f band analysis	D	
	ETAG	Age-adjusted MAC	0.8 MAC	
Surgically Anesthetized	EEG	Slow δ waves, ↓f	δ dominance	
	SEF_{95}	< 12 Hz.	10 Hz.	
	BIS	Bispectral coherence	42	
	Entropy	Low entropy	38	
	AAI	↑ing lat, ↓ing ΔAmp	22	
	NI	EEG f band analysis	E	
	ETAG	Age-adjusted MAC	1.3 MAC	
Deeply Anesthetized	EEG	BS, isoelectricity	Bursts & flat	
	SEF_{95}	< 2 Hz. (BS corrected)	2 Hz.	
	BIS	High BSR	9	
	Entropy	Burst suppression	8	
	AAI	↑ latency, ↓ ΔAmp	11	
	NI	EEG f band analysis	F	
	ETAG	Age-adjusted MAC	2 MAC	

TABLE 6–2 Checklist for preventing awareness.

- ✓ Check all equipment, drugs, and dosages; ensure that drugs are clearly labeled and that infusions are running into veins.
- ✓ Consider administering an amnesic premedication.
- ✓ Avoid or minimize the administration of muscle relaxants. Use a peripheral nerve stimulator to guide minimal required dose.
- ✓ Consider using the isolated forearm technique if intense paralysis is indicated.
- ✓ Choose potent inhalation agents rather than total intravenous anesthesia, if possible.
- ✓ Administer at least 0.5 to 0.7 minimum alveolar concentration (MAC) of the inhalation agent.
- ✓ Set an alarm for a low anesthetic gas concentration.
- ✓ Monitor anesthetic gas concentration during cardiopulmonary bypass from the bypass machine.
- ✓ Consider alternative treatments for hypotension other than decreasing anesthetic concentration.
- ✓ If it is thought that sufficient anesthesia cannot be administered because of concern about hemodynamic compromise, consider the administration of benzodiazepines or scopolamine for amnesia.
- ✓ Supplement hypnotic agents with analgesic agents such as opioids or local anesthetics, which may help decrease the experience of pain in the event of awareness.
- ✓ Consider using a brain monitor, such as a raw or processed electroencephalogram but do not try to minimize the anesthetic dose based on the brain monitor because there currently is insufficient evidence to support this practice.
- ✓ Monitor the brain routinely if using total intravenous anesthesia.
- ✓ Evaluate known risk factors for awareness, and if specific risk factors are identified consider increasing administered anesthetic concentration.
- ✓ Redose intravenous anesthesia when delivery of inhalation anesthesia is difficult, such as during a long intubation attempt or during rigid bronchoscopy.

Reproduced, with permission, from Mashour GA, Orser BA, Avidan

1- MAC targets 50% of the population, if you give only 1 MAC it will target 50% of the population and the other 50% might go to awareness.
2- For example if the pt has hypotension and we need to decrease the anesthetic.
3- We don't do it in every patient, just if we suspect anything happened or if the patient complains.

Processed EEG and Awareness Monitoring

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

01 BIS bispectral index scale
Aspect medical system

BIS monitor is the most widely used monitor in detecting patients awareness and depth of anesthesia .

This device integrates several parameters of an EEG into a calculated, dimensionless variable (0 to 100). BIS is a probability distribution where a measure 40 does not provide a 100% guarantee of no awareness.

- The term bispectral applies because it incorporates both power & phase spectrum of an EEG into the calculated 0 to 100 value.

- **Values:**
1. BIS values between 40 and 60 purportedly indicate adequate general anesthesia for surgery
2. 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.

Skipped by Dr

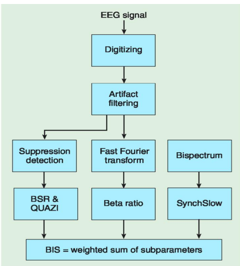


FIGURE 6–9 Calculation of the Bispectral Index. EEG, electroencephalogram; BSR, burst suppression ratio; BIS, Bispectral Index Scale. (Reproduced, with permission, from Rampil IJ: A primer for EEG signal processing in anesthesia. Anesthesiology 1998;89:980.)

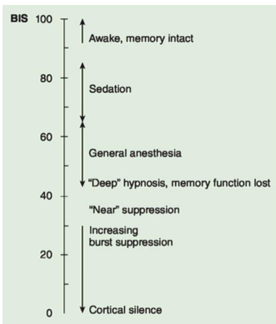
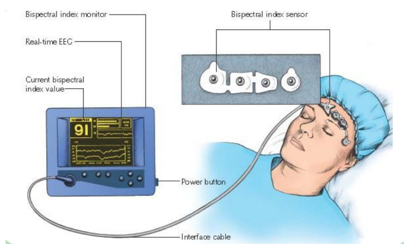


TABLE 6–2 Checklist for preventing awareness.

- ✓ Check all equipment, drugs, and dosages; ensure that drugs are clearly labeled and that infusions are running into veins.
- ✓ Consider administering an amnesic premedication.
- ✓ Avoid or minimize the administration of muscle relaxants. Use a peripheral nerve stimulator to guide minimal required dose.
- ✓ Consider using the isolated forearm technique if intense paralysis is indicated.
- ✓ Choose potent inhalation agents rather than total intravenous anesthesia, if possible.
- ✓ Administer at least 0.5 to 0.7 minimum alveolar concentration (MAC) of the inhalation agent.
- ✓ Set an alarm for a low anesthetic gas concentration.
- ✓ Monitor anesthetic gas concentration during cardiopulmonary bypass from the bypass machine.
- ✓ Consider alternative treatments for hypotension other than decreasing anesthetic concentration.
- ✓ If it is thought that sufficient anesthesia cannot be administered because of concern about hemodynamic compromise, consider the administration of benzodiazepines or scopolamine for amnesia.
- ✓ Supplement hypnotic agents with analgesic agents such as opioids or local anesthetics, which may help decrease the experience of pain in the event of awareness.
- ✓ Consider using a brain monitor, such as a raw or processed electroencephalogram but do not try to minimize the anesthetic dose based on the brain monitor because there currently is insufficient evidence to support this practice.
- ✓ Monitor the brain routinely if using total intravenous anesthesia.
- ✓ Evaluate known risk factors for awareness, and if specific risk factors are identified consider increasing administered anesthetic concentration.
- ✓ Redose intravenous anesthesia when delivery of inhalation anesthesia is difficult, such as during a long intubation attempt or during rigid bronchoscopy.



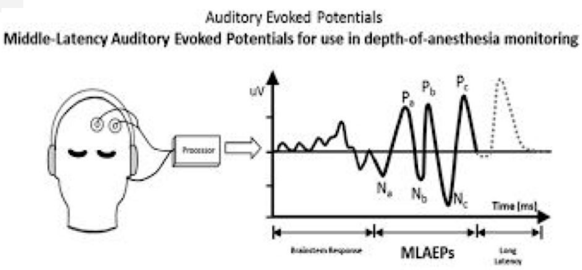
02 M-entropy module GE healthcare

TABLE 6–1 Characteristics of the commercially available monitors of anesthetic depth.

Parameters	Machine/ Manufacturer	Consumable	Physiologic Signals	Recommended Range of Values for Anesthesia	Principles of Measurement
Bispectral index (BIS)	A-2000/Aspect Medical Systems, Newton, MA	BIS sensor	Single channel EEG	40–60	BIS is derived from the weighted sum of three EEG parameters: relative α/β ratio; bio-coherence of the EEG waves; and burst suppression. The relative contribution of these parameters has been tuned to correlate with the degree of sedation produced by various sedative agents. BIS ranges from 0 (asleep)–100 (awake).
Patient state index (PSI)	Patient state analyzer (PSA 400)/ Physiometrix, Inc., N. Billerica, MA	PSArray[2]	4-channel EEG	25–50	PSI is derived from progressive discriminant analysis of several quantitative EEG variables that are sensitive to changes in the level of anesthesia, but insensitive to the specific agents producing such changes. It includes changes in power spectrum in various EEG frequency bands; hemispheric symmetry; and synchronization between brain regions and the inhibition of regions of the frontal cortex. PSI ranges from 0 (asleep)-100 (awake).
Narcotrend stage Narcotrend index	Nacrotrend monitor/ Monitor-Technik, Bad Bramstedt, Germany	Ordinary ECG electrode	1–2 channel EEG	Narcotrend stage D_{0-2} to C_1, which corresponds to an index of 40–60	The Narcotrend monitor classifies EEG signals into different stages of anesthesia (A = awake; B_{0-2} = sedated; C_{0-2} = light anesthesia; D_{0-2} = general anesthesia; $E_{0,1}$ = general anesthesia with deep hypnosis; $F_{0,1}$ = burst suppression). The classification algorithm is based on a discriminant analysis of entropy measures and EEG spectral variables. More recently the monitor converts the Narcotrend stages into a dimensionless number from 0 (asleep) to 100 (awake) by nonlinear regression.
Entropy	S/5 Entropy Module, M-ENTROPY/ Datex-Ohmeda, Instrumentarium Corp., Helsinki, Finland	Special entropy sensor	Single-channel EEG	40–60	Entropy described the 'irregularity' of the EEG signal. As the dose of anesthetic is increased, EEG becomes more regular and the entropy value approaches zero. M-ENTROPY calculates the entropy of the EEG spectrum (spectral entropy). In order to shorten the response time, it uses different time windows according to the corresponding EEG frequencies. Two spectral parameters are calculated: state entropy (frequency band 0–32 Hz) and response entropy (0–47 Hz), which also includes muscle activity. Both entropy variables have been re-scaled, so that 0 is asleep and 100 is awake.
Aline autore-gressive index (AAI)	AEP/2 monitor/ Danmeter A/S, Odense, Demark	Ordinary ECG electrode	AEP	10–25	AAI is derived from the middle latency AEP (20–80 ms). AAI is extracted from an autoregressive model with exogenous input (ARX model) so that only 18 sweeps are required to reproduce the AEP waveform in 2–6 s. The resultant waveform is then transformed into a numeric index (0–100) that describes the shape of the AEP. AAI > 60 is awake, AAI of 0 indicates deep anesthesia.
Cerebral state index (CSI)	Cerebral state monitor (CSM), Danmeter A/S, Odense, Demark	Ordinary ECG electrode	Single-channel EEG	40–60	CSI is a weighted sum of (1) α ratio, (2) β ratio, (3) difference between the two and (4) burst suppression. It correlates with the degree of sedation by an 'adaptive neuro-fuzzy inference system'. CSI ranges from 0 (asleep) to 100 (awake).

EEG, electroencephalogram; ECG, electrocardiogram; AEP, auditory evoked potential.
Reproduced, with permission, from Chan MTV, Gin T, Goh KYC: Interventional neurophysiologic monitoring. Curr Opin Anaesthesiol 2004;17:389.

03 Mid-latency auditory evoked potentials MLAEPS



Neurophysiologic Monitoring

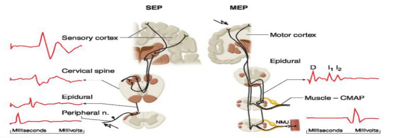
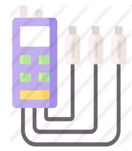
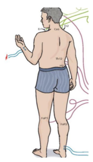
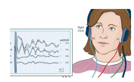
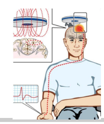
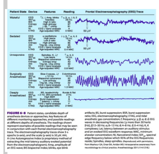
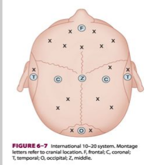
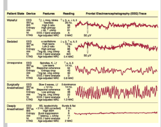


FIGURE 6–11 Neuroanatomic pathways of somatosensory-evoked potential and motor-evoked potential. The somatosensory-evoked potential (SEP) is produced by stimulation of a peripheral nerve wherein a response can be measured. The electrical volley ascends the spinal cord by the posterior columns and can be recorded in the epidural space and over the posterior cervical spine. It crosses the mid-line after synapsing at the cervicomedullary junction and ascends the lemniscal pathways having a second synapse in the thalamus. From there, it travels to the primary sensory cortex where the cortical response is measured. The motor-evoked potential (MEP) is produced by stimulation of the motor cortex leading to an electrical volley that descends to the anterior horn cells of the spinal cord via the corticospinal tract. After synapsing there it travels via a peripheral nerve and crosses the neuromuscular junction (NMJ) to produce a muscle response. The MEP can be measured in the epidural space as D and I waves produced by direct and indirect (via internuncial neurons) stimulation of the motor cortex, respectively. It can also be measured as a compound muscle action potential (CMAP) in the muscle. (Reproduced, with permission, from Sloan TB, Janik D, Jameson L: Multimodality monitoring of the central nervous system using motor-evoked potentials. Curr Opin Anaesthesiol. 2008;21:560.)

- 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, & peripheral nerve function prior to irreversible damage.
- Neuromonitoring is also useful in identifying anatomical structures.
- Neurophysiological monitoring e.g. The surgeon is removing a tumor from the spinal cord, we need to know if he's going too far into normal tissue or not. If it's a sensory area we stimulate the peripheral nerve from the legs and we will catch the signal going to the brain (sensory cortex) If the surgeon affect the normal pathway it will be showed in our monitor. Same goes for motor, but we stimulate from the brain area and catch the response in the peripheral muscle area. So if there is a spinal cord surgery how to make sure that the surgeon is only taking the tumor without normal tissue? By neurophysiological monitoring

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 - 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 anesthetized 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

- 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 be a sign of neurological events secondary to decreased cerebral oxygenation.

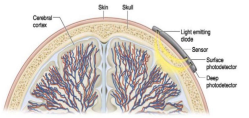


FIGURE 6–12 Principle of the INVOS® near-infrared spectroscopy technique. (Reproduced, with permission, from Rubio A, Hakami L, Münch F, Tandler R, Harig F, Weyand M: Noninvasive control of adequate cerebral oxygenation during low-flow antegrade selective cerebral perfusion on adults and infants in the aortic arch surgery. J Card Surg 2008;23:474.)

Invasive pressure monitoring

Central Venous Pressure Monitor fluids in the body and cardiac output	Pulmonary artery Pressure
Central venous pressure involves placement of a sterile catheter into one of the large central veins and allows for multiple modalities of intervention along with the option of monitoring central venous pressure (CVP). Indications: Gives an idea how much fluids you should give the patient, but if the heart is abnormal it will not be useful, you need to put pulmonary artery catheter. 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. - significant reduction in LV compliance (ischemia/diastolic dysfunction).	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 - 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".

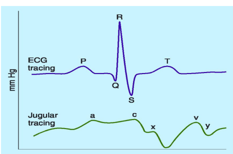


FIGURE 5–19 The upward waves (*a, c, v*) and the downward descents (*x, y*) of a central venous tracing in relation to the electrocardiogram (ECG).

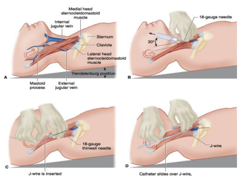


FIGURE 5–16 Right internal jugular cannulation with Seldinger's technique (see text).

A

B

FIGURE 5–17 A: Probe position for ultrasound of the large internal jugular vein with deeper carotid artery and B: corresponding ultrasound image. CA, carotid artery; IJ, internal jugular vein. (Reproduced, with permission, from Tintinalli JE, et al: *Tintinalli's Emergency Medicine: A Comprehensive Study Guide*, 7th edition, McGraw-Hill, 2011.)

Pulmonary artery catheter:

$$CO = SV \times HR$$

$$SV = CO/HR$$

$$\text{Blood pressure} = CO \times \text{systemic vascular resistance (SVR)}$$

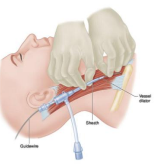


FIGURE 5–21 A percutaneous introducer consisting of a vessel dilator and sheath is passed over the guidewire.

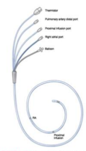


FIGURE 5–20 Balloon-tipped pulmonary artery flotation catheter (Swan–Ganz catheter). RA, right atrium.

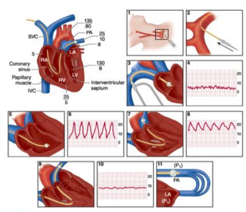


FIGURE 5–22 Although its utility is increasingly questioned, pulmonary artery catheters continue to be a part of perioperative management of the cardiac surgery patient. Following placement of a sheath introducer in the central circulation (panels 1 and 2), the pulmonary artery catheter is floated. Central line placement should always be completed using rigorous sterile technique, full body draping, and only after multiple, redundant confirmations of the correct localization of the venous circulation. Pressure guidance is used to ascertain the localization of the PA catheter in the venous circulation and the heart. Upon entry into the right atrium (panels 3 and 4), the central venous pressure tracing is noted. Passing through the tricuspid valve (panels 5 and 6) right ventricular pressures are detected. At 35 to 50 cm depending upon patient size, the catheter will pass from the right ventricle through the pulmonic valve into the pulmonary artery (panels 7 and 8). This is noted by the measurement of diastolic pressure once the pulmonic valve is passed. Lastly, when indicated the balloon-tipped catheter will wedge or occlude a pulmonary artery branch (panels 9, 10, and 11). When this occurs, the pulmonary artery pressure equilibrates with that of the left atrium which, barring any mitral valve pathology, should be a reflection of left ventricular end-diastolic pressure. (Redrawn and reproduced, with permission, from Soni N. *Practical Procedures in Anaesthesia and Intensive Care*. Butterworth Heinemann, 1994.)

Modalities for anesthetic monitoring

Transesophageal echocardiography (TEE)

Give us too much information about the heart

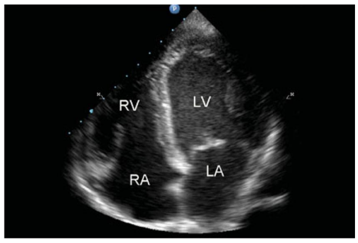


FIGURE 5–27 Normal apical four-chamber view. RV, right ventricial; LV, left ventricle; RA, right atrium; LA, left atrium. (Reproduced, with permission, from Carmody KA, et al: *Handbook of Critical Care and Emergency Ultrasound*. McGraw-Hill, 2011.)

- 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 but has become a mainstay in intraoperative cardiac anesthesia and its utility is extending into other areas as well.
- C.I. in case of esophageal varices
- most sensitive method for the diagnosis of air embolism

Peripheral nerve stimulation

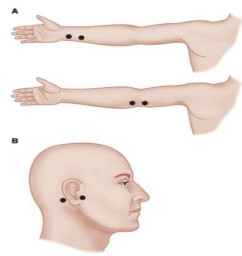


FIGURE 6–13 A: Stimulation of the ulnar nerve causes contraction of the adductor pollicis muscle. B: Stimulation of the facial nerve leads to orbicularis oculi contraction. The orbicularis oculi recovers from neuromuscular blockade before the adductor pollicis. (Reproduced, with permission, from Dorsch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

Indications

- all patients receiving intermediate- or long-acting **neuromuscular blocking** agents should be monitored.
- assessing paralysis during rapid-sequence inductions or during continuous infusions of short-acting agents.
- can help locate nerves to be blocked by regional anesthesia.

Contraindications

- There are no contraindications to neuromuscular monitoring Except if the pt has allergy to the electrodes.
- Atrophied muscles in areas of hemiplegia or nerve damage may appear refractory to neuromuscular blockade secondary to the proliferation of receptors.
- Determining the degree of neuromuscular blockade using such an extremity could lead to potential overdosing of competitive neuromuscular blocking agents.

Technique

- Peripheral nerve stimulator delivers current (60- 80 mA) to a pair of either ECG silver chloride pads or subcutaneous needles placed over a peripheral motor nerve.
- The evoked mechanical or electrical response of the innervated muscle is observed.
- Although electromyography provides a fast, accurate, and quantitative measure of neuromuscular transmission, visual or tactile observation of muscle contraction is usually relied upon in clinical practice.
- **Ulnar nerve** stimulation of the adductor pollicis muscle and **facial nerve** stimulation of the orbicularis oculi are most commonly monitored.
- Direct stimulation of muscle should be avoided.
- **Ulner nerve is used for neuromuscular junction monitoring during anesthesia**

Complications

- Complications of nerve stimulation are limited to skin irritation and abrasion at the site of electrode attachment.

Modalities for anesthetic monitoring

Peripheral nerve stimulation

Modes of transmission			
Single Twitch	**Train of four**	**Double Burst Stimulation**	**Post tetanic count**

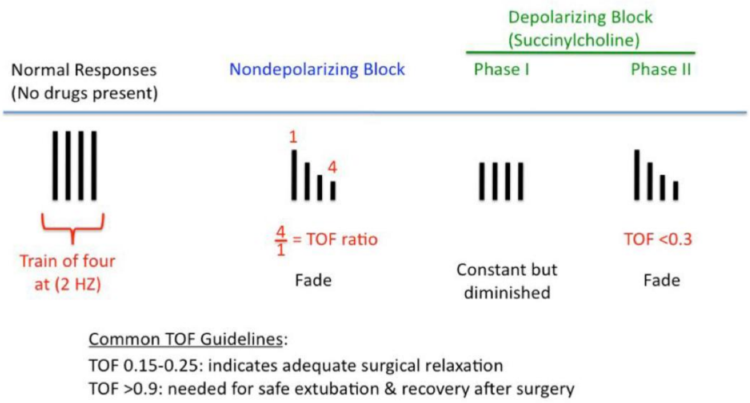
Train of four:

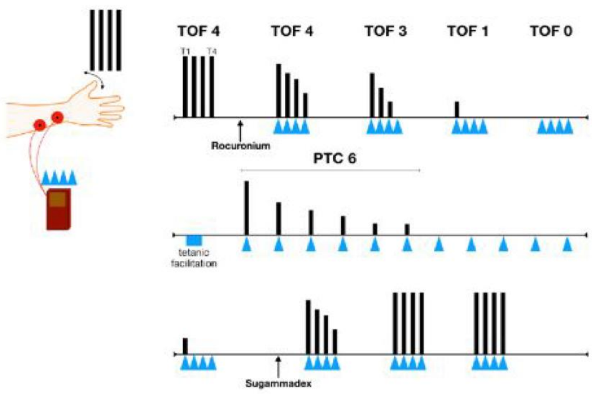
- **denotes four successive 200-μs stimuli in 2 sec (2 Hz).**
- **The twitches in a train-of-four pattern progressively fade as nondepolarizing muscle relaxant block increases.**
- **The ratio of the responses to the first and fourth twitches is a sensitive indicator of nondepolarizing muscle paralysis.**
- **Ratio o fourth twitch over the irst twitch should be greater than or equal to 90% to give the reversal (neostigmine and glycopyrrolate)**
- **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.
- the second twitch a 90% block.

- **Clinical relaxation usually requires 75% to 95% neuromuscular blockade.**





Modalities for anesthetic monitoring

Peripheral nerve stimulation
Extubation Criteria and clinical considerations

V1	The diaphragm, rectus abdominis, laryngeal adductors, and orbicularis oculi muscles recover from neuromuscular blockade sooner than do the adductor pollicis
V2	Other indicators of adequate recovery include sustained (≥5 s) head lift , the ability to generate an inspiratory pressure of at least –25 cm H_2O, and a forceful hand grip.
V3	Twitch tension is reduced by hypothermia of the monitored muscle group (6%/° C)
V4	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
V5	Postoperative residual curarization remains a problem in post- anesthesia care, producing potentially injurious airway and respiratory function compromise.
V6	Reversal of neuromuscular blocking agents is warranted, as is the use of intermediate acting neuromuscular blocking agents instead of longer acting drugs.

Electrolytes/Acid Base
Coagulation
Urine output

439: Recommended videos from doctor for more information

Monitoring Neuromuscular Function (2018)

Train of four technique with a peripheral neuromuscular stimulator

439 Lecture Quiz

Question 1: A 28-year-old female patient is scheduled for correction of kyphoscoliosis and insertion of Harrington rods. Which of the following intraoperative monitoring is most useful in detecting neurological injury during instrumentation of the spine?

A. Wake-up test.
B. Bispectral index.
C. Somatosensory evoked potentials.
D. Invasive blood pressure monitoring.
E. Peripheral nerve stimulation.

Question 2: A 70-year-old male patient with type II diabetes, hypertension and ischaemic heart disease is undergoing a laparotomy for carcinoma of the sigmoid colon. Which of the following monitors would be the most sensitive detector of intraoperative myocardial ischaemia?

A. Electrocardiography
B. Transesophageal echocardiography.
C. Pulmonary capillary wedge pressure measurement.
D. ECG monitoring with CM5 configuration.
E. Dipyridamole-thallium scanning.

Question 3: What is the most reliable way to ascertain correct placement of an endotracheal tube?

A. Detection of a pressure waveform on inflation
B. Direct visualization
C. Detection of breath sounds on auscultation
D. Measurement of end-tidal carbon dioxide concentration
E. Movement of the chest wall on manual inflation

Question 4: how frequent the anesthesiologist should monitor the patient during appendicitis surgery at minimum ?

A. Every hour
B. Every half hour
C. Every 5 minutes
D. During emergency the nurse have to page the anesthesiologist
E. No need, the surgeon can monitor the patient himself
F. Only in pediatric cases the anesthesiologist has to be monitoring the whole time

Key Answers: 1-C/ 2-B / 3-D / 4-C

441 Notes:

- Temperature monitoring was discarded previously, now its very crucial.
- (MAC) monitored anesthesia care means sedation and nothing at all but with monitoring.
- If no oxygenation by machine, what to do ?MANUALLY .
- if you changed site of one lead take baseline before so you don’t think something wrong happened.
- Lactate can be measured in blood invasively from radial nerve.
- Temperature is measured even if simple procedure due to the risk of arrhythmia caused by hypothermia.
- Smokers can have high SpO_2 so take ABG.
- Pt have methemoglobinemia (abnormal hemoglobin) ABG not SpO_2 since it can be falsely high.
- Always take baseline before surgery to compare during.
- Awareness is highest in emergency cases.
- Nerve stimulation can be used in extubation when muscle relaxant is used.

Team leader: Rand Aldajani

Team member:
Norah Alsewailem

Note Taker:
Lamya Alsanad