INTRODUCTION TO PATIENT MONITORING

In

ANESTHESIA

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Society for Technology in Anesthesia

Monitoring: Definition Word Monitor is from Monere means warning

- ... interpret available clinical data to help recognize present or future mishaps or unfavorable system conditions

- ... not restricted to anesthesia
  (change "clinical data" above to "system data" to apply to aircraft and nuclear power plants)

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Why monitoring anesthetized patients ?

- Anesthetic agents - cardiopulmonary depressants
- Homeostasis
- Patient's response to (physio & pharma & Surgical) interventions
- Proper function of anesthetic equipment

Detecting Mishaps Using Monitors

1. Disconnection
2. Hypoventilation
3. Esophageal intubation
4. Bronchial intubation
5. Circuit hypoxia
6. Anesthetic overdose
7. Hypovolemia
8. Pneumothorax
9. Air Embolism
10. Hyperthermia
11. Aspiration
12. Acid-base imbalance
13. Cardiac dysrhythmias
14. IV drug overdose

Source: Barash Handbook

These mishaps ...

Patient Monitoring and Management

Involves ...continual or continuous

- **Things you measure** *(physiological parameters & their measurement, such as BP or HR)*
- **Things you observe** *(e.g. observation of pupils)*
- **Planning to avoid trouble** *(e.g. planning induction of anesthesia or planning extubation)*
- **Inferring diagnoses** *(e.g. unilateral air entry may mean endobronchial intubation)*
- **Planning to get out of trouble** *(e.g. differential diagnosis and response algorithm formulation)*

What should be monitored ?

- Circulation (cardiovascular)
- Ventilation (respiratory)
- Oxygenation (cardiorespiratory)
- Maintain adequate tissue perfusion with oxygenated blood

Monitoring in the Past



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Monitoring in the Past

- Visual monitoring of respiration and overall clinical appearance
- Finger on pulse
- Blood pressure (sometimes)



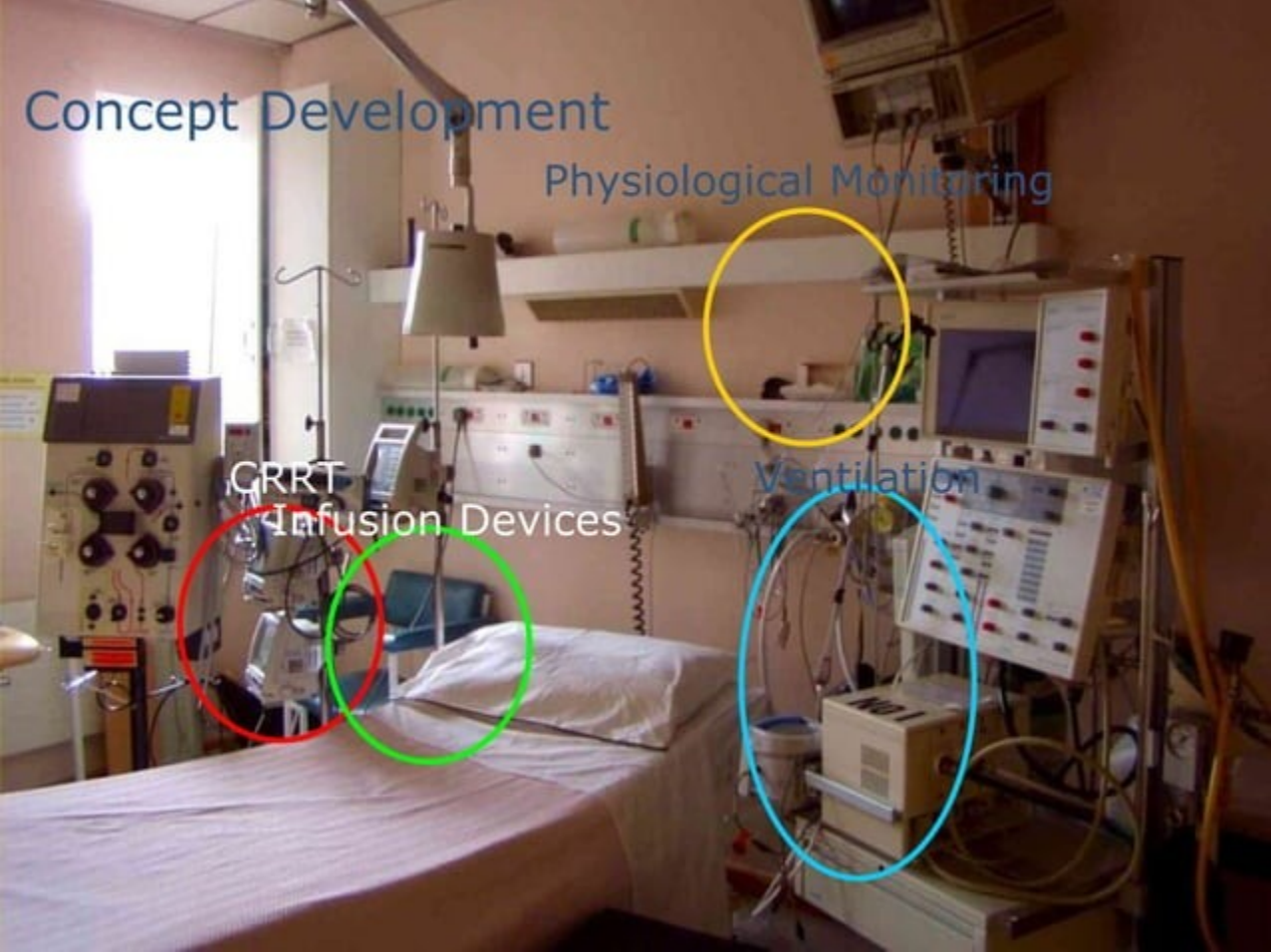
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Harvey Cushing

Not just a famous neurosurgeon …
but the father of anesthesia monitoring

- **Invented and popularized the anesthetic chart**
- **Recorded both BP and HR**
- **Emphasized the relationship between vital signs and neurosurgical events**
  (increased intracranial pressure leads to hypertension and bradycardia)




Concept Development
Physiological Monitoring
CRRT
Infusion Devices
Ventilation

Monitoring in the Present

- Standardized basic monitoring requirements (guidelines) from the ASA (American Society of Anesthesiologists), CAS (Canadian Anesthesiologists' Society) and other national societies
- Many integrated monitors available
- Many special purpose monitors available
- Many problems with existing monitors (e.g., cost, complexity, reliability, artifacts)

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ASA Monitoring Guidelines

- **STANDARD I**

Qualified anesthesia personnel shall be present in the room throughout the conduct of all general anesthetics, regional anesthetics and monitored anesthesia care.

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ASA Monitoring Guidelines

- **STANDARD II**

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

  http://www.asahq.org/publicationsAndServices/standards/02.pdf

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CAS Monitoring Guidelines

"The only indispensable monitor is the presence, at all times, of a physician or an anesthesia assistant, under the immediate supervision of an anesthesiologist, with appropriate training and experience. Mechanical and electronic monitors are, at best, aids to vigilance. Such devices assist the anesthesiologist to ensure the integrity of the vital organs and, in particular, the adequacy of tissue perfusion and oxygenation."

CAS Monitoring Guidelines

- The following are required:
  - Pulse oximeter
  - Apparatus to measure blood pressure, either directly or noninvasively
  - Electrocardiography
  - Capnography, when endotracheal tubes or laryngeal masks are inserted.
  - Agent-specific anesthetic gas monitor, when inhalation anesthetic agents are used.

CAS Monitoring Guidelines

- The following shall be exclusively available for each patient:
  - Apparatus to measure temperature
  - Peripheral nerve stimulator, when neuromuscular blocking drugs are used
  - Stethoscope — either precordial, esophageal or paratracheal
  - Appropriate lighting to visualize an exposed portion of the patient.

CAS Monitoring Guidelines

- The following shall be immediately available:
  - Spirometer for measurement of tidal volume.

Detecting Mishaps Using Monitors

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14. IV drug overdose

Source: Barash Handbook

These mishaps …

Detecting Mishaps with Monitors

Pulse oximeter	1,2,3,4,5,8,9,11,14
Mass spectrometer	1,2,3,6,9,10,12
Capnograph	1,2,3,9,10,12
Automatic BP	6,7,9,14
Stethoscope	1,3,4,13
Spirometer	1,2
Oxygen analyzer	5
EKG	13
Temperature	10

Source: *Barash Handbook*



... are detected using these monitors

Basic Monitoring

- **Cardiac**: Blood Pressure, Heart Rate, ECG
- **ECG**: Rate, ST Segment (ischemia), Rhythm
- **Respiratory**: Airway Pressure, Capnogram, Pulse Oximeter, Spirometry, Visual Cues
- **Temperature** [pharyngeal, axillary, esophageal, etc.]
- **Urine output** (if Foley catheter has been placed)
- **Nerve stimulator** [face, forearm] (if relaxants used)
- **ETT cuff pressure** (keep < 20 cm H_2O)
- **Auscultation** (esophageal or precordial stethoscope)
- **Visual surveillance** of the anesthesia workspace and some exposed portion of the patient

How to monitor circulation?

- Palpation, auscultation
- Arrhythmia, ECG
- Blood pressure
  - Doppler ultrasound flow detector
  - Automated oscillometric devices

How to monitor oxygenation ?

- Blood gas analysis (PaO_2)
- Pulse oximetry (SaO_2)
- Oxy-hemoglobin saturation
- Hemoximetry
  - Oxy-hemoglobin
  - Met-hemoglobin
  - Carboxy-hemoglobin

How to monitor ventilation ?

- Arterial blood gases
  - $PaCO_2$,PaO_2
- Capnography
  - End-tidal CO_2
    Respiratory Rate
- Respirometry
  - Tidal volume, minute volume

Capnography

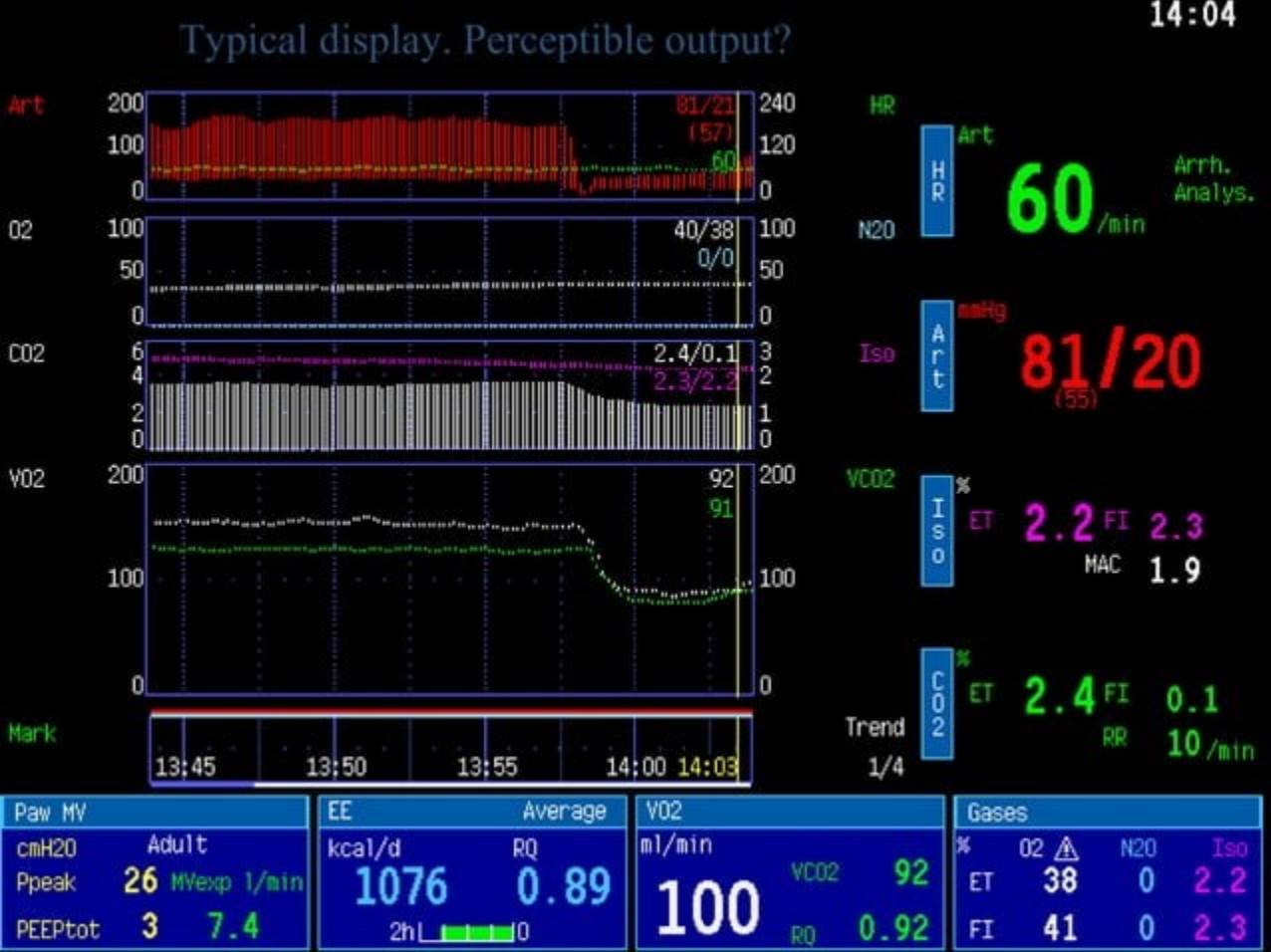
- Metabolism
- Circulation
- Ventilation
- Anesthetic equipment function
- Capnometer (no capnogram)
- Only one normal shape

Visual Surveillance

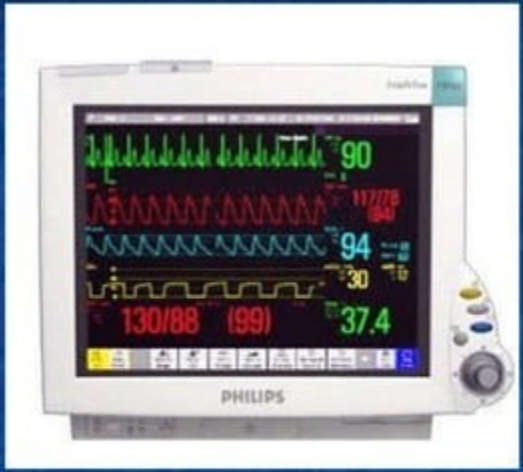
- **Anesthesia machine / workspace checkout**
- **Patient monitor numbers and waveforms**
- **Bleeding/coagulation *(e.g., are the surgeons using a lot of suction or sponges?)***
- **Diaphoresis / movements / grimaces**
- **Line quality *(is my IV reliable?)***
- **Positioning safety review**
- **Respiratory pattern *(e.g. tracheal tug, accessory muscle use etc.)***

Low Tech Patient Monitoring

- Manual blood pressure cuff
- Finger on the pulse and forehead
- Monaural stethoscope
  (heart and breath sounds)
- Eye on the rebreathing bag
  (spontaneously breathing patient)
- Watch respiratory pattern
- Watch for undesired movements
- Look at the patient's face
  - *color OK?*
  - *diaphoresis present?*
  - *pupils*


14:04
Typical display. Perceptible output?
Art
200
100
0
81/21
(57)
60
240
120
0
O2
100
50
0
40/38
0/0
CO2
6
4
2
0
2.4/0.1
2.3/2.2
3
2
1
VO2
200
100
0
92
91
Mark
13:45
13:50
13:55
14:00
14:03
HR
Art
HR
60 /min
Arrh. Analys.
N2O
Iso
mmHg
Art
81/20
(55)
VCO2
%
Iso
ET 2.2 FI 2.3
MAC 1.9
%
CO2
ET 2.4 FI 0.1
RR 10 /min
Trend
1/4
Paw MV
cmH2O
Adult
Ppeak 26 MVexp l/min
PEEPtot 3 7.4
EE
Average
kcal/d
RQ
1076 0.89
2h
0
VO2
ml/min
100
VCO2 92
RQ 0.92
Gases
% O2 N2O Iso
ET 38 0 2.2
FI 41 0 2.3

High Tech Patient Monitoring





Examples of Multiparameter Patient Monitors

High Tech Patient Monitoring



Transesophageal Echocardiography



BIS Depth of Anesthesia Monitor



Evoked Potential Monitor

Some Specialized Patient Monitors

Special Monitoring

- Pulmonary artery lines (Swan Ganz)
- Transesophageal echocardiography
- Intracranial pressure (ICP) monitoring
- Electrophysiological CNS monitoring
- Renal function monitoring (indices)
- Coagulation monitoring (e.g. ACT)
- Acid-base monitoring (ABGs)
- Monitoring depth of anesthesia__BIS

Alarms

- **Purpose:** Alarms serve to alert equipment operators that some monitored variable or combination of variables is outside some region

- **Motivation:** recognition of limited attentiveness capability in humans, even under good operating conditions

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Airway / Respiratory Axis

- Correct ETT placement
- ETT cuff pressure
- Airway pressure
- Oxygenation
- Ventilation
- Spirometry
- Pulmonary biomechanics
- Airway gas monitoring
- Clinical: *wheezing, crackles, equal air entry, color, respiratory pattern (rate, rhythm, depth, etc.)*

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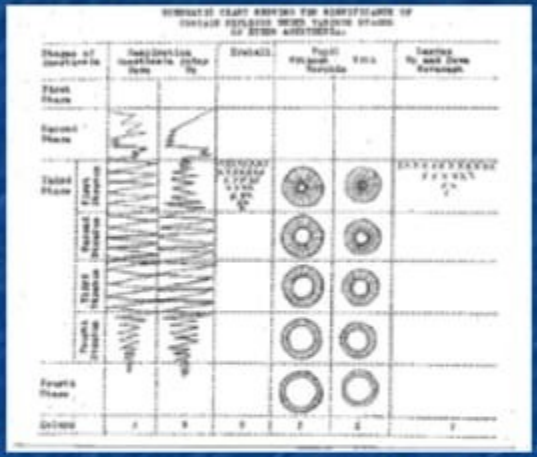
Circulatory Axis

- Cardiac output
- Input pressures (CVP, LAP)
- Output pressures (BP, PAP)
- Pacemaker: rate, conduction
- Cardiac contractility
- Vascular resistances (SVR, PVR)
- Intracardiac shunts

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Depth of Anesthesia

- Clinical Signs
  - *eye signs*
  - *respiratory signs*
  - *cardiovascular signs*
  - *CNS signs*
- EEG monitoring
- Facial EMG monitoring (experimental)
- Esophageal contractility (obsolete)



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CNS Monitoring

- **Clinical:** ***sensorium, reflexes, "wake up test"***
- **Electroencephalography:** ***raw EEG, compressed spectral arrays (CSA), 95% spectral edge, etc.***
- **Evoked potentials** ***(esp. somatosensory EPs)***
- **Monitoring for venous air emboli**
- **Intracranial pressure (ICP) monitoring**
- **Transcranial doppler studies (MCA flow velocity)** ***(Research)***
- **Jugular bulb saturation** ***(Research)***
- **Cerebral oximetry** ***(Research)***

Relaxation Axis

- Clinical Signs +/- Nerve Stimulator
- Mechanomyography
- Electromyography
- Piezoelectric methods
- Special methods (e.g. DBS)

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Temperature Monitoring

Rationale for use

- detect/prevent hypothermia
- monitor deliberate hypothermia
- adjunct to diagnosing MH
- monitoring CPB cooling/rewarming

Sites

- Esophageal
- Nasopharyngeal
- Axillary
- Rectal
- Bladder

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Electrolyte / Metabolic Axis

- Fluid balance
- Sugar
- Electrolytes
- Acid-base balance
- Nutritional status

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Coagulation Monitoring

- Clinical signs
- PT / PTT / INR
- ACT
- Platelet counts
- Factor assays
- TEG

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Monitoring Neuromuscular Function



- Mechanomyography
  - Measures tension
  - Resting Tension Reg'd
  - Cumbersome setup
  - Gold standard

Monitoring Neuromuscular Function



- Electromyography
  - Cpd. AP represents sum of motor units
  - More muscles accessible
  - Good correlation with tension

Monitoring Neuromuscular Function



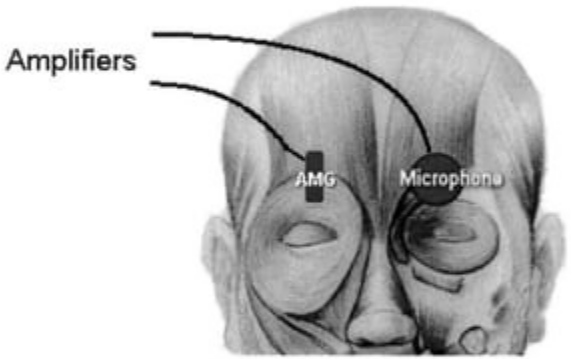
- Accelerometry
  - f = m X a
  - No resting tension reg'd
  - Again reliable !

Monitoring Neuromuscular Function



- Kinemyography
  - Datex M-NMT
  - Motion sensor ?
  - Reliability?

Monitoring Neuromuscular Function



Monitoring Neuromuscular Function

- REQUIREMENTS OF A STIMULATOR
  - Multiple modes of stimulation
  - Battery powered and charge indicator
  - Constant current,voltage variable output
  - Adjustable and monitored current output
  - Monophasic square wave pulse (0.2-0.3 msec)
  - At least 50mA of output current
  - Audible or LED indicators of output

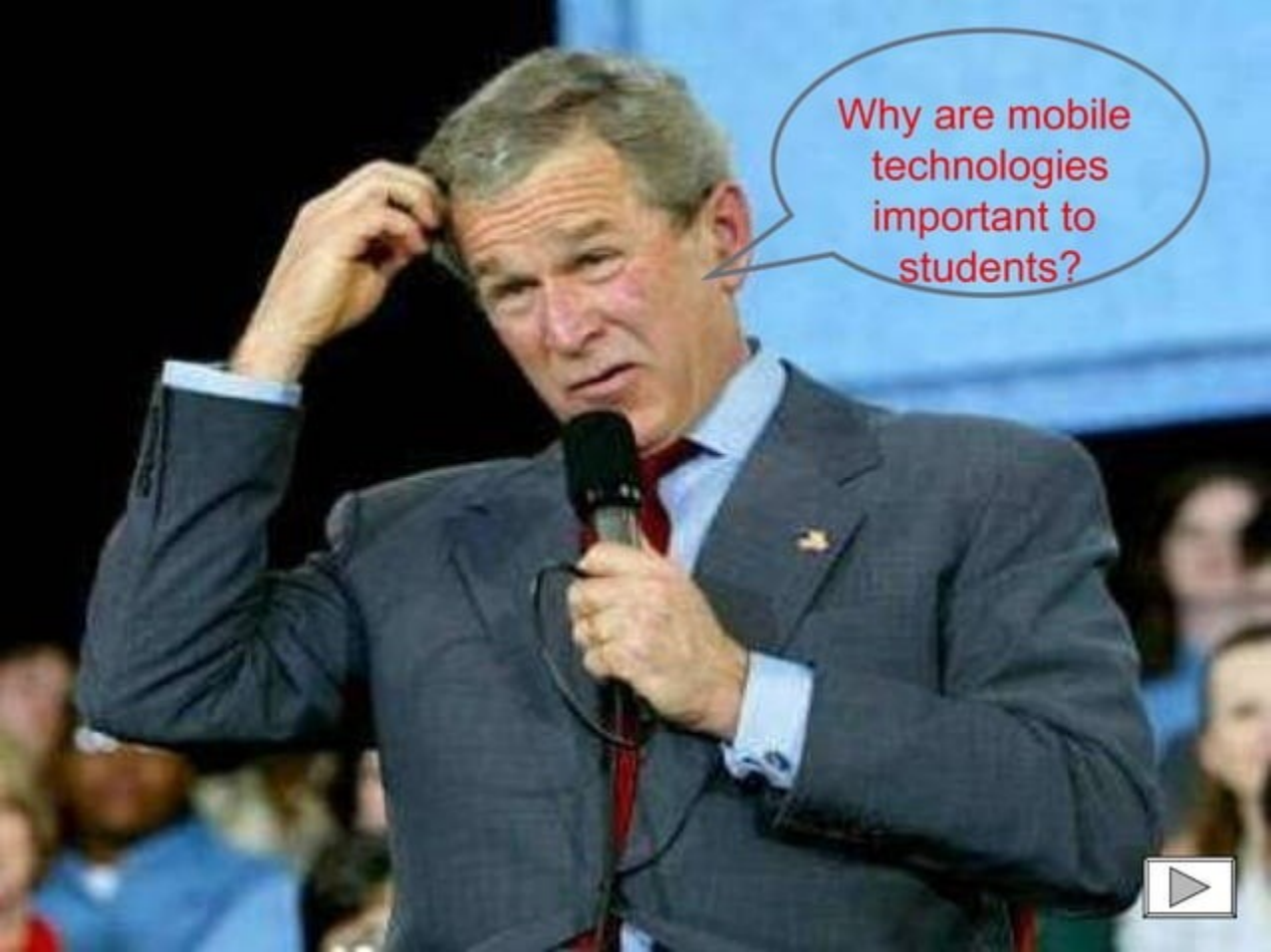


Monitoring Neuromuscular Function








Why are mobile technologies important to students?

THANK-YOU



Who is the Critical Patient?

- Trauma
- Post-operative
- Cancer
- Septic
- Pancreatitis
- Pyometra
- GDV
- Seizure
- Severe Gastroenteritis
- Heart failure
- Hemorrhage
- Immune-mediated disease.
- Renal failure
- Liver failure
- And the list goes on…….

The End

8 Axes of Clinical Anesthesia Monitoring
(A Conceptual Model)

- Axis I - Airway /Respiratory
- Axis II - Circulatory / Volume
- Axis III - Depth of Anesthesia
- Axis IV - Neurological
- Axis V - Muscle Relaxation
- Axis VI - Temperature
- Axis VII - Electrolytes / Metabolic
- Axis VIII - Coagulation

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Cardiac Monitoring Methods

- **Symptoms and signs:** ***eg, angina, diaphoresis, mental state***
- **Finger on the pulse:** ***rate, rhythm, pulse "volume"***
- **Auscultation:** ***rate, rhythm, murmurs, extra sounds***
- **Electrocardiogram*: rate, rhythm, ischemia***
- **Pulse oximeter waveform:** ***rate, rhythm***
- **Blood pressure:** ***cuff, oscillotonometry, art. line***
- **Volume Status:** ***low-tech, high-tech***

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