Medical Equipment I

(BIS 402)

Patient Monitoring

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Outline

- **Introduction**
- **The Concept of patient monitoring**
- **Integration with eHealth**
- **Patient Safety**
- **Modular Patient Monitoring Systems**
- **Main components of a patient monitoring system**
- **Parameter Modules**
- **Patient Monitoring Future**

General Definition

- It is an electronic device that measures a patient‘s ***vital signs*** and ***displays*** the data so obtained, which may or may not be transmitted on a monitoring network.

- Physiological data are displayed **continuously along the time axis** on a CRT or LCD screen as data channels.

- **Computed parameters** on the original data, such as maximum, minimum and average values, pulse and respiratory frequencies, and so on, may be displayed as well.

- **Provides warnings** (alarms) of fatal conditions before visible signs are noticeable to clinical staff.

Old Technology

- Analog systems mainly based on oscilloscopes.
- Most systems had one channel.

Main disadvantages are:

- Sensitivity to electrical interference.
- Base level fluctuations.
- Absence of numeric readouts and alarms.

New Technology

- Digital systems mainly based Digital Signal Processing (DSP).
- Most systems have several channels.

Main advantages are:

- Small in size, portable, and networkable (wired/wireless)
- Track many different vital signs at the same time.
- Automated numeric readouts and alarms.

Integration with eHealth

- Digital monitoring provides the possibility of integrating the physiological data from the patient monitoring networks into the patient electronic health record such as HIS, RIS, PACS using appropriate standards such as HL7 and DICOM.

- Digital patient monitor's embedded software can take care of the data coding according to these standards and send messages to the medical records application, which decodes them and incorporates the data into the adequate fields.

- This newer feature reduces the likelihood of human documentation error and will eventually reduce overall paper consumption and improve quality control.

Patient Safety

- Patient monitoring have been safety engineered so that failures are unimportant.

- There are strict limits on how much current and voltage can be passed through electrodes connected to a patient, even if the unit fails; e.g. grounding failure, or becomes wet.

Modular Patient Monitoring Systems

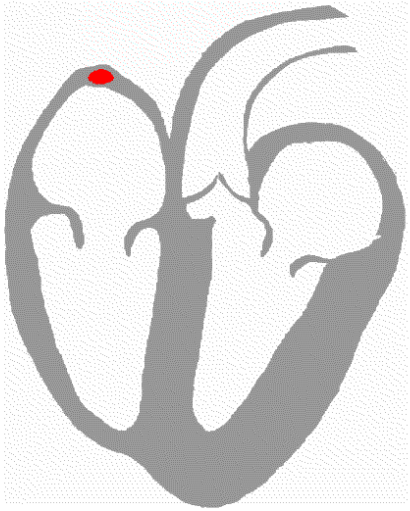
- Flexible patient monitoring systems
- Utilize a standard control panel.
- Hardware has the following main parts:
  - A display system that includes a control panel
  - A computer system that is connected to a slot plug-in rack.
  - Parameter modules.

What are the main components of a patient monitoring system?

Draw a block diagram

ECG/EKG Module

- ECG module measures the electrical activity of the heart over time captured and externally recorded by skin electrodes placed in standard positions.
- ECG machine/module amplifies the hearts electrical impulses from the skin.
- An electrode is an adhesive pad containing conductive gel.
- Electrodes are attached to wires which attach to ECG machine/module.
- Wires are color coded indicating placement.



A normal ECG/EKG wave

What are the main components of an ECG device?

Draw a block diagram

Temperature Module

- Electronic thermometers is used.
- Electronic circuit is used to automatically interpret the temperature measurements.
- Patient temperature is provided repetitively as configured.

NIBP Module

Blood Pressure (BP)

- BP is the pressure of the blood against the walls of the arteries.
- BP results from two forces.
  - One is created by the heart as it pumps blood into the arteries and through the circulatory system (systolic - the higher number).
  - The other is the force of the arteries as they resist the blood flow (diastolic – the lower number).

Cont.

NIBP Module

Blood Pressure (BP)

- BP decreases as the circulating blood moves away from the heart through arteries.
- The term BP usually refers to the pressure measured at a person's upper arm.
- A person's BP is usually expressed in terms of the systolic pressure and diastolic pressure (mmHg).
- The systolic pressure is always stated first. For example: 120/80 (120 over 80); systolic = 120, diastolic = 80.

Cont.

NIBP Module

Oscillometric Method to measure BP

- Observation of oscillations in the sphygmomanometer cuff pressure which are caused by the oscillations of blood flow, i.e., the pulse.
- It is essential that the cuff size is correct: undersized cuffs may yield too high a pressure; oversized cuffs yield too low a pressure.
- The cuff is inflated to a pressure initially in excess of the systolic arterial pressure and then reduced to below diastolic pressure over a period of about 30 seconds.

Cont.

NIBP Module

Oscillometric Method to measure BP

- When blood just starts to flow in the artery, it creates a "whooshing".
- The pressure at which this sound is first heard is the systolic BP.
- The cuff pressure is further released until no sound can be heard, at the diastolic arterial pressure.

Cont.

NIBP Module

BP Monitoring

- The term NIBP, for non-invasive blood pressure, is often used to describe oscillometric monitoring equipment.
- An electronic pressure sensor (transducer) is used to observe cuff pressure oscillations instead of depending on sounds.
- Electronic circuit is used to automatically interpret them, and automatic inflation and deflation of the cuff.
- It measures the pressure and the rate of change of pressure (dP/dt).
- Systolic, diastolic and mean blood pressures are provided repetitively with an average period of 10 minutes (configurable).
- The pressure sensor should be calibrated periodically to maintain accuracy.

SpO_2 Module - Pulse Oximeter

- SpO_2 is a measurement of the amount of oxygen attached to the hemoglobin in the circulatory system.
- In other words, it is the amount of oxygen being carried by the red blood cell in the blood.
- SpO_2 is given in as a percentage, normal is around 96%. The "S" stands for saturation.
- SpO_2 goes up and down according to how well a person is respiring (breathing) and how well the blood is being pumped around the body.

Cont.

SpO_2 Module - Pulse Oximeter

Different Definitions

Acronym	*Definition*
SpO2	Pulse Oximeter Oxygen Saturation
SPO2	Saturation of Peripheral Oxygen
SPO2	Spot Oxygen Saturation
SPO2	Saturation of Hemoglobin with Oxygen As Measured by Pulse Oximetry.

Cont.

SpO_2 Module - Pulse Oximeter

- The reading, obtained through pulse oximetry, uses a light sensor containing two sources of light (red and infrared)
- The light is absorbed by hemoglobin and transmitted through tissues to a photo detector.
- The amount of light transmitted through the tissue is then converted to a digital value representing the percentage of hemoglobin saturated with oxygen.
- It is calculated according to the following formula:

http://www.youtube.com/watch?v=qbsfvbz91AA&feature=related

$$S_pO_2 = \frac{HbO_2}{HbO_2 + Hb} \text{ X 100}$$

CO_2 Module

Capnometry

- The measurement and numerical display of the exhaled CO_2 maximum level.
- In normal lungs, the amount of CO_2 exhaled is very close to the level of CO_2 in the blood.
- It indicates how much CO_2 is being eliminated from the lungs by measuring exhaled CO_2.

Capnography

It is the graphic display of instantaneous CO_2 concentration versus time.

Cont.

CO_2 Module

- It may provide an early warning that the lungs are not functioning properly.
- It is a sensitive indicator of lung function and may help guide the doctor, nurse, or respiratory therapist to adjust the breathing machine.
- It is also widely used as a safety device because it is a fast and reliable indicator of proper placement of a breathing tube.
- Not all ICU patients require capnography.

Cont.

CO_2 Module

- The infrared measurement method is most widely used and most cost-effective.
- The infrared capnometer contains a source of infrared light, a chamber containing the gas sample, and a photo detector.
- When the exhaled CO_2 passes between the beam of infrared light and photo detector, the absorbance is proportional to the concentration of CO_2.
- It must be calibrated periodically, at different intervals in various models as per the manufacturers' guidelines.

Cont.

CO_2 Module

$ETCO_2$ – End Tidal CO_2

- $ETCO_2$ is the partial pressure or maximal concentration of CO_2 at the end of an exhaled breath, which is expressed as a percentage of CO_2 or mmHg.
- The normal values are 5% to 6% CO2, which is equivalent to 35-45 mmHg. CO_2 reflects cardiac output (CO).

Cont.

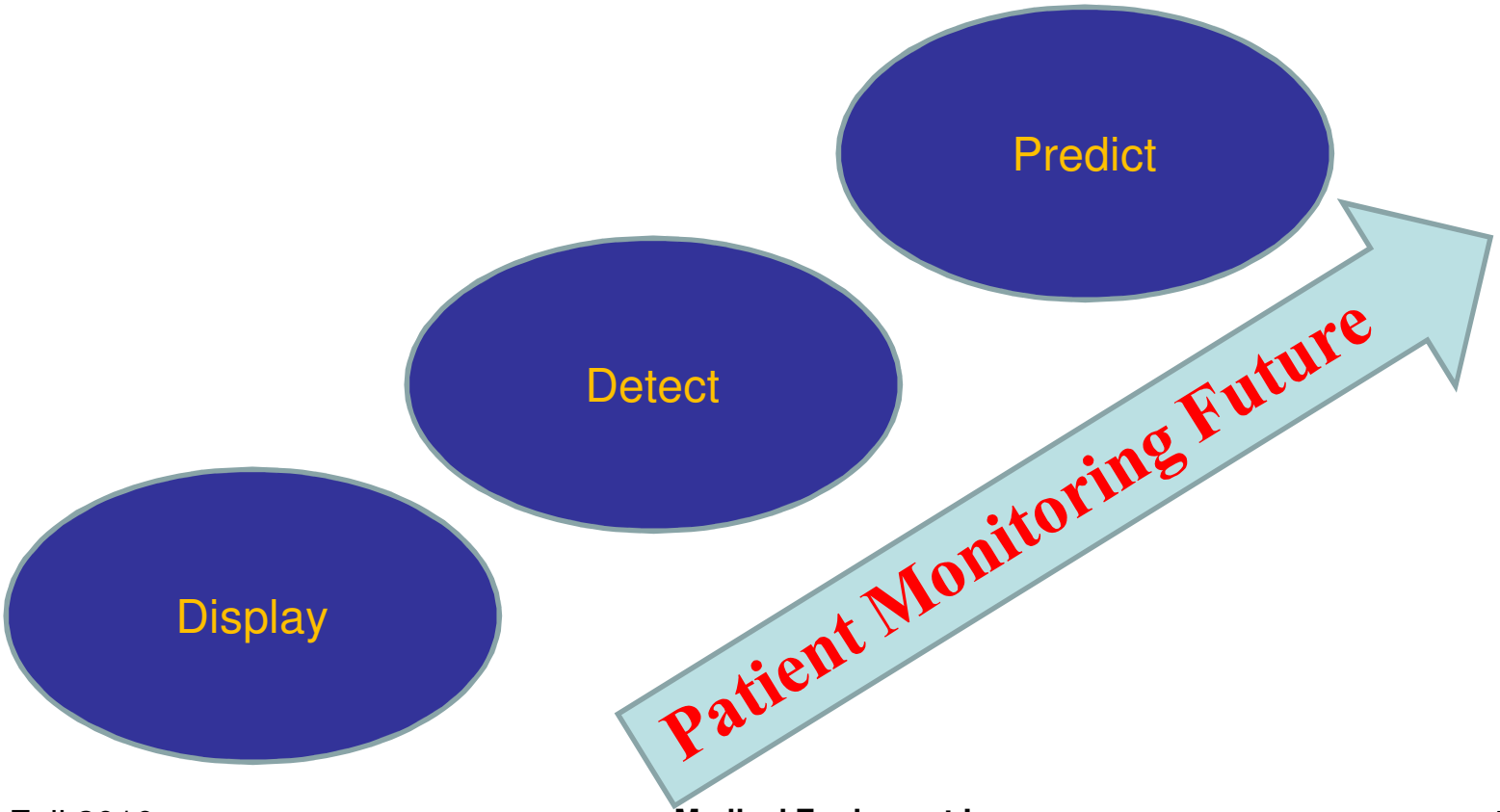
CO_2 Module

http://www.youtube.com/watch?v=9lrja6C0Quc

Other Patient Monitoring Measurements

- Cardiac Output (***CO***) is the volume of blood being pumped by the heart.
- ***APNEA*** is a term for suspension of external breathing.
- ***RESP*** monitors the respiratory system functionality/cycle.
- Pulse Oximeter ***PLETH*** (Plethysmograph) - A pulse oximeter measures oxygen saturation level (SpO_2) and the change in the volume of arterial blood with each pulse beat.
- Premature Ventricular Contraction (***PVC***), or Ventricular Premature Contraction (***VPC***), or Ventricular Premature Beat (***VPB***) - In a normal heartbeat, the ventricles contract after the atria, however, in a PVC, the ventricles contract first, which means that circulation is inefficient "skipped beat".
- Rates measurements and changes over time.

Patient Monitoring Future



Questions ?