19BMT202

Biomedical Sensors and Measurement

Unit – 4 Measurement of Non-Electrical Parameters

UNIT IV
Measurement of Non-Electrical Parameters

Invasive and non-invasive measurement of blood pressure

- **Invasive (direct) blood pressure measurement**
  - Measures blood pressure directly by connecting the bloodstream to a pressure transducer, usually by a column of incompressible fluid (eg. saline)
  - **Sources of error include:**
    - Transducer positioning ("levelling") and calibration
    - Damping and resonance, and all the things that affect it, for example length of water-filled tubing, air bubbles, clots, and the position of the catheter in the vascular tree
- **Non-invasive (indirect) blood pressure measurement**
  - Relies on a known counter pressure to change the characteristics of downstream blood flow, which can be detected and related to the pressures in the circulation
- **Methods of indirect BP measurement:**
  - Oscillometric (measures MAP, estimates SBP and DBP)
  - Auscultatory (measures SBP and DBP, estimates MAP)
  - Pulse palpation (measures SBP only)
  - Flush (measures SBP only)
  - Ultrasound (measures SBP and DBP, estimates MAP)

- **Oscillometric measurement:**
  - The arterial pulse changes the volume of a limb
  - This change in volume produces a change in pressure in an encircling cuff
  - The cuff is deflated gradually, and the maximum amplitude of the pressure change is recorded as the MAP
  - SBP and DBP are then calculated from the MAP using various algorithms
- **Auscultatory measurement:**
  - A cuff is inflated to obliterate distal blood flow, and the distal artery is auscultated
  - As the cuff is deflated, blood released into the distal limb makes characteristic sounds, which can be related to the pulse pressure range
  - By this means, SBP and DBP can be measured, and MAP is calculated from these values
- **Sources of error of NIBP methods**
  - Incorrect technique (eg. wrong cuff size, deflation speed too fast)
  - Interference with measurement (eg. patient movement, AF)
  - Unavoidable errors of calculation (i.e. use of equations and constants to calculate derived variables from measured values)
- **Limitations of NIBP methods**
  - Oscillometric measurement overestimates BP in hypotension and underestimates BP in hypertension
  - Auscultatory measurement underestimates BP in hypotension, and may be unable to detect BP in low cardiac output states
  - Reliability of these methods rests on the correct matching of cuff width and length to the patient's arm size.

Blood Pressure Measurement: Invasive vs Non-Invasive Methods		
Domain	**Invasive (arterial catheter)**	**Non-invasive (cuff manometer)**
Equipment	• Arterial catheter • Incompressible tubing • Pressure transducer • Monitoring • Counter pressure fluid	• Inflatable cuff • Cuff manometer • Release valve
Physical principles and method	• Pressure wave transmitted via fluid column • Pressure changes are converted to resistance changes in a Wheatstone bridge transducer • The resulting change in current is displayed as a graph • By calibrating the sensor against a known range of pressures, this can be converted to a graph of pressure over time	• Counter pressure is applied to a perfused limb • Pulse from the limb arterial supply is detected (eg. by auscultation) • Increasing counter pressure is applied to the limb • This counter pressure decreases the amplitude of the detected pulse until the pulsations are no longer detected • The counter pressure at which pulse is eliminated is recorded as the systolic pressure; • Maximum counter pressure at which there is no pulse amplitude change is recorded as the diastolic pressure
Practical advantages	• Thought to be the "gold standard" • Allows continuous monitoring • Gives access to the bloodstream for sampling • Waveform is a source of information	• No invasive procedures required • Cheap and reusable • Requires minimal training • Requires no monitoring equipment or electronics • Minimal moving parts, robust setup, durable • Does not require regular recalibration
Practical disadvantages	• Requires arterial puncture • Non-reusable kit • Monitoring equipment is required for display • Requires regular re-zeroing and re-leveling • Training is required for staff • Transducers can drift • Relatively expensive parts	• Less reliable measurements at pressure extremes • Continuous monitoring is not possible • Can become painful if set to repeat too frequently • Can give rise to pressure areas • Maximum accuracy requires manual operation (i.e. automatic modes are unreliable in unstable patients)