Graduate School of Biomedical Engineering
BIOM9420

Cardiac Monitoring Tutorial

Answers only

Answers

Test 1 Answers

a) Refer to the lecture notes, and the worked example, on slides 33-34.
RA = -0.2mV, aVR = -0.45mV.

$$I = LA - RA$$
$$RA = LA - I$$
$$RA = 0.3 - 0.5 = -0.2\, mV$$
$$aVR = RA - \frac{(LA + LL)}{2}$$
$$aVR = -0.2 - \frac{0.3 + 0.2}{2}$$
$$aVR = -0.45\, mV$$

b) No, it's mainly signal noise. Notice how the signal in I, V4-6 has normal elements of the ECG waveform, with some distorted signals at the start. Compare these waveforms with those in the lecture notes. So you could say that the electrical activity is normal, but there is a lot of noise present.

c) Reasons include: Poor electrode attachment, unshielded cables, 50Hz noise, interference from other electrical signals in the body, cables become unattached. To mitigate: Use correct electrodes (attached correctly), ensure cables are attached, aware of possible contaminants of noise (mobile phone), ensure electrodes are located properly anatomically.

Test 2 Answers

a) This is a trick question: Most students will use the diagram on slide 40 as an example, and line up the three points on the y axis. This gives SP ~ 170mmHg, DP ~ 20 mmHg and MAP ~ 100mmHg. The hypertension classification is Grade 2 hypertension with isolated systolic hypertension. However, as discussed in the lecture, this is not necessarily how all oscillometric BP devices work. We always need to check that the values we measure are physiologically reasonable. While SP and MAP are reasonable, DP is not (as highlighted in part b) of this question.

b) To get the correct DP reading, use the equation on slide 36 (repeated on slide 38) and rearrange for DP. This process assumes that our oscillometric readings for SP and MAP are correct. DP = (3*100-170)/2 = 65mmHg.

c) Disadvantages include: White coat hypertension, and only measuring the BP once. To mitigate both, Harry should use an ambulatory blood pressure measurement. Another disadvantage is that this may be a distal blood pressure measurement, in which the systolic blood pressure is higher than that at the heart. You (the engineer) would need to check whether this device measures distal pressure or whether it is an estimate of the proximal (true) arterial blood pressure.

Test 3 Answers

a) 5.1 L/min. Use the equations on slide 50 (and example on slide 52) of the lectures

$$VO_2 = O_2 \text{ out} - O_2 \text{ in} = 220\text{mL/min}.$$

$$\mathrm{CO} = \frac{\mathrm{VO_2}}{\left(\mathrm{O_2}_{\mathrm{pv}} - \mathrm{O_2}_{\mathrm{pa}}\right)}$$

$$\mathrm{CO} = \frac{220\ \mathrm{mL/min}}{210\frac{\mathrm{mL}}{\mathrm{L}} - 167\ \frac{\mathrm{mL}}{\mathrm{L}}}$$

$$\mathrm{CO} = \ 5.1\ \mathrm{L/min}$$

b) Use the same equation as a), but rearrange for VO2

$$\mathrm{VO_2} = \mathrm{CO} * \left(\mathrm{O_2}_{\mathrm{pv}} - \mathrm{O_2}_{\mathrm{pa}}\right)$$

$$\mathrm{VO_2} = 5.1 * \ (215 - 170)$$

$$\mathrm{VO_2} = 229.5\ \mathrm{mL/min}$$

c) Not a direct measurement of cardiac output. Relies on accurate determination of O_2, which requires sampling blood from the pulmonary venous and systemic arterial systems. There are formulae for determining oxygen concentration from haematocrit concentration, but they may be inaccurate. Also, the location that you take blood from also affect the reading – you want to be as close to the lungs as possible, but this is not always practical to do. Requires an analysis of oxygen inhalation and exhalation, which can be expensive. There are assumptions that you can make in the absence of the breathing analysis, but they are assumptions which may not apply to everyone.

Test 4 Answers

a) Use slide 53 (and example on slide 56) to explain

$$CO = \frac{amount\ of\ dye\ injected}{area\ under\ curve}$$

$$CO = \frac{30}{0.5 * 11 * 0.084}$$

$$CO = 64.94\frac{mL}{s}$$

$$CO = 3.9\frac{L}{minute}$$

b) The indicator dilution technique only measures the flow in one segment of the circulatory system. The measurement points in this example are the Inferior vena cava and the radial artery. There are branching vessels between these two points (particularly along the aorta – there are other branches going to the brain and left side of the body whose flow is not measured), so the measured flow is only a fraction of the total cardiac output. To get a true cardiac output, the clinicians need to perform this procedure along the aorta, prior to any branches. This is difficult to do – it's hard to access the aorta without uncomfortable catheterisation, while the radial artery is easy to access. Also, the coronary arteries branch off the aorta almost immediately distal of the aortic valve, so it would be difficult to get a true cardiac output measure using this technique even while measuring in the aorta.

c) Indicator dilution: Injects a dye or drug into the blood stream, relies on complex methods to measure concentration (such as light absorption). Thermodilution: injects a cold fluid upstream, and measures temperature of fluid downstream to measure transit time of cold fluid. Temperature is a lot easier to measure than dye concentration, so thermodilution has superseded indicator dilution. Thermodilution using a Swan-Ganz (once implanted) is very time-efficient, more so than indicator dilution. Multiple measurements can be taken over time. However, there are disadvantages with catheter associated morbidity. This is not an easy procedure to perform, and so there is a risk for the patient. However, once the Swan-Ganz catheter is inserted then the cardiac output measurement is easy to perform.