Graduate School of Biomedical Engineering
BIOM9420

Cardiac Monitoring Tutorial

Student's copy

This tutorial involves team-based activities, and there is a prize for the team with the most points at the end.

Activity 1: Racing Hearts

Everyone in the team must measure their own heart rate. Then, as a team, they must calculate:

- average heart rate for the team
- sample standard deviation for the team (you may have to search how to do this)
- How confident they are that their average value is representative of their team (0-100%)?

Teams must write final values down before time is up for points to be counted. Spokesperson will share their answers with the rest of the group.

Time limit: Strictly two minutes

Points awarded

- **Team with the highest average heart rate: 1 Point**
- **Team with smallest sample standard deviation: 1 Point**
- **Team/s with highest confidence level: 1 Point IF the team can give a valid scientific reason why they have such a high confidence level.**

Activity 2: Harry the Heart Failure Patient

Harry is experience shortness of breath when exercising, which is a classic symptom of heart failure. After visiting his General Practitioner, he is sent to the local cardiac rehabilitation clinic for a suite of different tests:

- echocardiogram
- oscillometric blood pressure measurement
- cardiac output measured using the Fick Principle
- cardiac output measured with indicator dilution.

In a hospital environment, clinicians will use results from a range of tests. Clinicians may meet with biomedical engineers in the real world to discuss the tests, particularly the caveats of each test, so you must be aware of them. Lucky for you, you've just been exposed to these tests in the lecture!

In this tutorial, each team will look at *one* of these tests, answering some questions based on the results.

Then, we'll simulate a meeting of clinicians to discuss Harry's tests results, by bringing the teams back together. The spokesperson from each team should be prepared to present their team's answers to the class – they can use the whiteboard or use the main screen to show which formulae from the lecture they used.

Point allocation for each question

- Correct Answer: 1 point
- Good explanation of each answer (Regardless as to whether the answer is correct or incorrect): 1 point
- Bonus points awarded at tutor's discretion – extra research (Search engines are your friend!).

Test 1: Echocardiogram

a) A three lead ECG is used on Harry, and at a certain point in time: the left leg is at +0.2 mV; the left arm is at 0.3mV; and lead I is reading 0.5 mV. Calculate the right arm voltage, and the aVR voltage.

b) A nurse has attached a 12 lead ECG to Harry and they note "chaotic electrical activity" on the monitor. The waveform is shown in Figure 1 (top), compared to a normal looking ECG waveform (bottom). The nurse thinks that this patient is suffering from ventricular fibrillation. Do you agree with their assessment? Why/why not?

c) Name three factors that can cause noise in ECG signals? How can the nurse mitigate these factors? Hint: You many need to think outside the lecture notes!

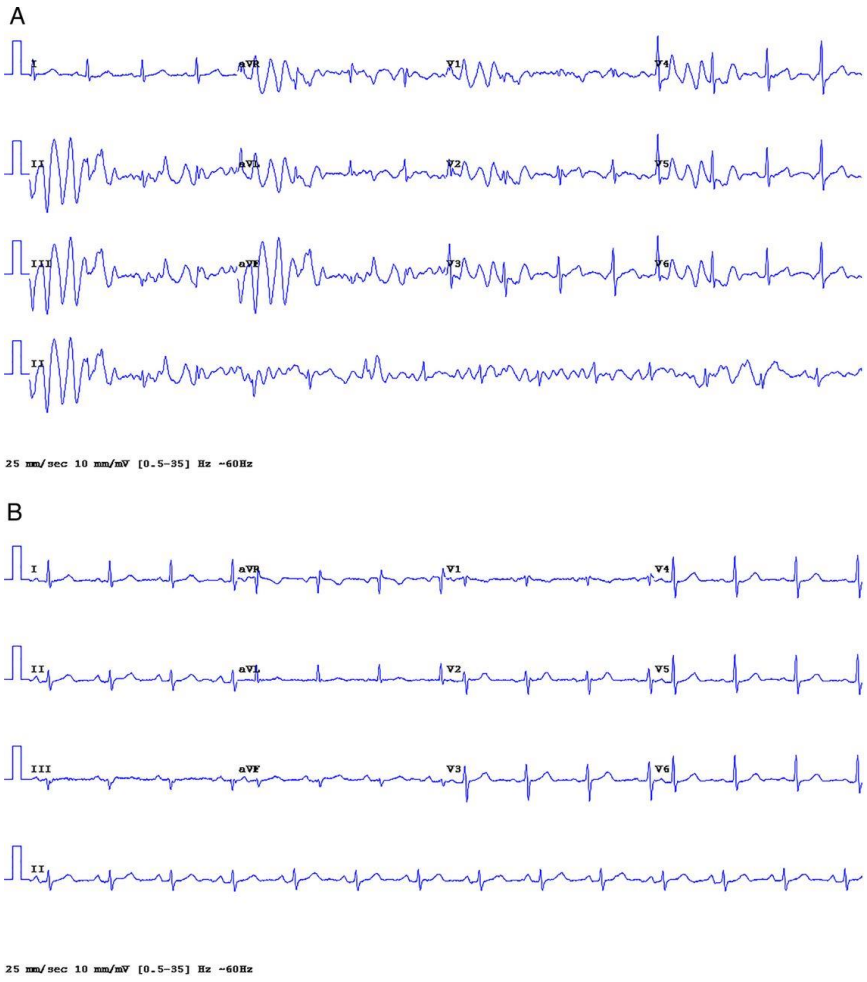

Figure 1: Harry's 12 lead ECG (A) compared to a normal 12-lead ECG (B).

Figure sourced from Khan GM A new electrode placement method for obtaining 12-lead ECGs. Open Heart 2015;2:e000226. doi: 10.1136/openhrt-2014-000226

Test 2: Oscillometric Blood Pressure Measurement

a) Using the oscillometric test result in Figure 2, give values for systolic, diastolic and mean arterial blood pressure, and diagnose the stage of hypertension using the table in Figure 3.
b) Your colleagues note that the body needs a minimum diastolic arterial pressure of 60mmHg for your end organs to receive correct oxygenation. Check your answer from part (a) – does it meet this requirement? If not, then determine the correct value. Hint: You may need to check the lecture notes on blood pressure to calculate this.
c) Name two disadvantages with performing blood pressure measurements using a cuff-based device and describe how Harry and his clinical team could mitigate these disadvantages.

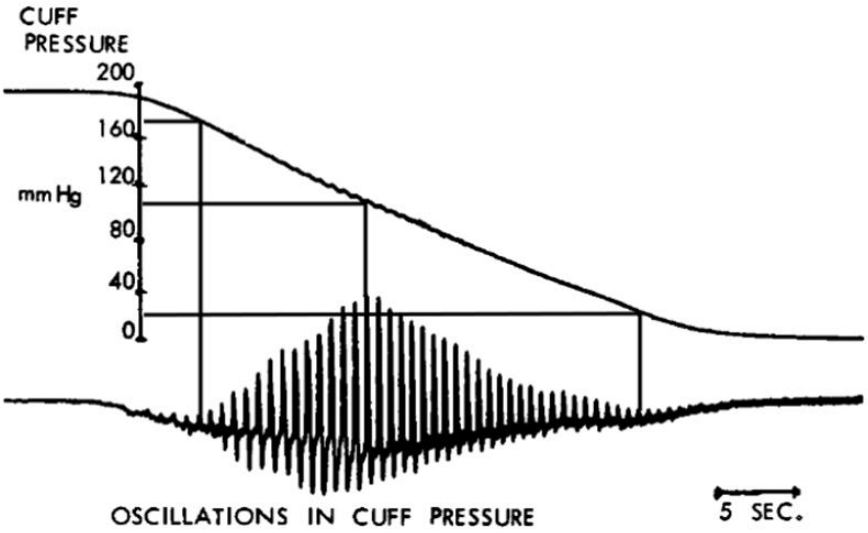

Figure 2: Oscillometric Blood Pressure Results for Harry

Definitions and classification of office blood pressure levels (mmHg)

Category	Systolic		Diastolic
Optimal	<120	and	<80
Normal	120–129	and/or	80–84
High normal	130–139	and/or	85–89
Grade 1 hypertension	140–159	and/or	90–99
Grade 2 hypertension	160–179	and/or	100–109
Grade 3 hypertension	≥180	and/or	≥110
Isolated systolic hypertension	≥140	and	<90

G. Mancia, R. Fagard, K. Narkiewicz, J. Redon, A. Zanchetti, M. B ohm, et al., 2013 ESH/ESC Guidelines for the management of arterial hypertension: The Task Force for the management of arterial hypertension of the European Society of Hypertension (ESH) and of the European Society of Cardiology (ESC)., European Heart Journal. 34 (2013) 2159–219.

Figure 3: Classification of Hypertension

Test 3: Cardiac Output using Fick's Principle

a) Harry undergoes blood tests that reveal that the Oxygen (O_2) concentration in the arterial system is 210 mL/L and in the venous system is 167mL/L. An analysis of Harry's breathing reveals that he breathes in 1050 ml/min of O_2 and exhales 830 mL/min of O_2. Using the Fick principle, determine Harry's approximate cardiac output.
b) Harry comes in for a follow-up measurement, which reveals his O_2 concentration in the arterial and venous systems are 215 and 170 mL/L respectively. However, the breathing analysis machine is broken. If Harry's cardiac output is unchanged from part (a), calculate the approximate oxygen consumption (VO_2) during this second test.
c) Describe at least one caveat of using the Fick Principle to determine cardiac output. Hint: Think about how Oxygen concentration is measured, and at which points in the circulation.

Test 4: Cardiac Output using Indicator Dilution Technique

Harry undergoes an indicator dilution technique to corroborate the cardiac output measurement from Test 3. 30mg of dye is injected into the inferior vena cava. Figure 4 shows the concentration of dye in his radial artery over time.

a) Calculate the approximate cardiac output.
b) The average cardiac output is approximately 5 L/min. Compare your answer from a) to this value and explain why there is a difference. What should the clinicians change about this measurement to correctly measure true cardiac output? Is this practical?
c) Explain the difference between an indicator dilution technique and a thermodilution technique. Which test should Harry's clinicians be using? Hint: The answer isn't in the lecture notes – refer to http://www.foxlinton.org/cardiac_output/LDCOpages/indicator_dilution.html

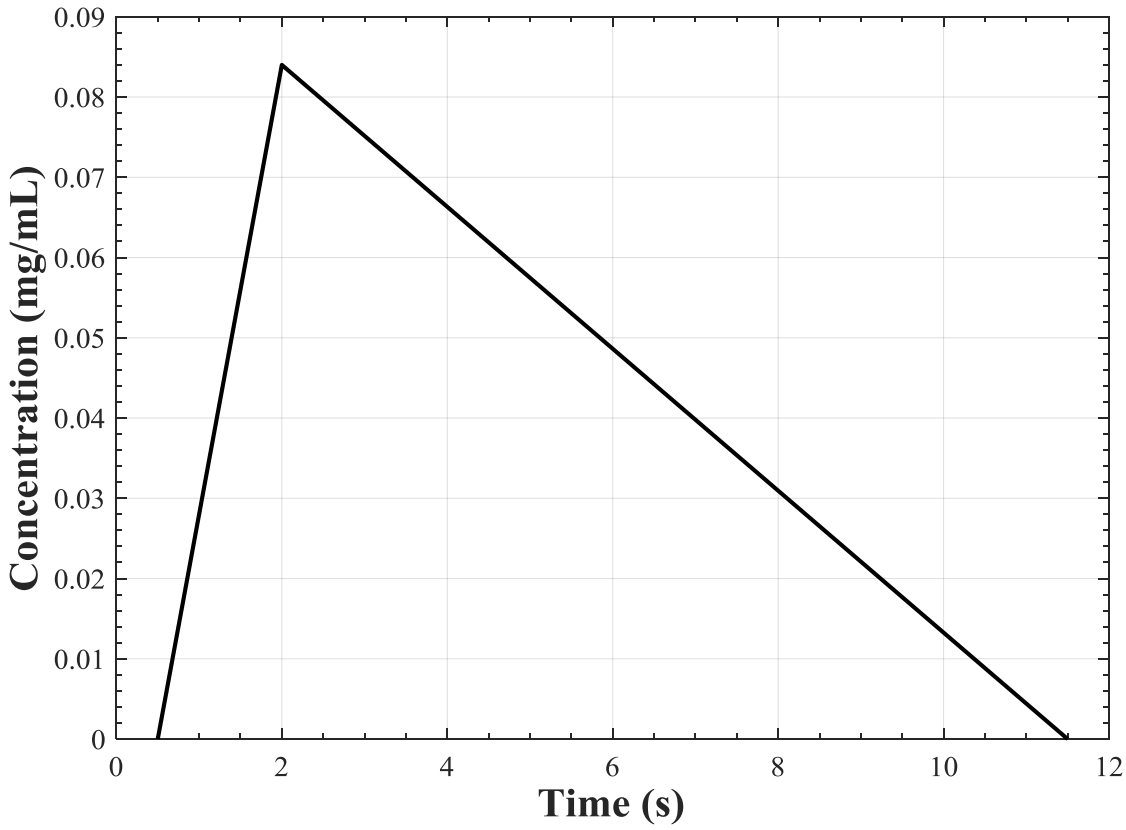

Figure 4: Harry's results from the Indicator Dilution Technique