

ECG Guide

EXAMPLES ILLUSTRATING USE OF EPICARDIO SIMULATION™
DURING GROUP TEACHING SESSIONS

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INTRODUCTION

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The basic ECG trace

What do the various features of the ECG trace represent?

Core Concept

The electrical activity of the heart follows a pattern that is dictated by key anatomical components. Understanding this activity in three dimensions makes interpretation of ECG recordings a logical exercise.

Learning Objectives

1. To be able to describe the anatomy of the main conduction pathway in the heart
2. To be able to explain the main functions of the Sino-Atrial node, Atrio-Ventricular node and the bundle of HIS
3. To be able to draw a typical ECG trace
4. To be able to describe what electrical activity is taking place during each of the main features of the basic ECG
5. To be able to describe the main direction of the electrical vector.

Exercise 1

Introduction

The physiological nature of myocardial conducting cells might be discussed, with an explanation of the role of sodium, potassium and calcium channels and the concept of pre-potential depolarisation.

Instructions to learners

1. Click on the "burger" icon at the top left hand corner of the screen, then click on "User guide" and go to page 4.

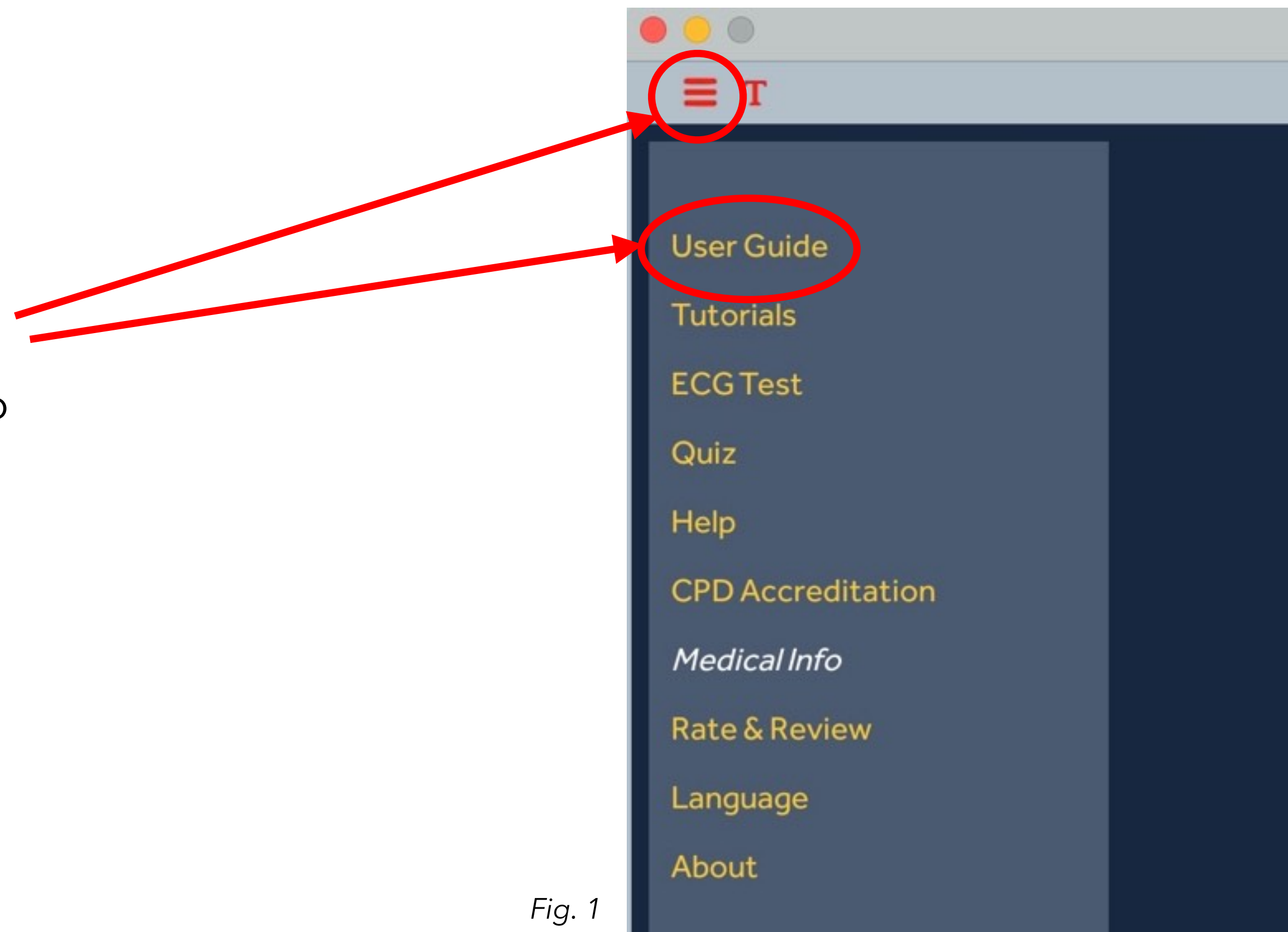


Fig. 1

Exercise 1

The screen will look as in Fig. 2

The User Guide window will also act as the text window for every tutorial.

The Tutorial Parameters window will display physiological parameters and controls that are relevant to each tutorial.

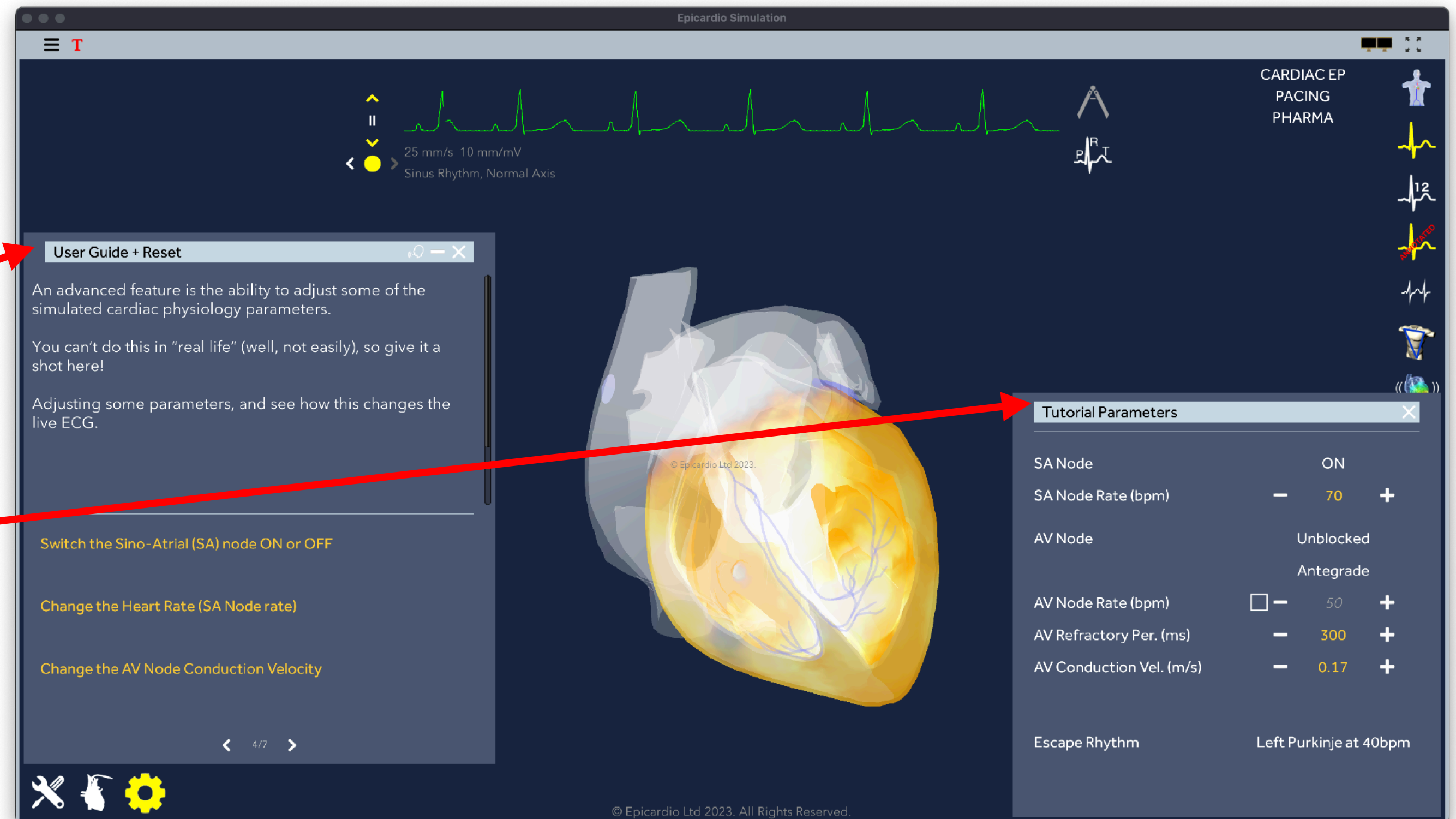


Fig. 2

Exercise 1

Tip: to create more space on the screen you can hide the "User Guide" window by clicking on the "X" in its top right corner. If you need to show it again click on the "T" next to the "burger" icon.

Tip: the "Tutorial Parameters" window can be hidden or shown by clicking on the cogwheel icon in the bottom left corner of the screen.

Tip: clicking on the heart icon next to the cogwheel icon will display a series of anatomy and viewing controls up the left margin; the "+" and "-" signs can be used to zoom in or zoom out on the heart image.

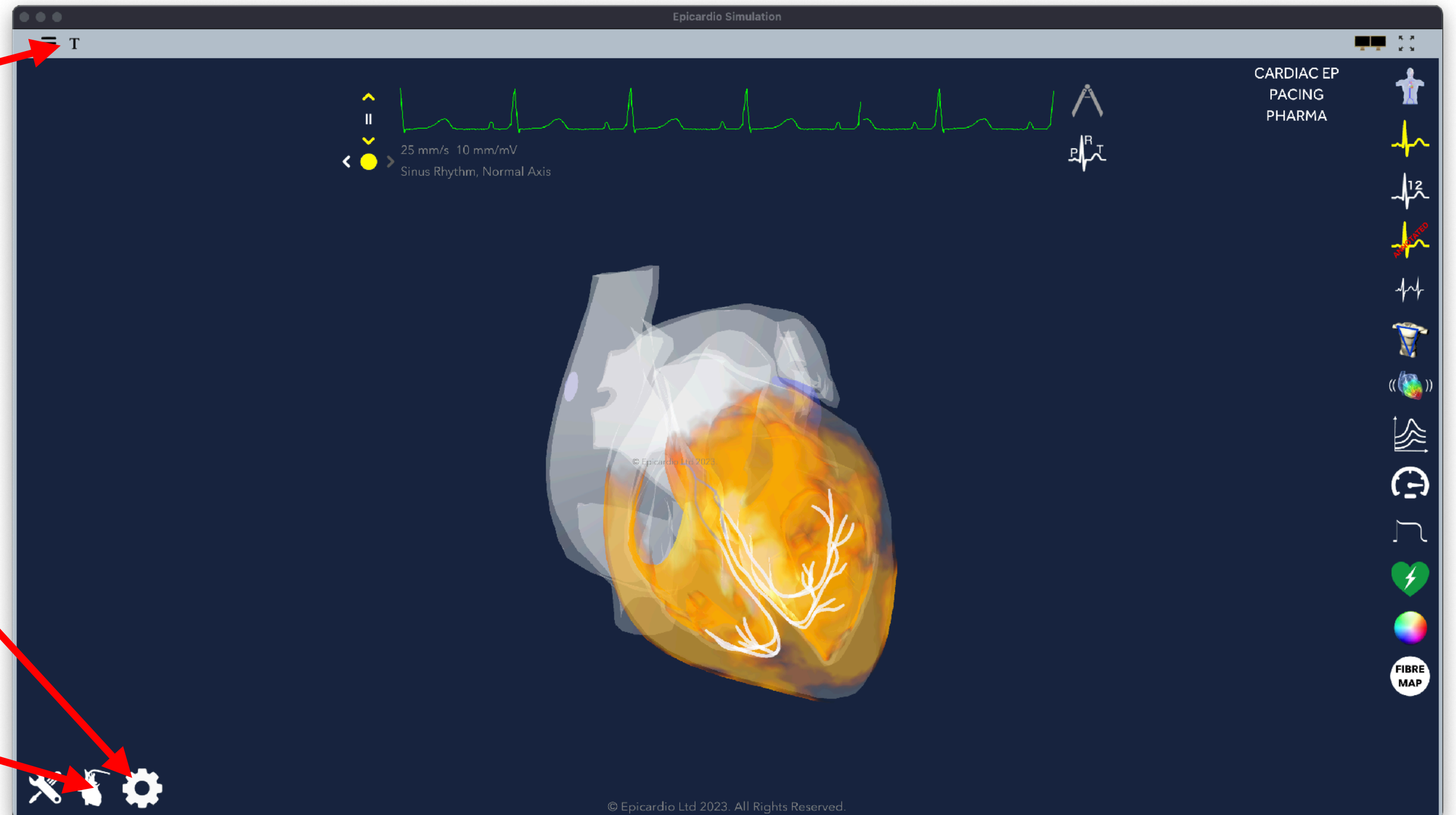


Fig. 3

Exercise 1

2. Explore the propagation of the electrical depolarising wave (transmembrane action potential wave) down the conducting pathways and into the myocardium. Manipulate the heart image by holding the cursor on the image and dragging the image to rotate.

Action: Can you select a view from the anatomy view controls and rotate the image into a position where the SA and AV nodes are easily seen?

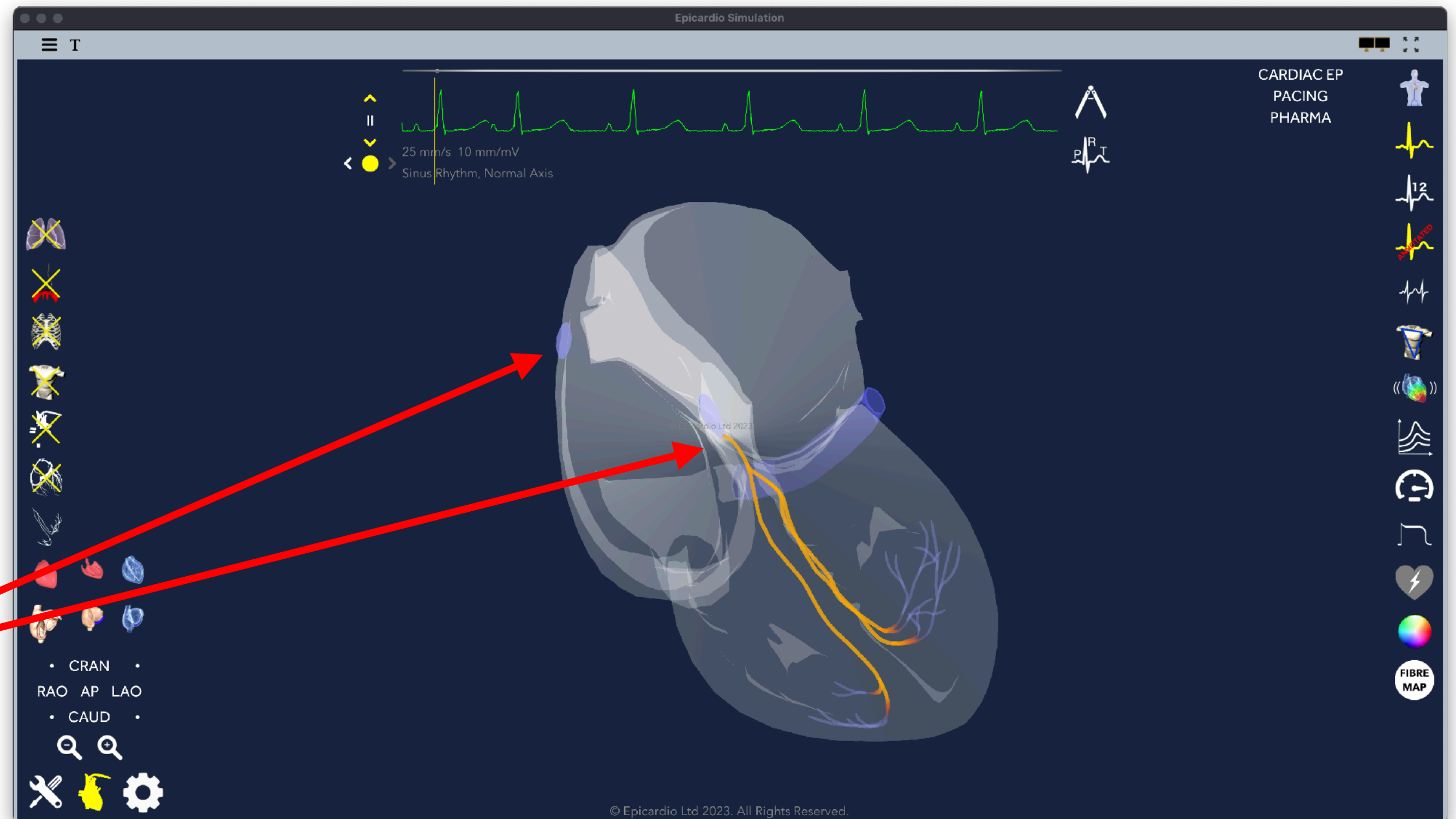


Fig. 4

Exercise 1

3. Pause the simulation by clicking over the ECG trace. A horizontal grey line will appear above the trace, with a small grey link and a vertical yellow line on the trace. You can scroll back the simulation at various points to see what is happening with the depolarisation wave and the corresponding ECG trace.

Action: to scroll you will need to click on the small grey circle on the horizontal line and drag your cursor left and right. Click again on the ECG to continue the simulation.

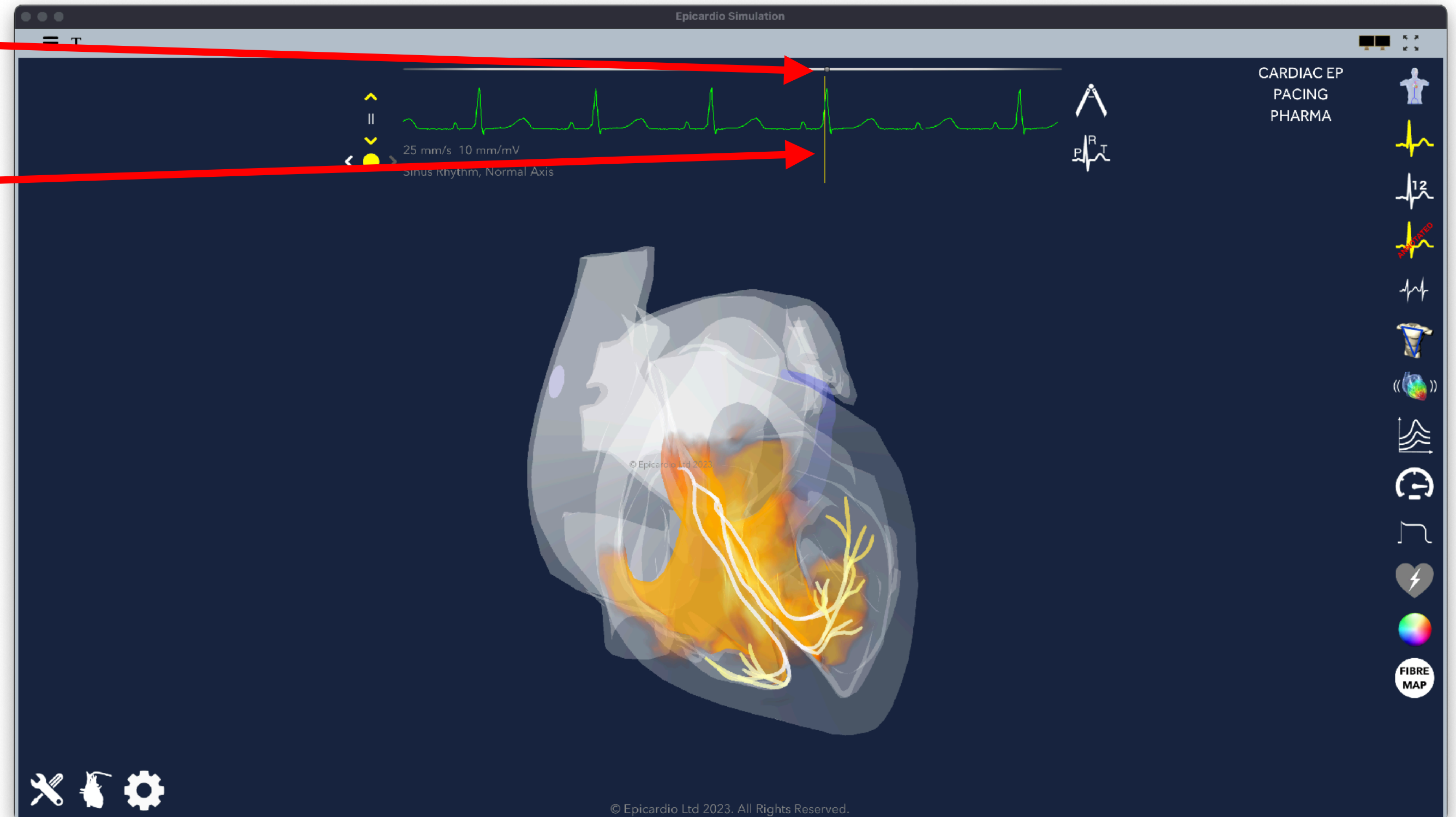


Fig. 5

Exercise 1

4. Observe the pause that occurs when the depolarisation wave reaches the AV node. What happens at the very start of the R wave; where is the depolarisation wave seen at this stage?

Discussion: What is the advantage of the pause in electrical propagation at the AV node? As the simulation is scrolled slowly through the "P" wave and the "QRS" complex, observe what is happening during the phase between the end of the "P" wave and the beginning of the "QRS" complex. Where does the depolarisation of the ventricle first occur?

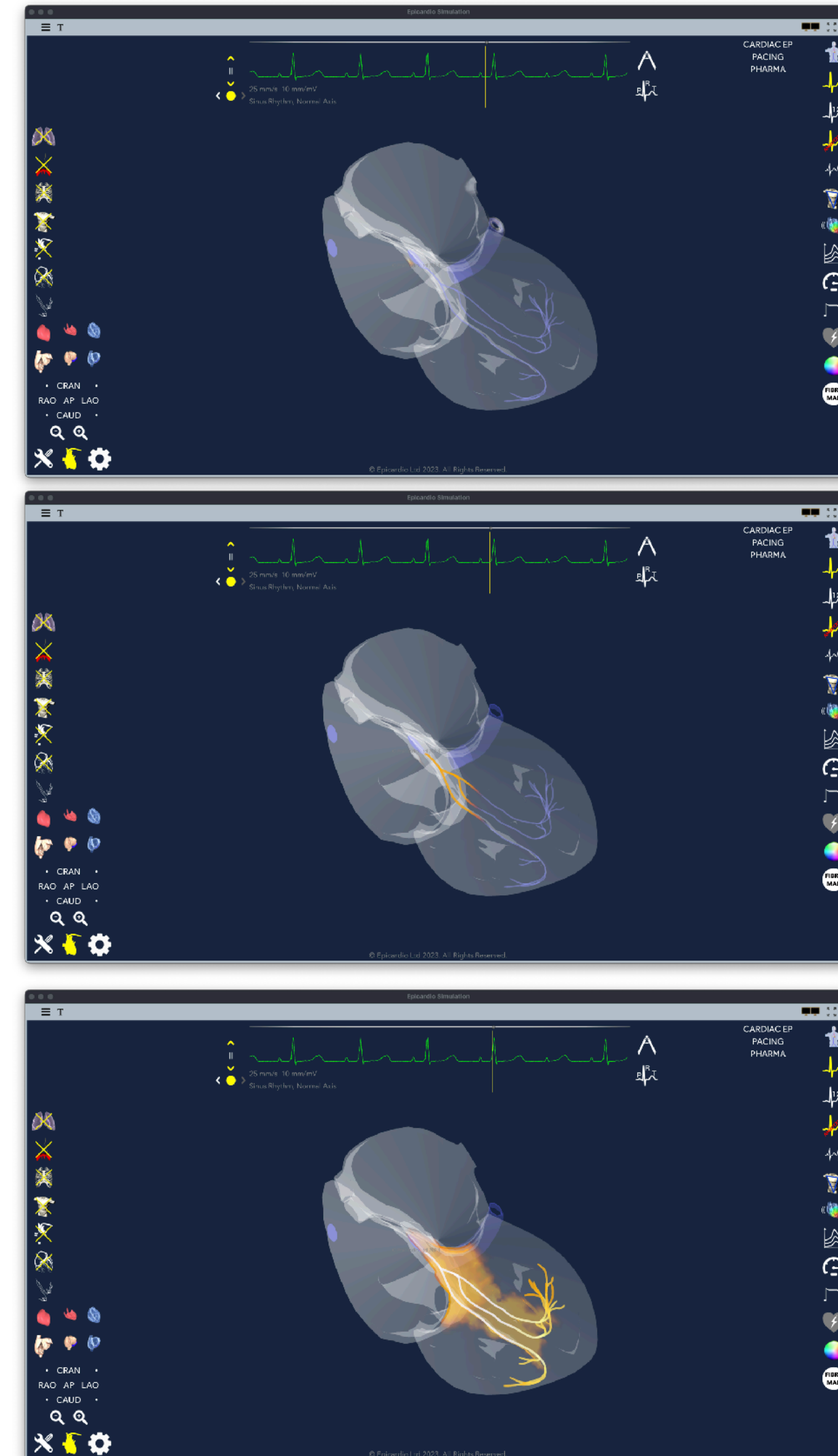


Fig. 6

Exercise 1

Action: To return to the original orientation of the heart image click on the "AP" sign as shown above. Other pre-set orientations can also be selected from these controls, such as cranial view, caudal view etc. and by clicking again on the "AP" (Anterior-Posterior) control the image will move to a PA (Posterior-Anterior) view.

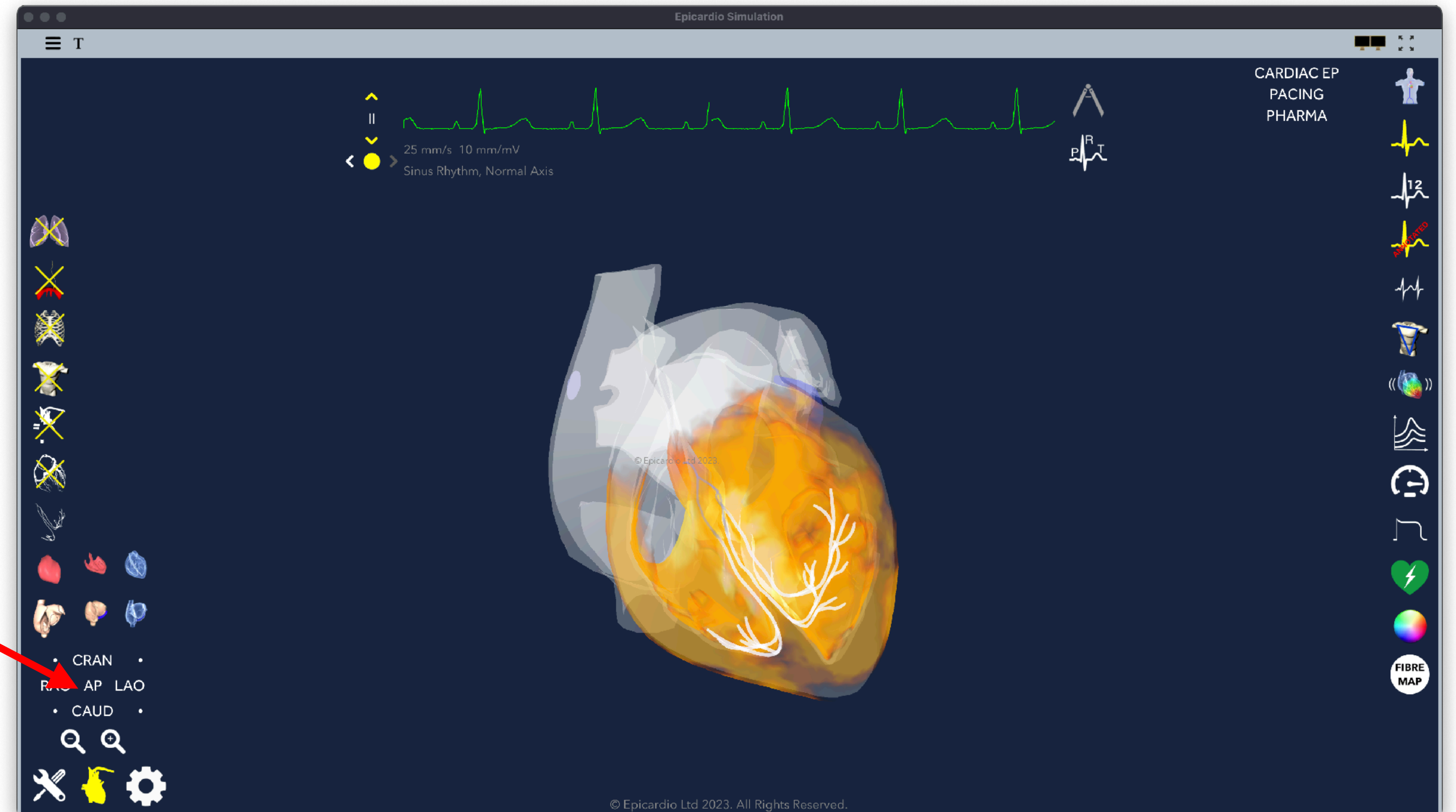


Fig. 7

Exercise 1

5. Open the "Tutorial Parameters" window by clicking on the cogwheel icon. Turn the SA node off and observe what happens to the ECG. Note that the P wave has disappeared but what else has happened?

Discussion: where is the depolarising wave now commencing? If necessary remind the learners to click on the ECG trace and scroll back and then forward again.

Action: what happens if the SA node is turned on again, but the AV node is blocked? What is the relationship between the "P" wave and the "QRS" complex?

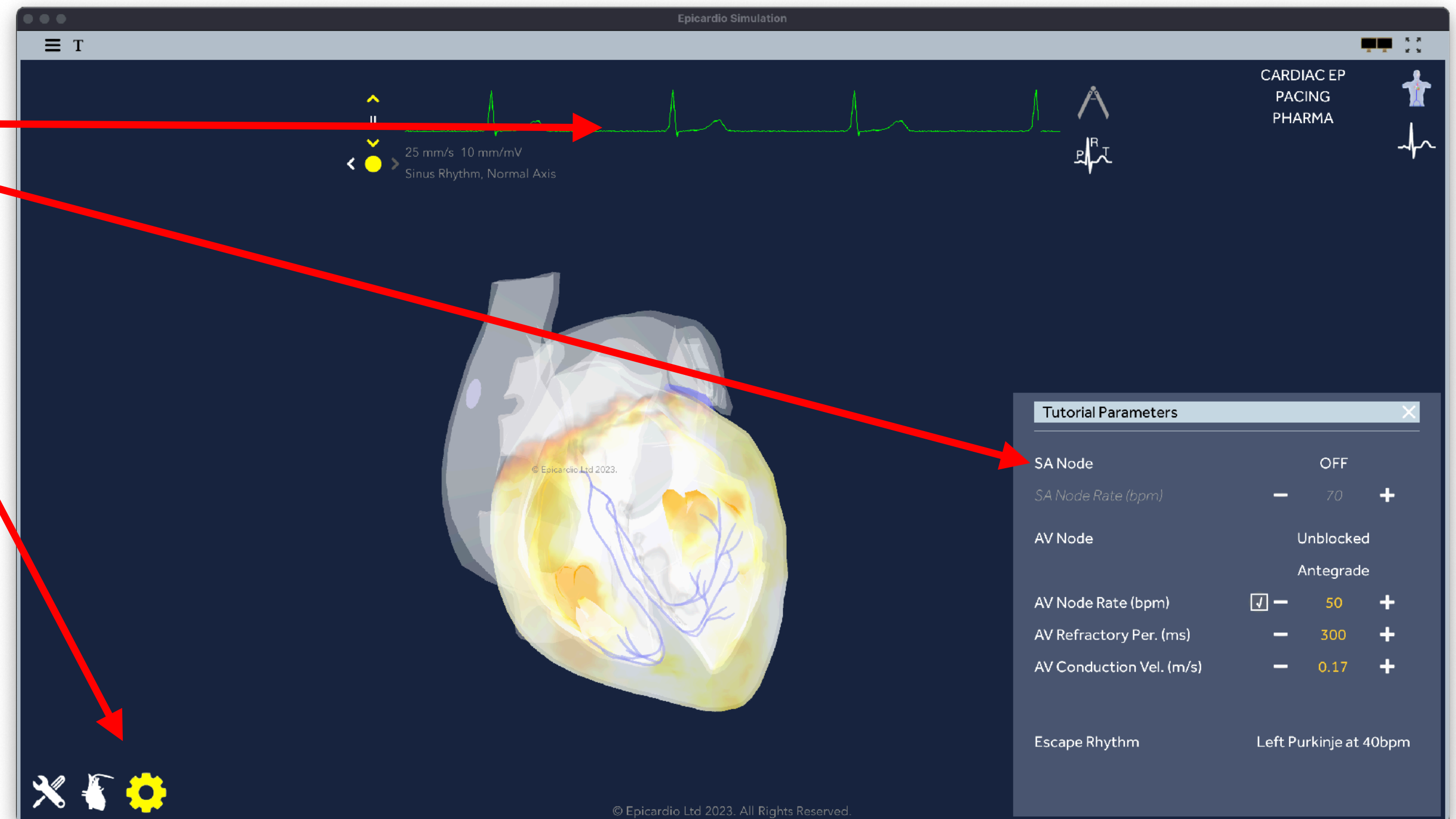


Fig. 8

Exercise 1

6. The previous figures show only a relatively small range of electrical potentials and you will find that nothing appears to be happening during the T wave. To visualise a wider range of electrical potentials on the heart image click on the colour icon in the left margin. By clicking on the colour bar the range of colours to be displayed can be selected and by using the sliders alongside the colour bar the range of transmembrane voltage that is displayed can be selected. Select a range from about 10mV to -60mV.

Action: Now click on the ECG trace to pause and slowly scroll through the trace. What is happening during the T wave? What is happening to the voltage in the atria when the ventricles are depolarising (-ve transmembrane voltage)?

Discussion: Why is the repolarisation of the atria not visible on the normal ECG trace?

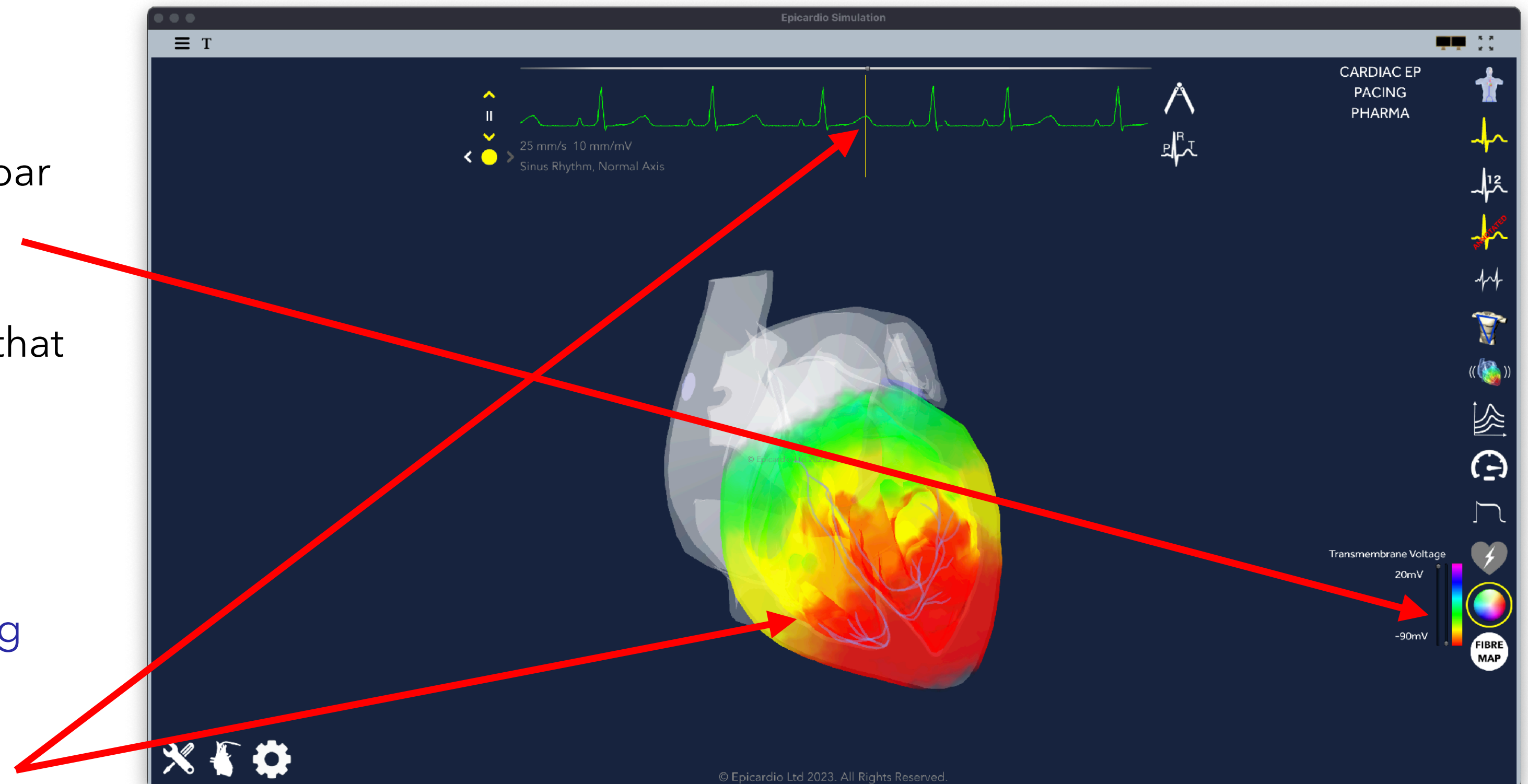


Fig. 9

Exercise 1



Discussion: What has been learnt? Key learning points.

Exercise 1



Pre-Exercise assessment of existing level of knowledge or **Post-Exercise** assessment of gained knowledge

Q1: In the normal ECG the P wave represents:

- a) depolarisation of the right ventricle
- b) depolarisation of the left ventricle
- c) repolarisation of the right ventricle
- d) repolarisation of the right atrium
- e) depolarisation of the atria

Q2: In the heart:

- a) SA node cells are the only ones that can undergo spontaneous depolarisation
- b) Spontaneous depolarisation occurs as a result of slow leakage of calcium ions
- c) Purkinje fibres can undergo spontaneous depolarisation, typically at a rate of 50 bpm
- d) AV node cells, bundle of His cells and Purkinje fibres can all undergo spontaneous depolarisation
- e) The cells of the fibrous skeleton of the heart transmit the repolarising wave

Q3: On the ECG tracing:

- a) The PR wave represents the time for the depolarising wave to pass from the SA node to the bundle of His
- b) The repolarisation of the atria is shown by the T wave
- c) The repolarisation of the atria is hidden within the QRS complex
- d) If there is a complete electrical block at the AV node the QRS complex will be very wide
- e) The T wave represents the depolarisation of the right ventricle

Exercise 1



Answers to questions:

Q1 (e)

Q2 (d)

Q3 (c)

Limb leads, augmented limb leads, chest leads and introduction to cardiac axis

Core Concept of session

Rather than attempting to master basic ECG interpretation by rote learning, it is easier to develop an understanding of the actual electrical activity in the heart; an understanding of how the vector of the electrical activity in the heart will appear on the various leads of the ECG. This helps understand the “viewpoint” represented by each ECG lead.

In this exercise you will explore interactively how the vector is visualised on the ECG, and why the individual features may be seen as either positive or negative on the various leads of the 12-lead ECG.

This exercise presumes knowledge of the what electrical activity is taking place during the “P”, “QRS” and “T” components of the basic ECG.

Learning Objectives

- 1.To be able to describe the “direction of view” of each of the 12 leads of the ECG (i.e. which direction of vector will result in a positive deflection of the trace, and which a negative)
- 2.To be able to predict from basic principles which leads would be expected to show the predominant vector of the QRS complex to be positive and which negative
- 3.To be able to explain the concept of normal cardiac axis and to show how this can be calculated from the ECG
- 4.To be able to show how the chest leads could be used to show if the propagation of the electrical vector to part of the heart is delayed.

Exercise 2

Instructions to learners

1. Learners should: click on the "burger" sign in the top left of the screen; then select "Tutorials - "Basics" - "Introduction to the heart"

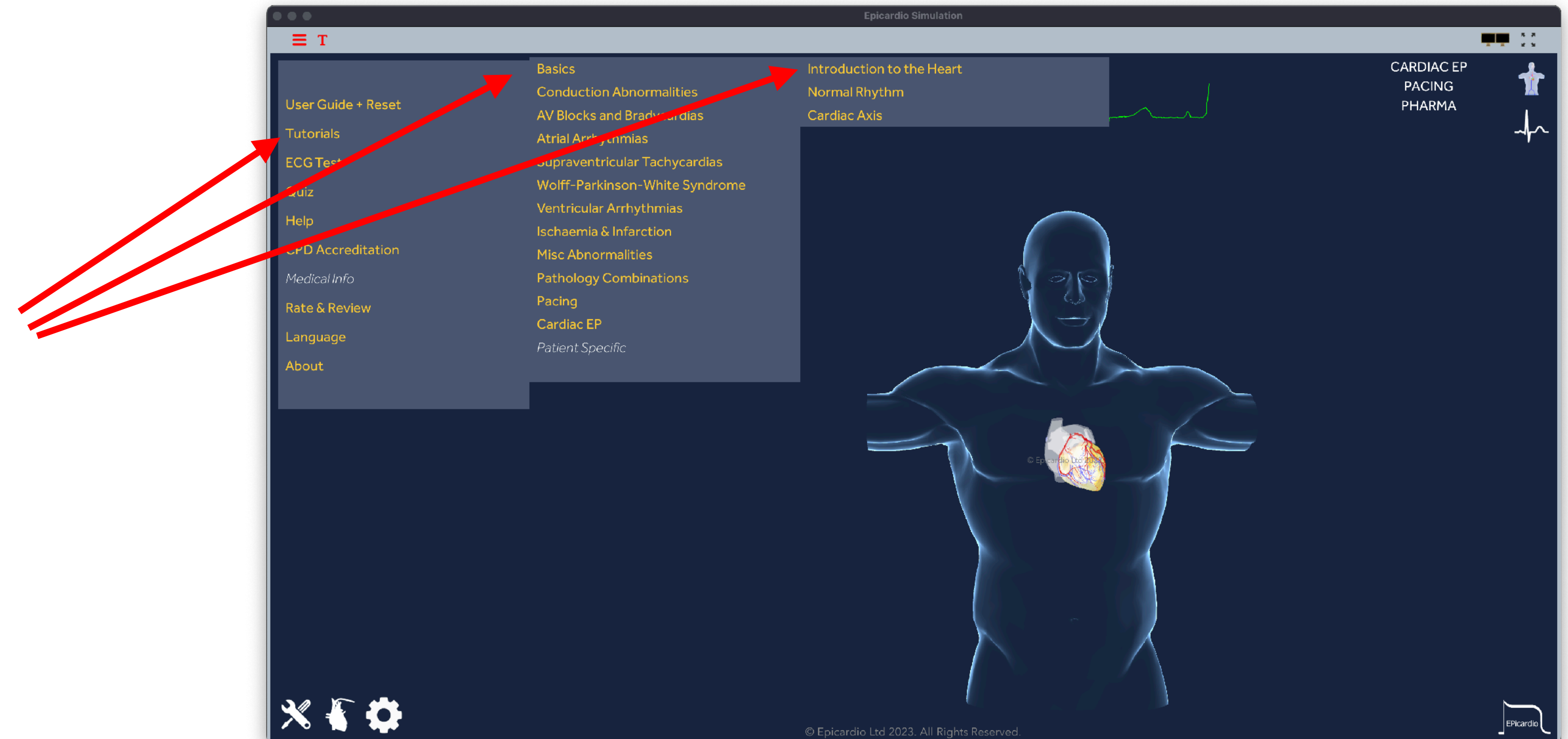


Fig. 10

Exercise 2

2. Go to page 23. Looking at the movement of the white line on the "RA/LL" axis and by reference to the ECG trace at the top of the screen, what is the predominant direction of the electrical vector along this line and from which direction is it being viewed?

Discussion: it can be seen by reference to the vector of the average electrical activity, as shown by the fluctuating white line on the "II" lead, which is highlighted in blue. The moving ECG trace at the top of the screen, has a predominant average electrical activity which is positive. In lead "II" the electrical activity is being seen as if looking from LL (approximately representing the apex of the heart) towards RA (representing the SA node on the right atrium).

Note: the thin guide lines show you the projections of the electrical vector on Lead II and the ECG.

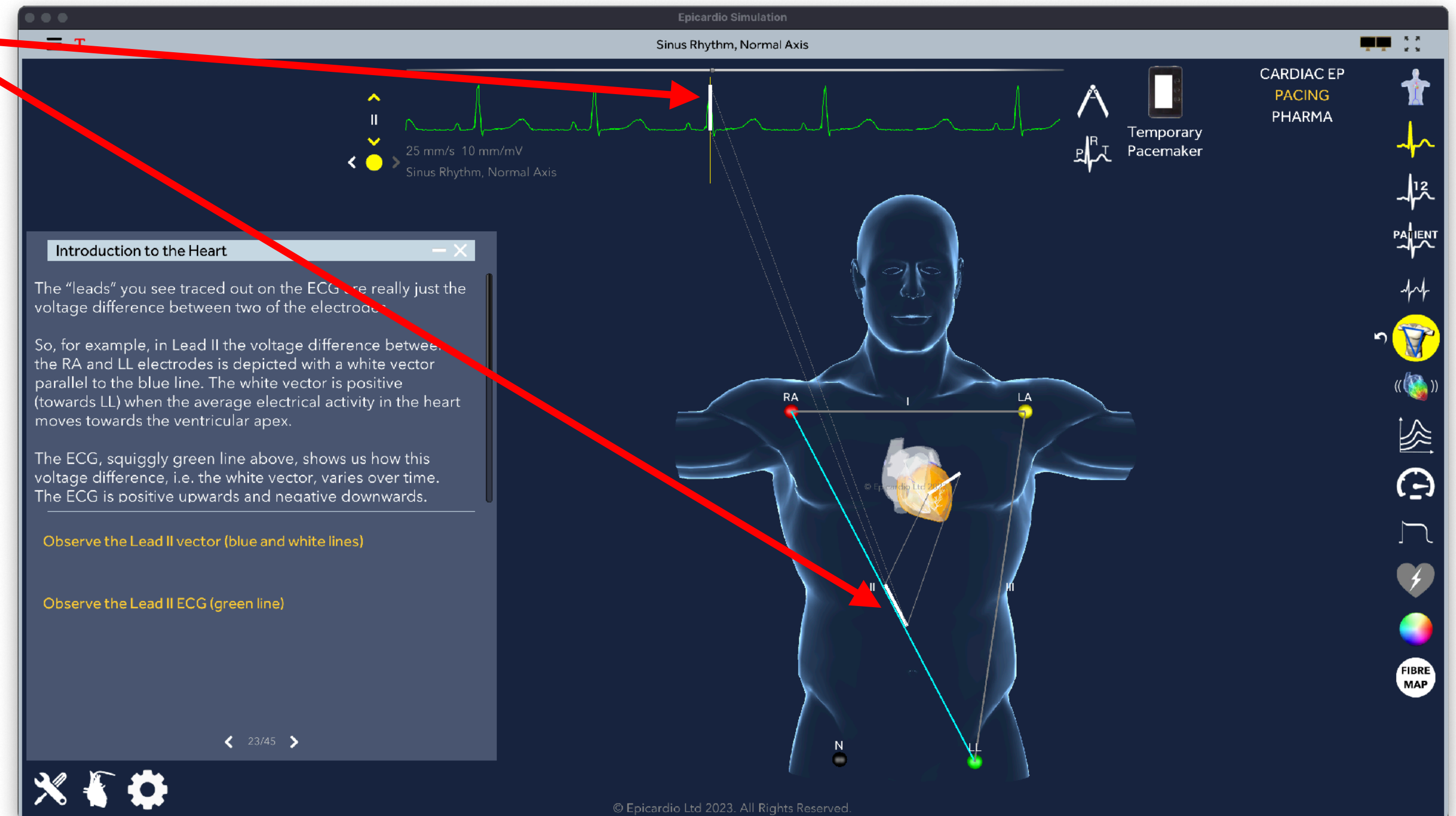


Fig. 11

Exercise 2

3. Using the lead selection control at the left of the ECG trace change the lead to "I".

Discussion: what is the direction of view in this lead. Then change to "Lead III" and consider the direction of view.

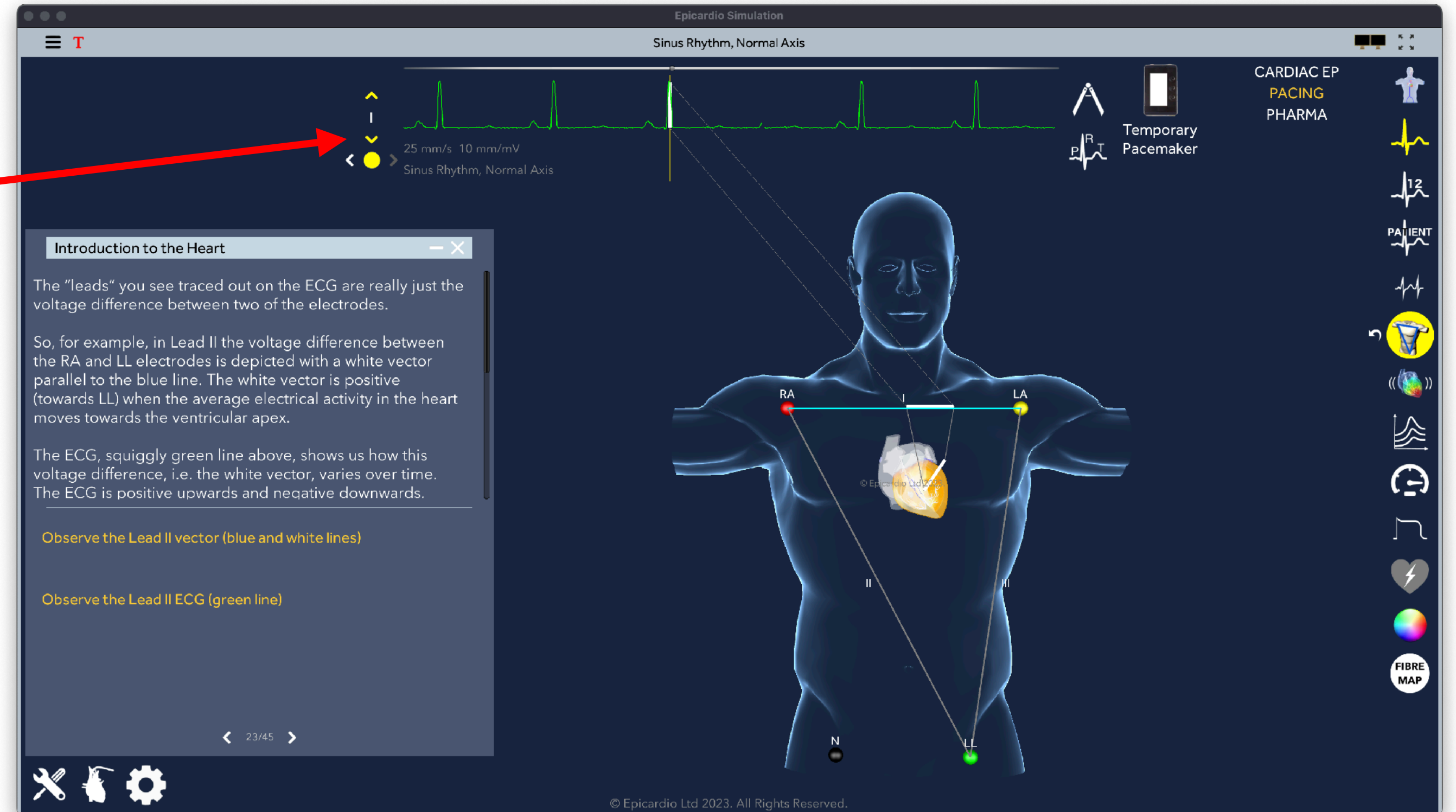


Fig. 12

Exercise 2

4. Go to "page 24". Read the text and then explore the predominant direction of the predominant vector for the QRS complex for each of these three "augmented" leads aVR, aVL and aVF.

Discussion: with particular reference to aVR the direction of the predominant vector can be considered in relation to the different leads. It can be shown that from these six leads the frontal view of the heart can be divided into approximately 30° arcs, from which the axis of the QRS complex can be determined.

Tip: remember that in all of these simulations the orientation of the torso can be changed by holding the cursor on the torso image and dragging to rotate the image to view it from the left and right, or top and bottom.

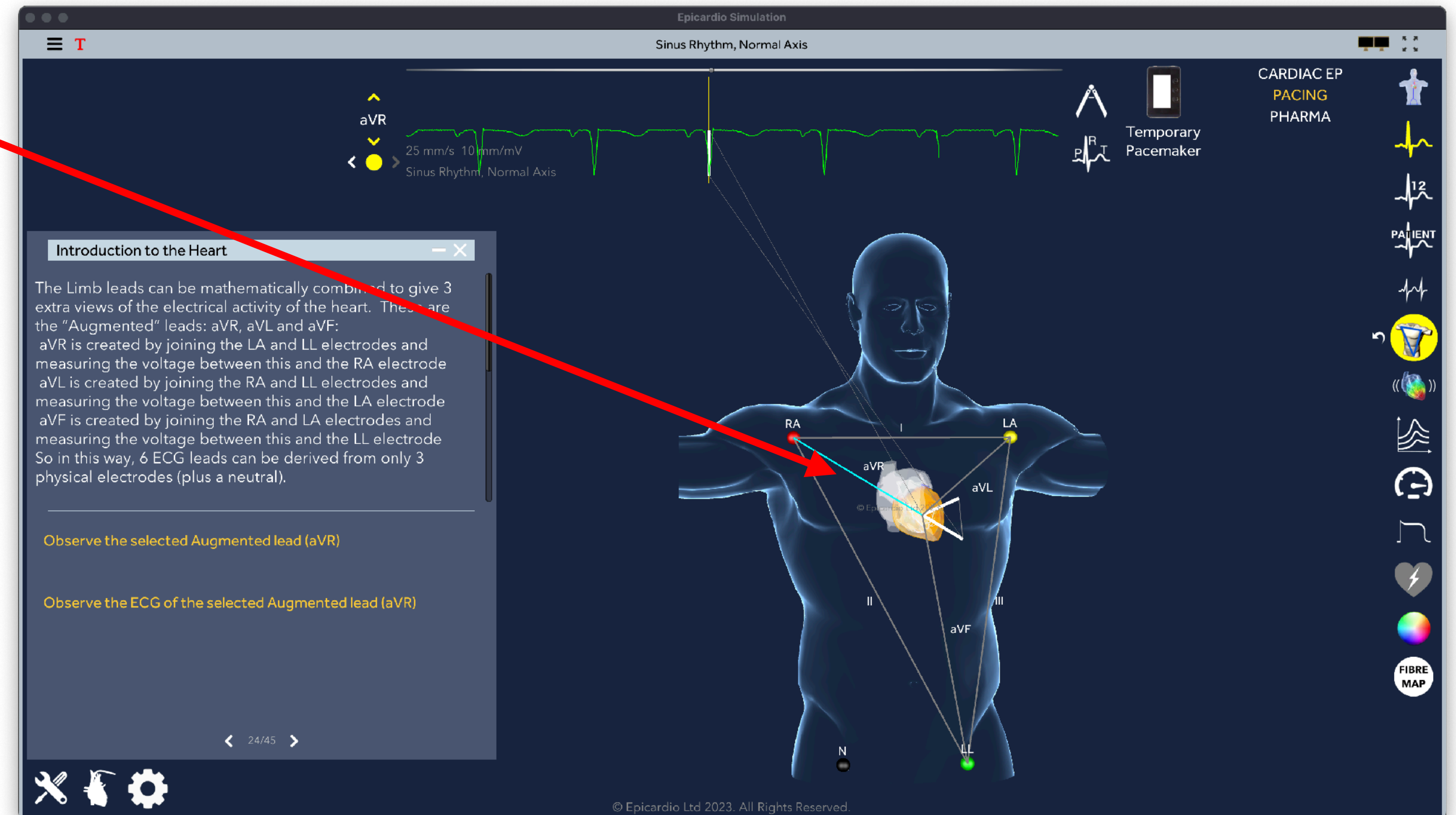


Fig. 13

Exercise 2

5. Go to the "burger" sign and from the drop down menu select: "Tutorials" - "Basics" - "Cardiac Axis", and go to page 8.

Discussion: Using pages 8 and 9 of the Cardiac Axis tutorial discuss the concept of axis and left and right axis deviation.

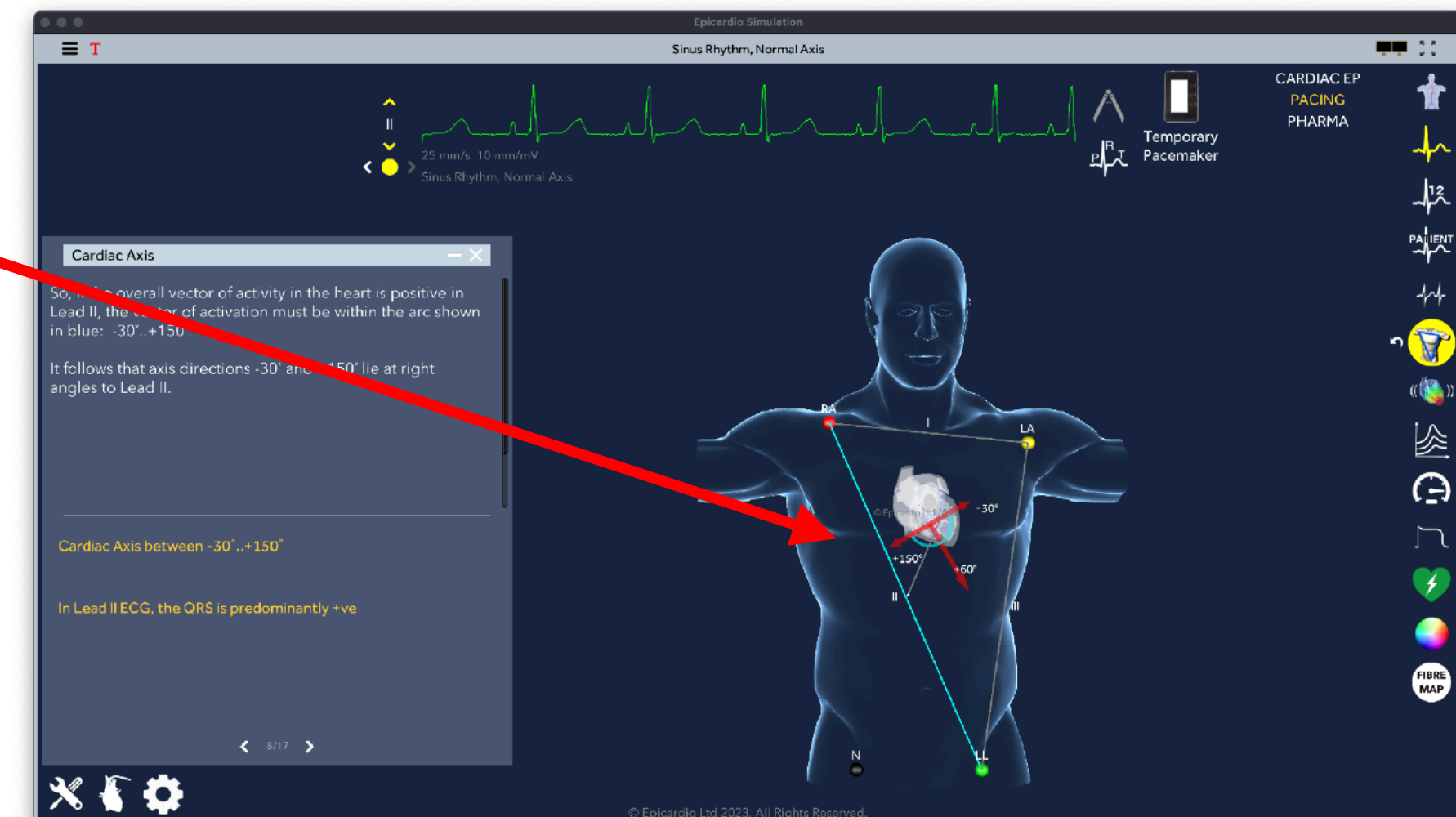
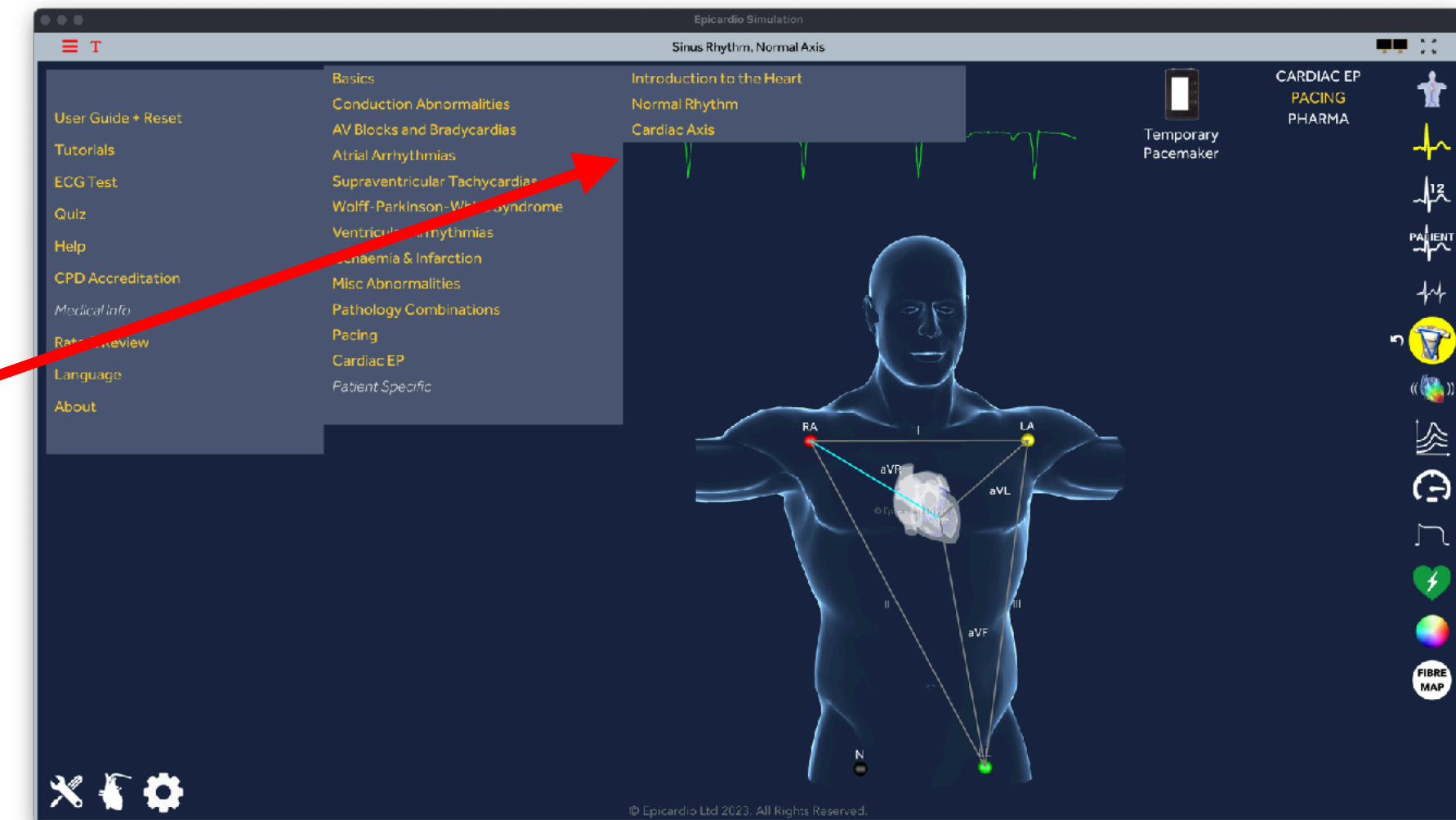


Fig. 14

Exercise 2

6. Experiment with different positions of the limb leads to see how this changes in ECG appearance. You can pick-drag-drop each of the electrodes and place them on different positions on the torso.

Discussion: general discussion about the results of shifting the position of the limb leads. Encourage learners to explore the appearance of the different limb and augmented limb leads.

Tip: to reset the limb lead positions click on the right hand ECG icon and then click on the rest icon (bent arrow) next to the yellow torso icon.

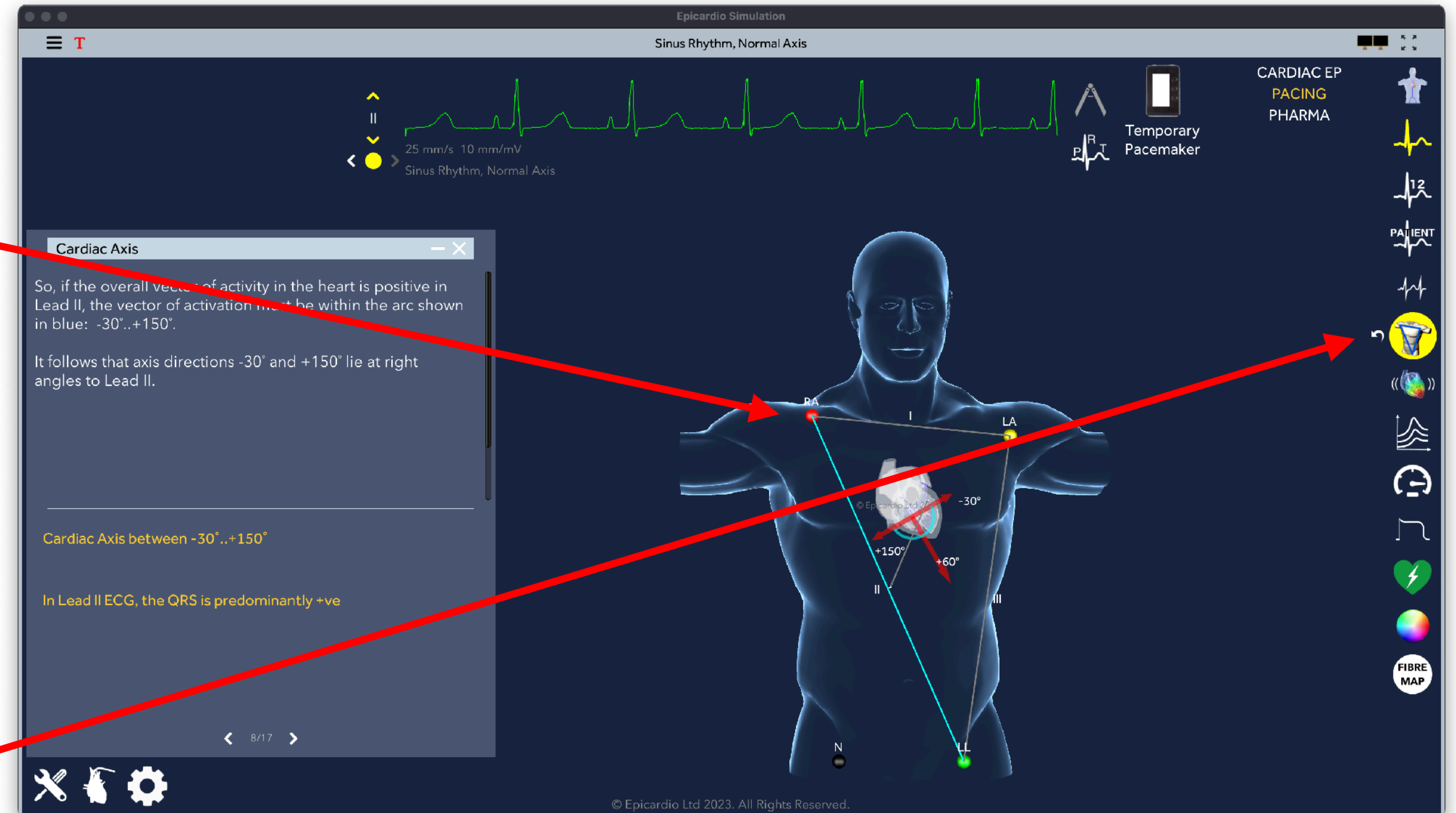


Fig. 15

Exercise 2

7. Go to "burger" icon and go back the the tutorial "Introduction to the heart". Go through to pages 25 to 27.

Discussion: give explanation of the position of the chest leads.

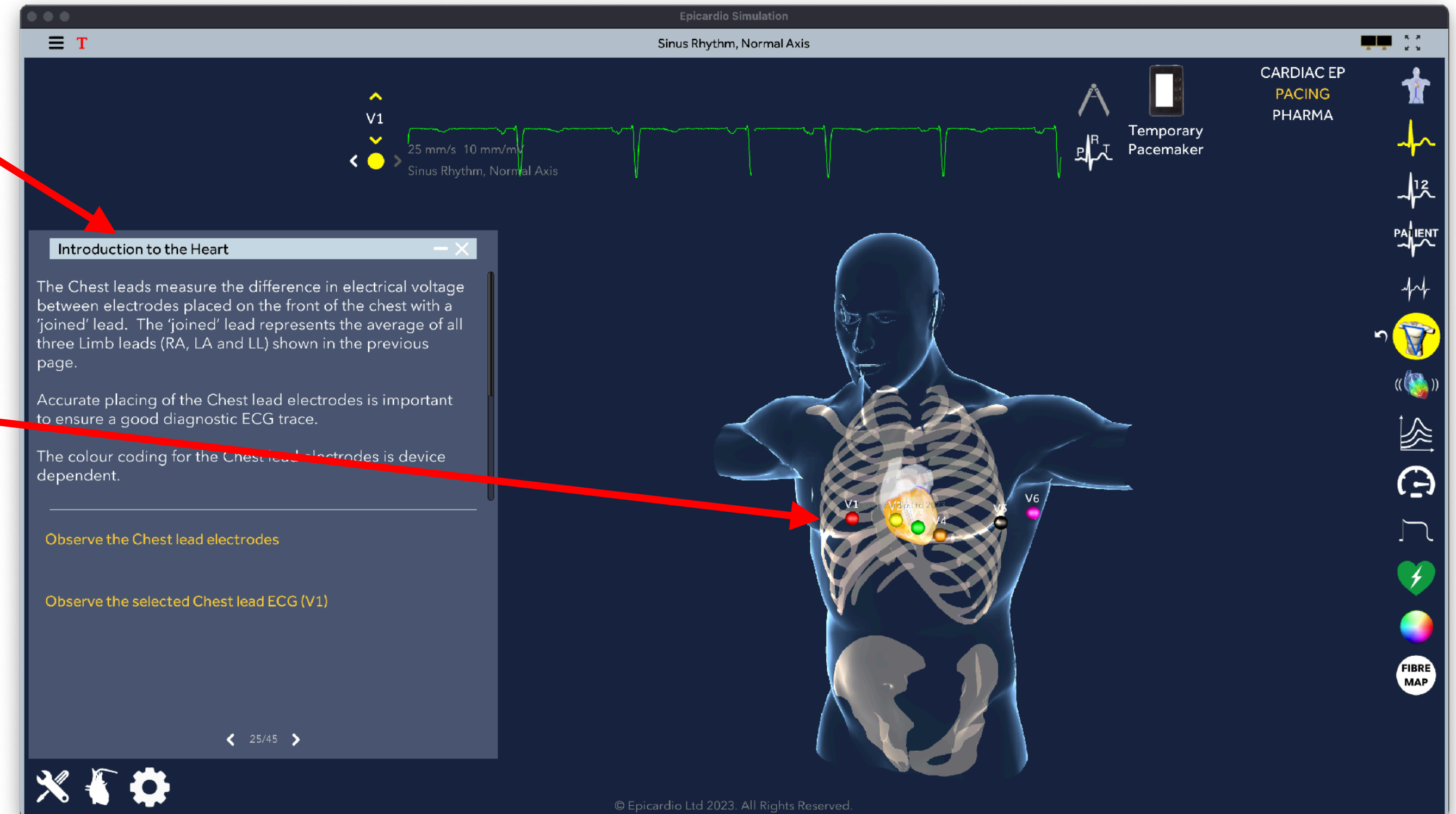


Fig. 16

Exercise 2

8. Go to “burger” icon and select “User Guide”. This action also resets all previous display and simulation changes.

Tip: by clicking on the heart icon in the bottom left corner of the screen the “anatomical views” menu will be displayed. You can select which elements of the anatomy to display.

Tip: by clicking on the ECG icon on the right side you can access a list of ECG display and simulation tools.

Tip: remember that the view can be changed using the mouse or pad and image can be enlarged by using the zoom control in the left icon list, or by dragging two fingers on the pad.

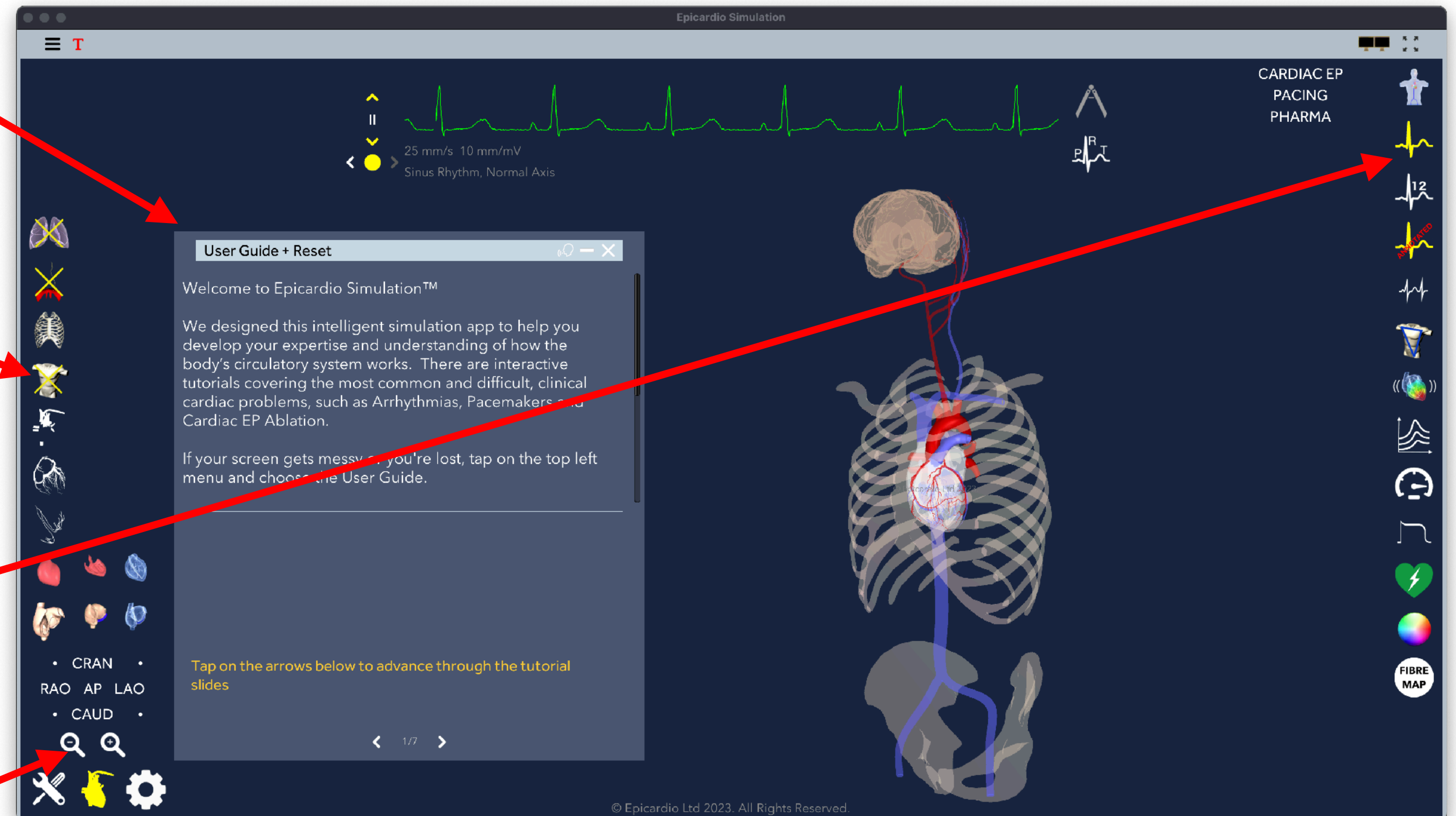


Fig. 17

Exercise 2

9. Go to "burger" icon and explore other tutorials, e.g. Go to "Tutorials" - "Conduction Abnormalities" - "Left Bundle Branch Block".

Discussion: explore how propagation of the depolarisation wave might be changed if one area of the heart depolarises later due to a bundle branch block.

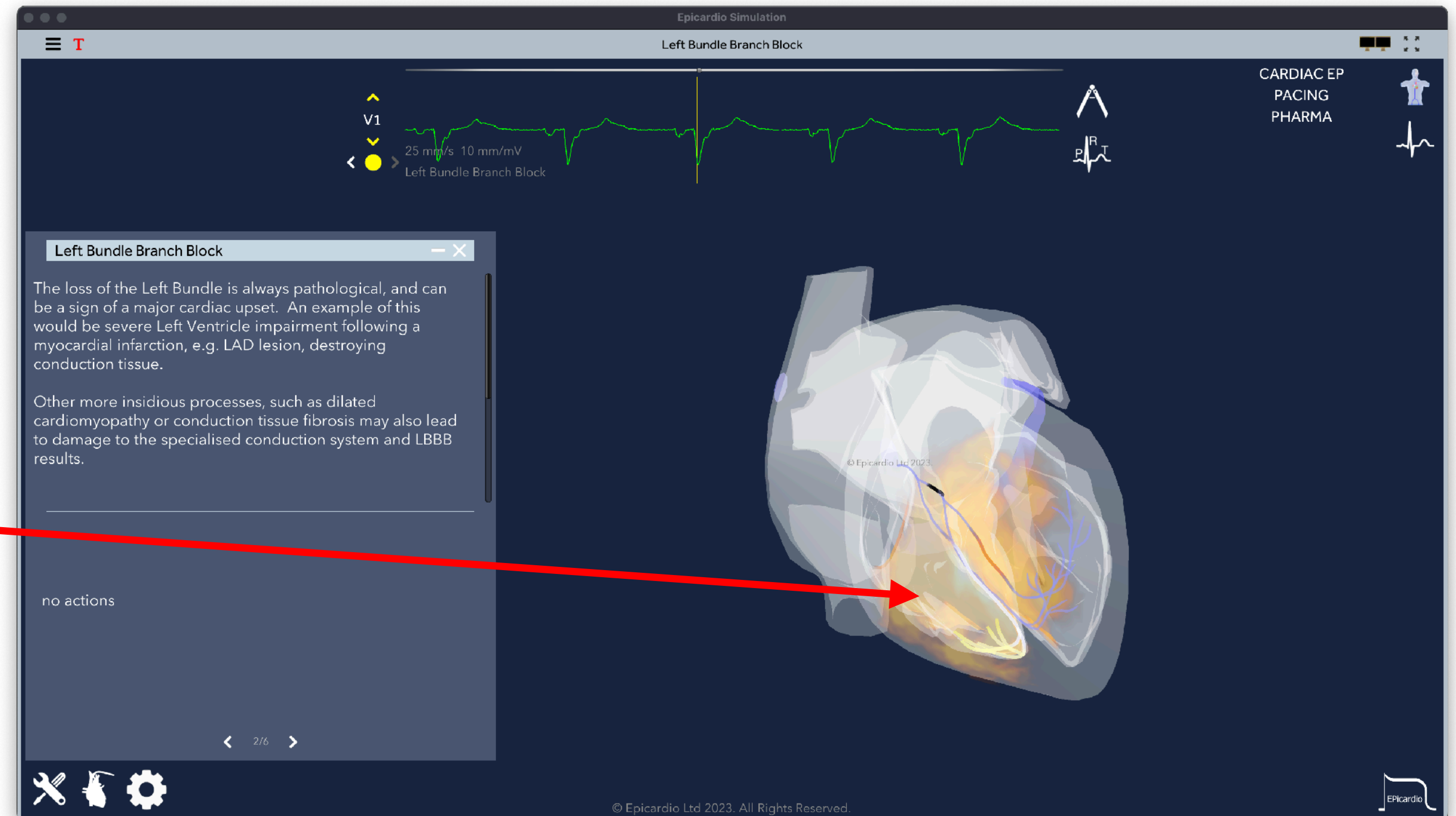


Fig. 18

Discussion: What has been learnt? Key learning points.

Pre-Exercise assessment of existing level of knowledge or **Post-Exercise** assessment of gained knowledge

Q1: In the normal ECG the predominant QRS deflection is:

- a) Positive in lead I and positive in aVR
- b) Positive in lead II and negative in aVR
- c) Negative in lead III and negative in aVR
- d) Positive in aVF and positive in aVR
- e) Negative in lead I and negative in aVR

Q2: The normal range for Cardiac Axis is:

- a) 0 to 90°
- b) 0 to +90°
- c) +30° to -90°
- d) 0 to 150°
- e) -30° to +90°

Q3: The cardiac axis is within the normal range if:

- a) Leads I and II are both positive
- b) Leads II and III are both positive
- c) Lead I and aVR are both positive
- d) Leads I and II are both negative
- e) aVR and aVF are both negative

Exercise 2



Answers to questions:

Q1 (b)

Q2 (e)

Q3 (a)