Critical Care Monitoring: Lesson 01

Objective: The overall aim is to enable a critical evaluation of information presented on monitor screens in critical care areas. This first lesson highlights the information that can be extracted from the 'acute' real-time screen and at the end of the lesson you should be more aware of the strengths and weaknesses of the various items on the screen.

Please note...in lessons 3 onward are some videos, they are best seen in full screen mode.

The ten lessons in this module will address how information is presented in critical care monitoring. ***The relationship between the physical collection methods and the digital output that displays the signals will be explored revealing to the critical care health worker a better understanding of the physical realities which digital displays represent over time.***

Awareness of where the monitored information comes from and what makes up the components of the signals will help observers determine if a system-based error is presenting information that should be investigated. As new technologies emerge the basic screen may look the same but the methods of generating, presenting and storing the screen information will evolve. Understanding this fact will make all health workers more capable users of the current and future technology.

The principle biological goal

A principle goal of physiology is to maintain the body's metabolism; the delivery of oxygen and nutrients to the cells and the excretion of the metabolic products.

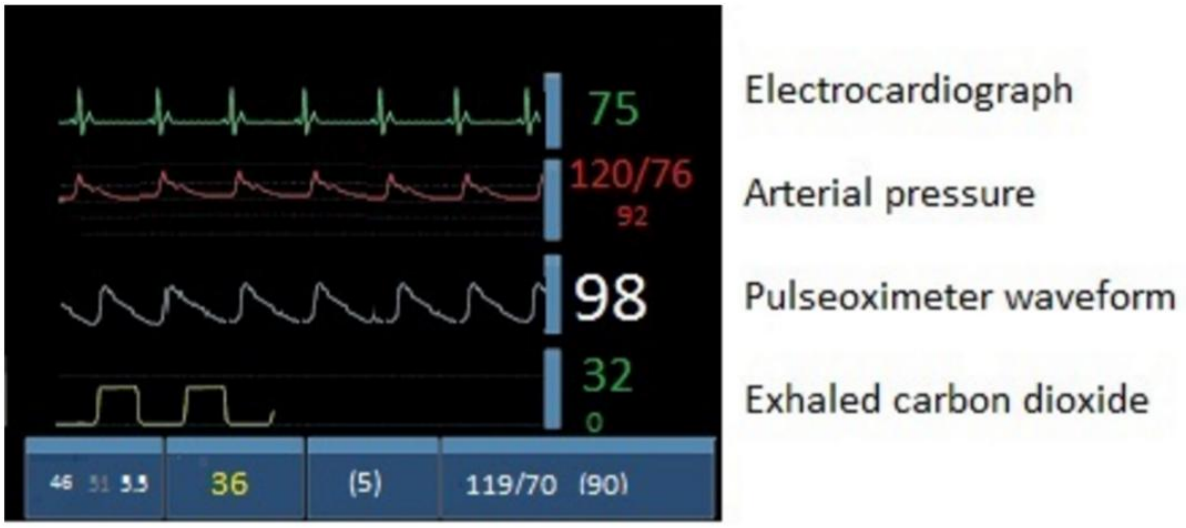
Oxygen delivery depends on the continuous flow of blood to the cells; a combination of cardiac output and the resistance of the blood vessels. ***Excretion of metabolites also depends on blood flow, in this case from the tissues to the lungs, kidneys and liver. The purpose of monitoring is to be able to continually assess the physiology of the patient.***

Monitors used routinely in critical care areas help in this assessment but their abilities and limitations should be known. This is the purpose of this educational course.

The electronic monitoring of patients takes place in many places and situations; in ambulances, accident and emergency departments, coronary care and intensive care units and in operating rooms.

This course is designed to help you read the monitor, recognise common false readings, and recognise certain events.

A typical monitor screen is shown here.



Typical monitor screen with data traces

What information can you get from the ECG? Please try to answer the question before seeking the answer by the hyperlink (Cntrl-Click on 'Answer')

1. Can the ECG provide the heart rate? Answer A1
2. Can the ECG provide information about the heart rhythm? Answer A2
3. Can the ECG provide information about myocardial ischaemia? Answer A3
4. Can the ECG provide information about electrolyte changes? Answer A4
5. Can the ECG provide information about cardiac output? Answer A5
6. What is cardiac output? Answer A6

Invasive Blood Pressure

'Invasive blood pressure' – this is measured when a fine plastic cannula is inserted into an artery. The pressure is measured continuously using an electronic transducer. What information does the invasive arterial blood pressure trace give?

1. Heart rate? Answer A7
2. Rhythm? Answer A8
3. Electrolyte problems? Answer A9
4. Myocardial ischaemia? Answer A10
5. Cardiac output? Answer A11
6. Diastolic pressure? Answer A12
7. What would be the mean arterial blood pressure if the blood pressure was 120 mmHg /80 mHg ? Answer A13

The pulseoximeter

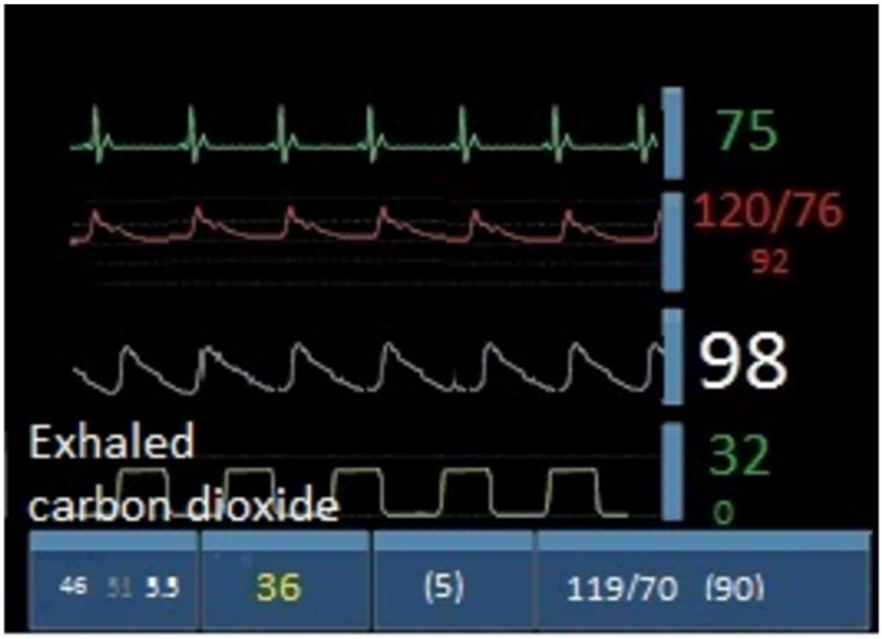
Can the pulseoximeter trace give the following information?

1. Heart rate? Answer A14
2. Oxygen content of the blood? Answer A15
3. Rhythm? Answer A16
4. Myocardial ischaemia? Answer A17
5. Cardiac output? Answer A18
6. The pulseoximeter produces a wave that looks similar to an arterial wave.

   What are the units of measurement for the pulseoximeter waveform?

   Answer A19
7. Can the pulseoximeter assess sympathetic tone? Answer A20

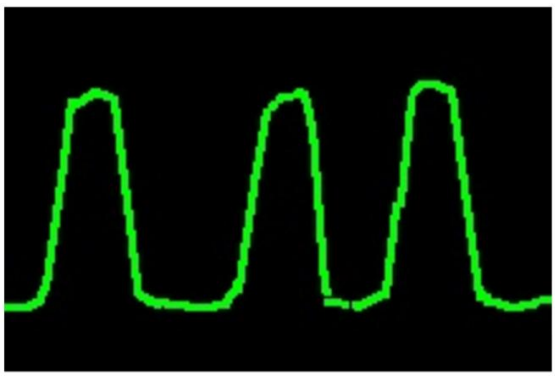
Exhaled Carbon Dioxide ($EtCO_2$)



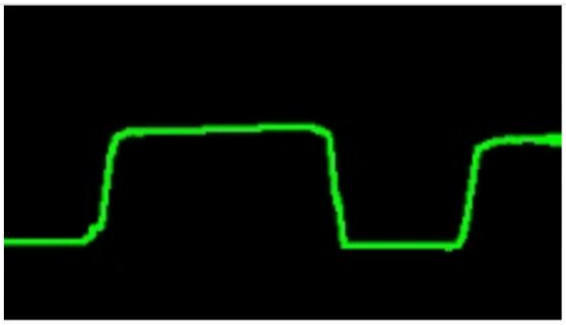
What information does the exhaled carbon dioxide trace give?

1. Respiratory rate? Answer A21
2. Carbon dioxide level in the blood? Answer A22
3. Type of lung ventilation? Answer A23
4. Cardiac output? Answer A24

The shape of the trace can also be diagnostic**....**

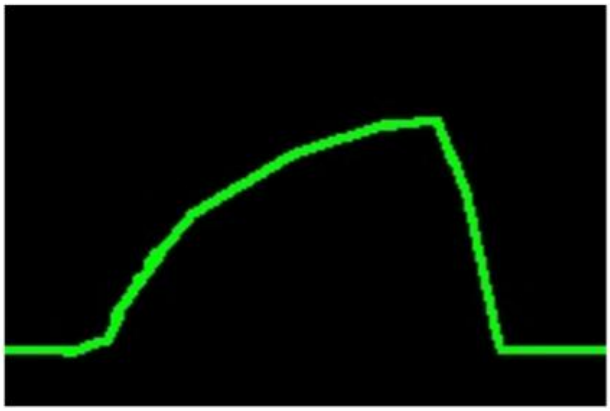


Spontaneous breathing ....when the patient breathes without mechanical help.

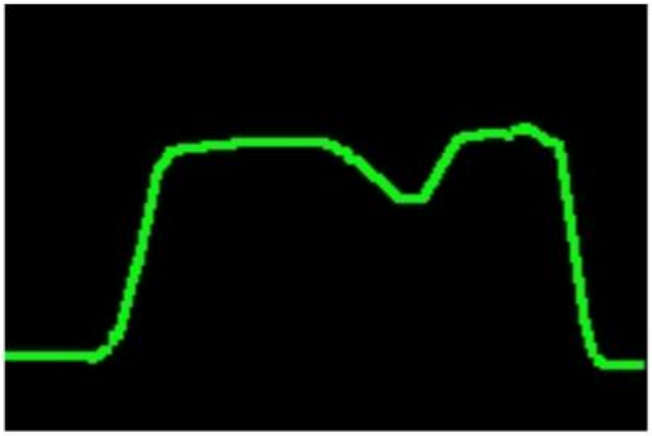


Mechanical breathing – IPPV – is when the lungs are inflated by a machine; they are of many types and different waveforms but typically are of the form illustrated

The shape can be diagnostic



Bronchospasm



The patient is trying to breathe during IPPV

These have been sourced from the following web site:- more capnographs ....

The end-tidal CO_2 ($EtCO_2$) is affected by temperature. If the temperature goes up and IPPV is unchanged what happens? Answer A25

You now have the basic information required to understand what information can be gathered from the monitor screen. The following lessons will give you more information about limitations and diagnostic methods.

Kia ora

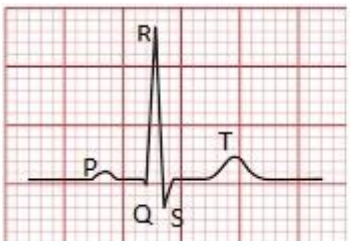
Answer A1

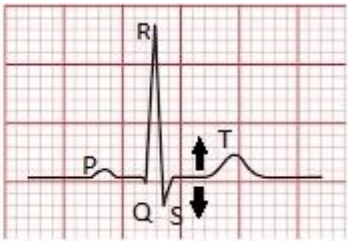
Yes...the ECG signal is directly from the heart. Go back

Answer A2

Yes... the ECG is the most accurate way of determining a heart rhythm. Go Back

Answer A3





Yes, the height and shape of the ST segments change...the ST segment can go up or down.

Go Back

Answer A4

The T wave height changes with K^+ levels. Increasing levels of potassium causes 'peaking' of the T wave.

Go Back

Answer A5

If the heart rate is very low (less than 40 beats per minute) the cardiac output may fall. If the heart rate is very high (more than 160 bpm) the cardiac output may fall. In between it does not; it is only an electrical signal.

Go Back

Answer A6

It is the volume of blood flowing from the heart per minute delivering oxygen and nutrients.

The cardiac output is the stroke volume x heart rate.

The stroke volume is the amount of blood ejected from the heart with each contraction of the left or right ventricle

Go back

Answer A7

No.....it gives the pulse rate. Can the heart rate be different to the pulse rate? Yes.
Weak ventricular contractions (like some ectopic beats) may not produce a pulse wave.

Go Back

Answer A8

Yes, but not so comprehensively as the ECG.

Go Back

Answer A9

No

Go Back

Answer A10

No, not directly. A very low blood pressure may lead to myocardial ischaemia.

Go Back

Answer A11

No, it’s a pressure wave and cardiac output is flow. Imagine a BBQ gas cylinder with the tap turned off, there is still pressure but there is no flow of gas.

Go Back

Answer A12

Yes. The arterial pressure recording will give the systolic pressure, the mean (average) pressure and the diastolic. 120 mmHg /80 mHg is a textbook example of systolic and diastolic pressures.

Go Back

Answer A13

The mean would be about 93 mmHg - it is normally close to the diastolic + 1/3 of the pulse pressure (systolic – diastolic), this is because the arterial wave is ‘fatter’ at the lower (diastolic) part of the wave.

Go Back

Answer A14

No.....it gives the pulse rate, this is because it is measured on the periphery of the body, like the arterial pressure. It can be measured on the fingers, on the toes and on the ears.

Go Back

Answer A15

No. A pulseoximeter measures the saturation of the haemoglobin with oxygen (SpO_2), not the actual amount of oxygen. The amount depends on how much haemoglobin there is in 100ml (Hb g/dL) and the saturation (Hb x 1.34 x SaO2). There is also a little dissolved in the plasma. The unit of measurement is percentage – normally 97 - 100%.

Go Back

Answer A16

Yes, but not so comprehensively as the ECG**.**

Go Back

Answer A17

No, not directly, but if the oxygen saturation of the blood is very low then the oxygen in the organs is also low.

Go Back

Answer A18

No, it’s an optical (light) measurement and cardiac output is flow.

Go Back

Answer A19

It has no units

Go back

Answer A20

Yes. Vasoconstriction is part of the response to adrenaline-like drugs and the amplitude (the overall vertical size) of the waveform will reflect this. If the blood vessels are constricted the amplitude decreases, if the sympathetic tone is low the amplitude increases.

Go Back

Answer A21

Yes

Go Back

Answer A22

Yes

Approximately....the waveform is like a square wave and the highest point is called the end-tidal CO_2 ($EtCO_2$). The alveolar gas is very close to the blood in the pulmonary circulation and gas diffusion makes them very similar.

Go Back

Answer A23

Yes

Spontaneous breathing....or mechanical breathing - Intermittent Positive PressureVentilation (IPPV)

Go Back

Answer A24

Yes

The carbon dioxide gas that is exhaled is delivered to the lungs by blood flowing from the heart (the cardiac output). If that is reduced AND IF the ventilation of the lungs stays the same the $EtCO_2$ will decrease. During a cardiac arrest there will be no blood flow to the lungs and the $EtCO_2$ will fall rapidly.

Go back

Answer A25

With an increase in temperature the metabolism increases, more oxygen is used and more carbon dioxide is produced. If the lung ventilation is unchanged the concentration of carbon dioxide in the exhaled gas must go up.

Go Back