SATIS 2.0

Life Support

Author: Evie Bently

INTRODUCTION AND SYLLABUS

This unit is intended for biology and human biology courses. It is suitable for use quite early in biology courses and might be linked to a study of homeostasis. More generally the unit could be used following a discussion of what students perceive as 'life', or a consideration of how an unconscious person, on life support, can still be considered as possessing 'life'.

SCIENCE, TECHNOLOGY AND SOCIETY

This unit illustrates:

- the work of doctors and nurses in an intensive care unit.
- some of the issues and dilemmas involved in hightechnology medicine

This unit gives students the opportunity to:

- consider alternative solutions to a problem and suggest a preferred solution,
- discuss the allocation of resources to various areas of medical technology

SPECIALIST BIOLOGY

In this unit it helps if the students have some familiarity with the following:

- homeostasis,
- human reproduction,
- gaseous exchange in the lungs,
- blood circulation,
- temperature control,
- medical shock.

This unit gives students the opportunity to:

- apply biological knowledge to explain reported observations,
- evaluate biological information and suggest explanations.

USING THE UNIT

TIMING

This unit has been tackled succesfully in private study. Afterwards a review of all the questions followed by a discussion of the more general issues needs about an hour in class.

A SUGGESTED APPROACH

One way into this unit might be to start with a discussion during which students explore what they mean by 'life'. In such a discussion they can explore the everyday and scientific connotations of the word. Students can also explore what it means to be disabled and reflect on the notion of 'quality of life'

The Association for Science Education

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Study Document

INTENSIVE CARE

'...the patient was rushed to the local district hospital where she was taken to intensive care and put on life support...'

How often have you heard such a statement on the news? What does it mean to be 'put on life support'? Why is it necessary?

The nurses and doctors in an intensive care unit strive to save people's lives by sustaining normal bodily functions such as breathing, heartbeat, body temperature, blood pressure and blood composition. In other words, the medical team takes over when homeostasis fails.

The purpose of intensive care is to maintain life while stabilising the patient so that normal treatment and recovery can follow.

QUESTION 1

A: In what circumstances may homeostasis be disrupted so that a person needs intensive care? Explain why homeostasis fails as a result of your chosen examples

B: What is "Medical Shock"? Which of the circumstances you have listed in A can lead to the condition which doctors call "shock"?

C: Why is a patient unlikely to recover if homestatically unstable

QUESTION 2

A: Patients in intensive care are likely to be very lightly clad because they have to be connected by so many wires to tubes and monitoring equipment. They may barely be conscious. How do you think doctors and nurses keep their patients:

1. Warm,
2. Supplied with nutrients
3. free from bed sores

B: Why is warmth important for a patient in intensive care?

A CASE HISTORY

A young married woman in her mid twenties came into hospital complaining of severe pain in her abdomen. She was three months pregnant. Until now her pregnancy had been normal. An ultrasound scan showed a very small uterus with an abnormal amount of fluid around one Fallopian tube. After a further scan the doctors decided to operate. They found an ectopic pregnancy which they removed.

QUESTION 3

What is the difference between a normal pregnancy and an ectopic pregnancy?

An ectopic pregnancy can be very serious but these days doctors can usually deal with it simply and successfully. In this case all seemed well for three days after the operation but then, quite suddenly, the young woman complained of severe breathlessness. Ultrasound scans revealed nothing abnormal but the problem got worse and she had to be taken into intensive care, sedated and put on a ventilator.

Ventilators sustain breathing by forcing air or oxygen in and out of the patient's lungs. Doctors can vary the amount and frequency of each breath; they can also control the composition of the mixture of air and oxygen supplied to the lungs.

In this case the woman seemed to be in a state of 'medical shock', her

condition got steadily worse. Her blood pressure started to fall and her heart rate rose. Despite treatment the amount of oxygen getting into her bloodstream fell even when they supplied her with 100 per cent oxygen from the ventilator. They tried to maintain her blood volume with transfusions but her blood pressure continued to fall.

The doctors suspected that fluid was leaking from the capillaries into their patient's lungs as a result of breakdown of capillary walls. Loss of blood fluid can contribute to a fall in blood pressure.

QUESTION 4

What reasons can you think of the a patient to suddenly complain of breathlessness?

QUESTION 5

What might have caused the schock three days after the initial operation?

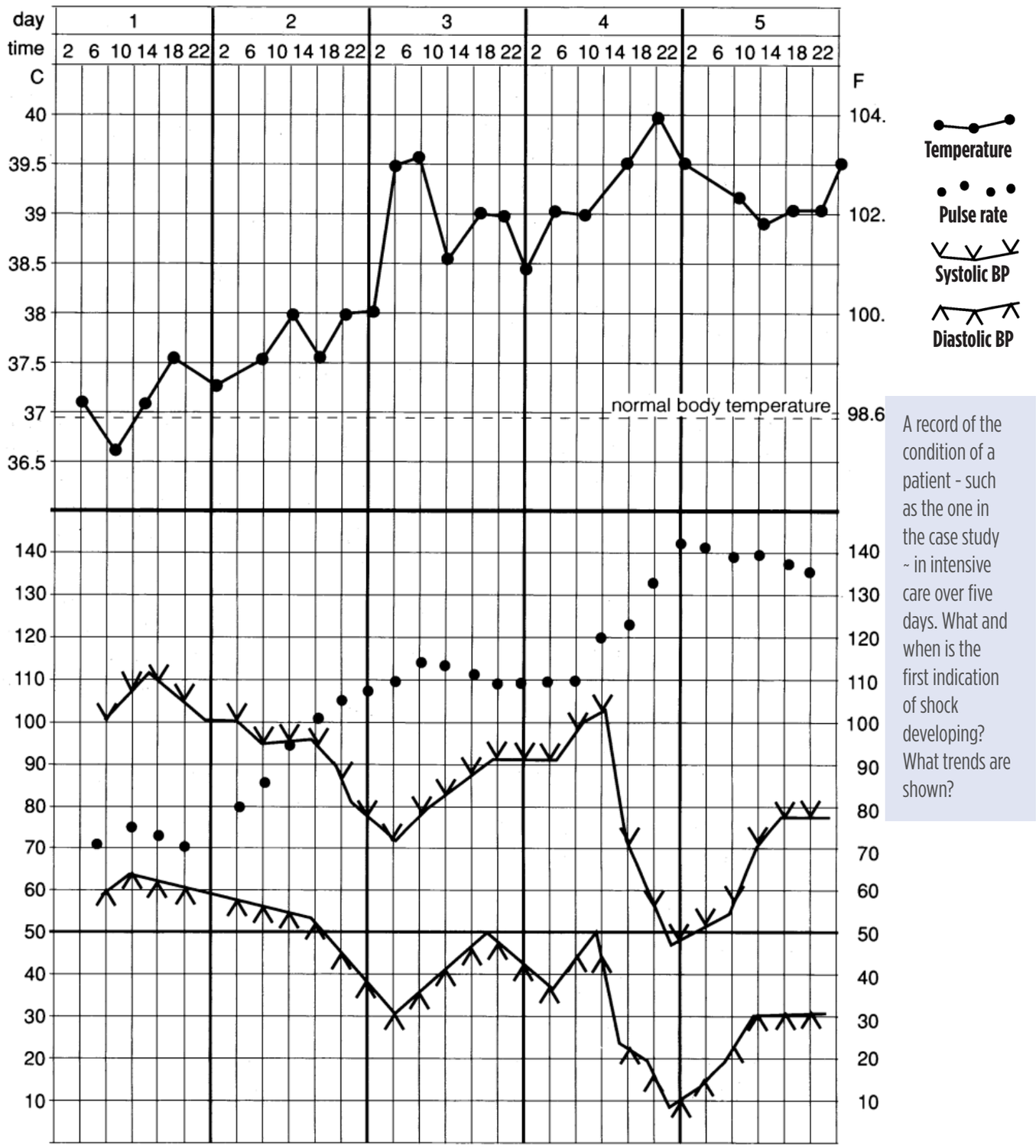
QUESTION 6

A: How would you expect the brain to be affected by a very slow heartbeat, or a very low blood pressure?

B: What are the likely consequences of what you have mentioned in A?

QUESTION 7

Once ventilation was started why did the patient need 100 per cent oxygen just to maintain blood oxygen levels?



A record of the condition of a patient - such as the one in the case study - in intensive care over five days. What and when is the first indication of shock developing? What trends are shown?

A further deterioration followed a deep fall in blood .pressure but the exact cause was uncertain. The young woman's state got even worse when alveoli began to burst. This allowed inspired air to take the 'path of least resistance', avoiding the remaining gas-exchange surfaces and escaping into the pleural cavities.

Normally the two pleural layers lie close together but now air forced them apart. The build up of air pressure outside the lungs squashed them and made them more difficult to ventilate.

QUESTION 8

The doctors were not sure whether the deep dip in blood pressure in the left side of the heart was due to a "knock-on" effect of too little blood reaching the right side of the heart, or failure of the left side of the heart iteslf. How do you think the doctors might have set about trying to determine the cause?

A: How do you think the doctors might try to get rid of the air which has leaked out of the pleural cavities?

B: What problems would remain even if the doctors manage to remove the air?

C: How might the suggested treatments make the problem worse? How might these problems be overcome?

QUESTION 9

Despite the doctors' success with their efforts to improve the circulation, there was a prolonged period of low blood. pressure. This in tum damaged the kidneys which began to fail. The doctors felt that they might be able to cope with the build up of waste products in the blood but they knew it would be better if their patient could be treated on a kidney dialysis machine.

The doctors had to weigh up the risks and possible benefits:

1. The patient could be kept at their hospital and all efforts to stabilise her continued even though the outlook seemed poor,
2. The could be moved onto a dialysis unit at another hospital which would increase her chances.

The second choice might seem the obvious one, but the doctors had to take into account that the nearest available dialysis unit was 40 miles away. Their patient was in such a perilous state that moving her would in itself pose a tremendous risk, and could kill her.

QUESTION 10

What would you have decided to do if you were one of the doctors? What decision would you have made, and with what reasons? What would you have said to the patient's husband?

QUESTION 11

What plans would doctors have had to make if they decided to arrange the move to another hospital 40 miles away?

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Notes on the questions

QUESTION 1

A: Accident or disease can damage vital internal parts of the body such as: the control centres in the brain, the detectors which sense the internal state of body, the effectors which provide control, or the neural pathways which connect the control centres to the detectors and effectors.

B: Medical shock is a condition in which heartbeat varies abnonnally, blood pressure falls dramatically and the brain may start to be starved of oxygen and glucose. Shock can be the result of a sudden and/or large loss of blood.

C: Normal body functioning depends on nonnal metabolism which depends on a steady internal environment. The maintenance of this steady internal environment is homeostasis. Usually homeostatic mechanisms cause adjustments to restore stability. In medical shock these mechanisms may fail.

QUESTION 2

A: The following apply in intensive care units.

- The air temperature is kept warmer than nonnal. Anns and legs, (with their high surface to volume ratio) are covered; the legs, for example, can be protected with over-knee socks or stockings if nonnal bedding or clothes would get in the way of tubes and wires. The elastic stockings also aid venous return.
- Patients are often fed intravenously via a drip-feed.
- Beds are fitted with a flexible/moving mattress such as a water bed. Some ITU beds have sand-filled mattresses which are turned into a 'fluidised bed' by a flow of air under pressure. The advantage of sand is that there is no liquid to spill, and no aqueous medium for pathogens to grow in. A sand mattress is easier to move because it becomes hard and flat when the flow of air is switched off.

B: A fall in core body temperature affects enzyme action and hence metabolism. A slowdown of metabolism affects patients further making the re-establishment of homeostatic stability less certain, thus hindering recovery and increasing the chance of death. There is also an automatic diversion of resources including oxygen to generate heat at the expense of recovery.

QUESTION 3

Pregnancy is a nonnal result of sexual intercourse. Spenn swim from the vagina into one or other Fallopian tubes· where they fertilise a ripe ovum. The zygote fonned moves down towards the uterus, dividing into a ball of cells as it goes. Nonnally, after it gets into the uterus, the zygote implants into the thickened lining and continues to develop, but in a very few cases (0.7 per cent), for some reason, it implants in the Fallopian tube. This is called an ectopic pregnancy. At first things go well, but soon the woman suffers from congestion, bleeding and much pain. If nothing is done the woman dies, mainly from blood loss and consequent shock. If detected the outlook (prognosis) is good.

Ectopic pregnancies do not usually lead to serious illness or death. Ectopic pregnancies are not common -pregnancies are! There were just eight deaths as a result of ectopic pregnancies in the UK between 2018 and 2020.

QUESTION 4

Breathlessness is a sign of lack of oxygen. This can be due to:

- insufficient oxygen in the inspired air,
- insufficient gas exchange surface,
- insufficient blood going through the lungs to pick up oxygen (perhaps because the circulating blood volume is too small or because of a fall in blood pressure).

In this case the third reason is the most likely because of the falling blood pressure. This might be the result of internal bleeding. Perhaps the Fallopian tubes bled as a result of the operation. There may have been damage undetected at the time of the operation. There is also the possibility of infection after the operation which would suddenly become severe and produce shock.

Both blood loss and sudden deep infection can lower blood pressure, though loss of circulating volume is usually compensated for by raising the blood pressure homeostatically. A drop in blood pressure means less blood per minute going through the lungs and consequently less oxygen

being carried in the blood. If this is serious, breathlessness results.

QUESTION 5

This could have been the result of sudden blood loss and/or a sudden, intense 'blossoming' of infection. Neither of these would show up as unusual on a scan until the effect (such as a swelling) was rather large. After any internal operation there is nonnally some swelling or bruising.

QUESTION 6

A: Both conditions mean that insufficient blood is moving through the organs including the brain. This means that there is a low delivery of glucose and oxygen - so low that the brain may not get enough to sustain nonnal. respiration.

B: As a result of the condition described in a, the brain may be short of energy. If so, the less essential parts of the brain are 'shut down' as their blood supply is automatically shunted elsewhere to the essential homeostatic control.

QUESTION 7

Increasing the co~centration of oxygen in the lungs increases the concentration gradient across the walls of the .alveoli. This makes it more likely that the available blood will be fully saturated with oxygen. This helps to compensate for a reduced blood flow or low blood volume.

8 Low blood pressure in the left auricle and left ventricle has a knock-on effect onto the general blood pressure and hence the right auricle and right ventricle. This then produces a very poor pulmonary flow, resulting in poor oxygenation and poor return to the left side of the heart.

Blood pressure at various places, such as the heart chambers, can be measured accurately using fine wires which carry tiny sensors at one end. These 'lines' are introduced through a suitable.vessel, usually a wrist artery, and floated along to the appropriate place. The lines are connected to monitoring equipment.

Using lines doctors can measure:

- the filling pressure of the right auricle,
- the output pressure of the right ventricle,
- the filling pressure of the left auricle (and therefore the input to the left side of the heart), and
- the output pressure of the left ventricle.

This all gives quite a good picture of how the heart is functioning, and treatment can then be balanced by:

- supporting the heart with drugs stimulating contraction, and
- correcting th(eamount of circulating fluid.

This was in fact done in this case, and a steady improvement maintained for some time.

QUESTION 9

A: There was a sudden deterioration. There were no signs of sepsis caused by toxins from infection passing into the blood and affecting the body generally. In spite of all efforts further deterioration took place and more alveoli were bursting. so air was able to get into the pleural cavities. Air can be removed from the cavities by thrusting tubes through the thorax wall into the pleural space so that the air (and escaped fluid) can be drained out.

B: Removing the air does not stop further leakage of air or fluid from the lungs.

C: Removing the air can make things worse by encouraging the flow of air (or fluid) by providing a passage for it to get out. There is no easy solution. If conditions within the body are slowly stabilised, little by little the return towards normality.seems to reduce the leakage of air and fluid until it eventually stops.

QUESTION 10

In the end the doctors decided to move their patient to another hospital with a renal unit. Later scans showed a collection of infected tissue in the abdomen and this was removed carefully and successfully. This on its own explained her sudden slide into severe difficulties in those few days after the operation. The patient eventually recovered fully and two months later was back at home.

QUESTION 11

The doctors had to find the largest size of ambulance to carry their patient together with two essential companions: a member of the ambulance staff and the consultant anaesthetist from the intensive care unit. The ambulance was fitted with monitoring and basic maintenance equipment. The doctors had to estimate the time of the journey (allowing for busy roads) so that they could decide how many oxygen cylinders they would need.

The doctors might have planned the journey when traffic was likely to be light or contacted the police to arrange an escort.