The Royal College of Pathologists
Pathology: the science behind the cure

Blood Clotting
Activity Guide

Equipment:

- Plastic shotglasses (can be rinsed and reused)
- Water-soluble red food colouring
- Sodium alginate
- pipettes
- 2 (or 4) x Large clear containers: one labelled 'clotted blood' other labelled 'fresh blood' (to act as 'blood reservoirs')
- Plastic spoons
- Plastic syringes without needles

Set up

Make sure there are at least two containers in front of the attendees:

Container 1: Clotted blood (made up of red food colouring, a splash of black food colouring, water and enough sodium alginate to thicken up with 'clots' (about 2 spoonfuls). Volunteers will need to make sure it is stirred regularly so that it doesn't separate
Container 2: Fresh blood (made up of red food colouring, splash of black food colouring and water)

Then lay out shot glasses along the table with the pipettes, spoons and syringes. You may want to have some paper towels available as it can get messy. (It does wash off hands and clothes).

Example of set up (if delivering in groups in a classroom you can just distribute the containers and syringes between tables)

Background:

Blood transfusions during the war were done directly using syringes to transfuse from the donor into the patient with mixed results. The donor had to lie on a bed next to the patient and a small operation was done to connect a tube from the donor's artery to the vein of the patient. It was dangerous for both.

The safe amount of blood to collect was unknown. Sometimes up to two pints of blood were taken and the donor was unwell afterwards. The equipment required included surgical equipment and red rubber tubing. All of the equipment had to cleaned each time to be used again.

Blood groups had been discovered in 1901 but it took time for the science to be available to the doctors. Doctors knew that the wrong blood was dangerous. As understanding of blood groups developed they began to test if blood was suitable by first syringing a small amount, seeing how the person reacted and then deciding whether or not to transfuse the rest.

By adding an anticoagulant, such as sodium citrate, and refrigerating the blood, it seemed that blood could be stored. And so blood banks were established. Oswald Hope Robertson, a medical researcher and U.S. Army officer, set up the first blood bank while serving in France during WW1. In 1914 Albert Hustin performed the first non-direct transfusion, using sodium citrate as an anticoagulant.

This practical activity offers attendees the chance to compare fresh blood to clotted blood and what the clotting process would have meant for conducting donor-recipient direct blood transfusions during the war. Attendees will find out about how sodium citrate prevented blood from clotting.

Instructions:

- Pathologists/volunteers will explain why learning how to store blood was important during the war and the reason why blood 'clots' when outside the body.

- Whenever your skin becomes broken, blood vessels are damaged, blood is released and the sticky platelets contained in the blood form clots to stop blood flow. As soon as blood from a wound is exposed to the air, the platelets disintegrate and react with fibrinogen to create fibrin, a mass of tiny threads. This triggers a whole series of sequential reactions that rely on adequate levels of calcium and vitamin K to work and this process is known as the 'clotting cascade'. The fibrin hardens very quickly to form a scab, sealing the wound. The wound heals and the clot dissolves. Unless prevented from doing so, blood collected into glass bottles or blood bags undergoes the same process and will clot.

- Ask attendees to look at the consistency of the fresh blood, and compare to the clotted blood. They can use pipettes, syringes and teaspoons to take some out into the shot glasses to look at further.

- Make sure the attendees understand that blood needs to be prevented from clotting using an anticoagulant, and this is sodium citrate.

- Citrate ions, in the form of sodium citrate or CPD (citrate phosphate dextrose), is used to disrupt the clotting cascade and thereby prevent clotting. The citrate binds to the calcium, forming calcium citrate in the blood, and by reducing the amount or effectiveness of calcium, the clotting cascade cannot begin. The citrate needs to be present in the freshly collected blood because clotting begins very rapidly after collection (in the first few minutes). Once blood has clotted, the later addition of citrate will not 'un-clot' it.

- During the war, the citrate method of anticoagulation was performed as follows: 60cm^3 of sterile 2% sodium citrate solution was added to a 500cm^3 sterile glass container. The donor's arm would be constricted in order for a large-bore hollow needle to be inserted into an elbow vein, allowing the blood to flow freely into the citrate solution. This would be stirred with a glass rod, and blood would continue to flow until the 500cm^3 mark was reached. The citrated blood was then strained through a sterile gauze to remove the froth and introduced into the recipient's vein via saline infusion apparatus at a rate of 50cm^3/minute. [From: Blood Transfusion in War Surgery, The *Lancet*, June 1, 1918].

- Volunteers to then let attendees know that in modern day transfusions, whole blood is separated into its components (red cells, plasma, platelets) and the red cells are re-suspended in an additive solution to a concentration range which is best for the patient, and blood bags now already contain sodium citrate.

- Can also discuss how we have moved from glass bottles for storing to plastic blood bags and the benefits of this.

(Information can be adapted to suit age/knowledge of attendees)