Section 6

Principles of Intraoperative Cell Salvage

Aim

- To enable the learner to develop an understanding of the various stages of Intraoperative Cell Salvage (ICS)

Learning Outcomes

- Identify the three main stages of ICS
- Identify the different ICS systems that exist
- Describe the end product of ICS

Introduction

As highlighted in Figure 2 (Section 3), if whole blood is allowed to settle, it will separate into its constituent components. Red blood cells (RBC) are the most dense component of blood and consequently will settle at the bottom.

A centrifuge can significantly increase this rate of separation. It is through this process of centrifugation that many cell salvage machines separate red blood cells from the mixture of whole blood and anticoagulant that is salvaged from the surgical field.

ICS begins with the collection of shed blood from the surgical field. The blood is anticoagulated as it is aspirated with low suction into a collection reservoir where it passes through a filter. Separation of RBCs from whole anticoagulated blood occurs through centrifugation. The RBCs are washed using IV normal saline (0.9% NaCl) solution and then pumped into a bag for reinfusion to the patient. There are a variety of ICS systems available. All of the systems produce a comparable end product, i.e. the patient's own RBCs suspended in IV normal saline (0.9% NaCl).

This section looks at the various stages of processing and the different systems that exist.

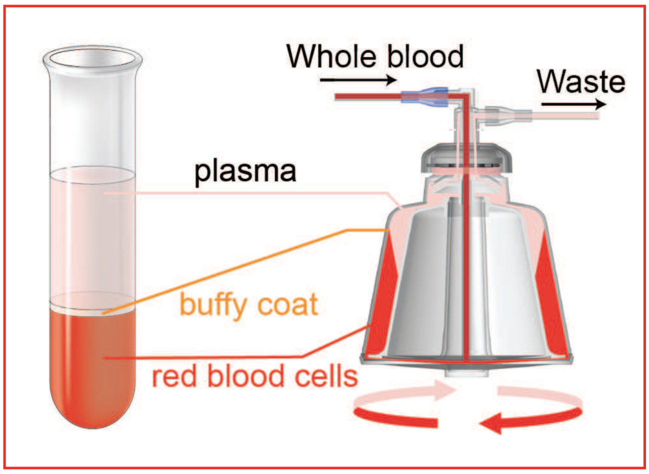
6.1 Fixed Volume Bowl System

The fixed volume bowl rotates at speeds of up to 6,000rpm, and processes the salvaged blood in fixed volume batches. As anticoagulated whole blood is pumped into the spinning bowl, the centrifugal force separates the blood into its components as the bowl fills. As more blood is pumped into the bowl the RBCs are retained in the bowl while the supernatant, which is made up of the remaining components plus the anticoagulant, is expressed through the outlet port and into the waste bag.

When the machine detects an adequate amount of RBCs within the bowl, a wash solution of IV normal saline (0.9% NaCl) is pumped into the bowl passing through the red cell layer and displacing most of the remaining non-red cell component into the waste bag. Excess IV normal saline (0.9% NaCl) is also expressed through the outlet port and into the waste bag.

The fixed volume bowl may be available in a range of sizes (depending on the manufacturer) to suit the anticipated blood loss. In order to provide a consistent and high quality end product, fixed volume bowls require a predetermined volume of RBCs to be reached within the bowl before the machine will trip automatically into the wash stage.

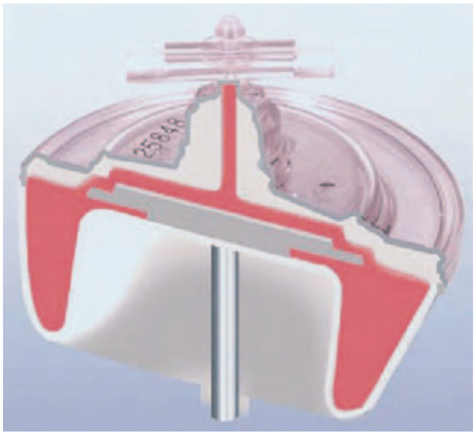
Figure 7. Separation of Red Blood Cells in a Fixed Volume Bowl



Choosing to operate an ICS machine in manual mode will remove the safety benefits and will affect the consistent, high quality end product offered by the automatic mode.

6.2 Variable Volume Disk System

Figure 8. Variable Volume Disk System



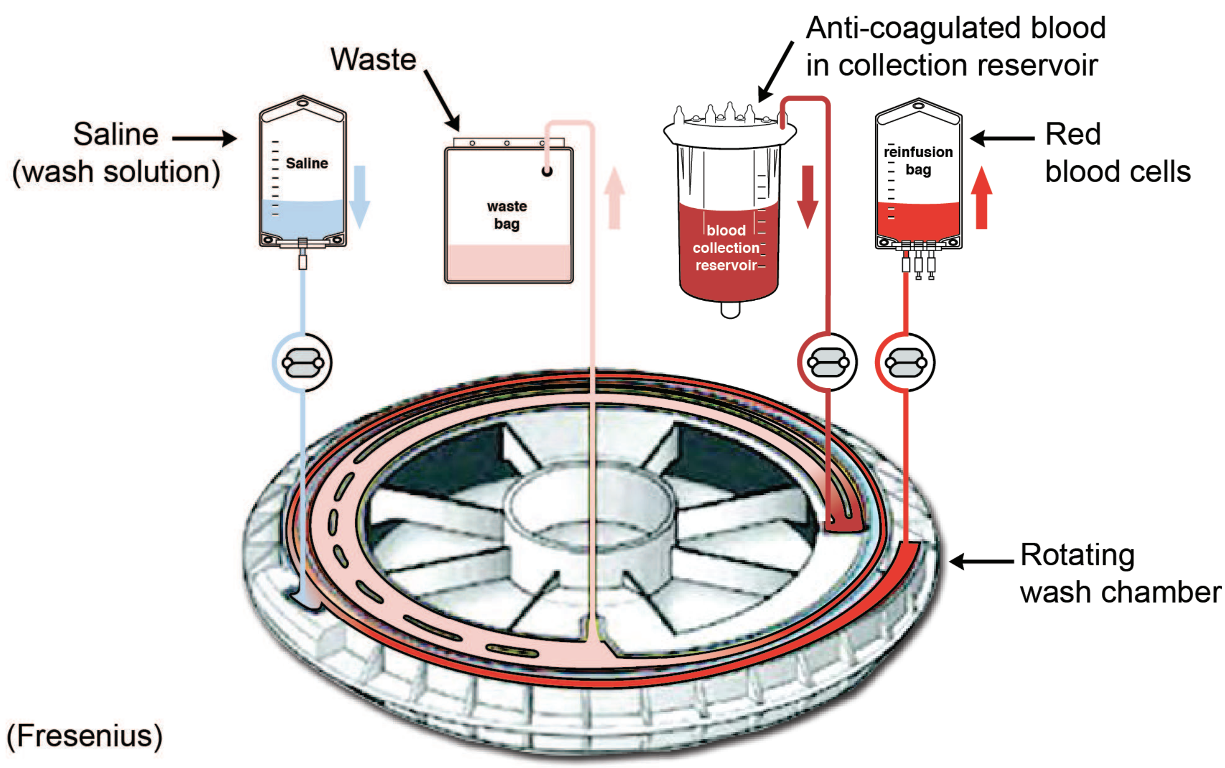
(Haemonetics)

The variable volume disk (dynamic disk) system is similar in principle to the fixed volume bowl in the separation of RBCs through centrifugation and washing with IV normal saline (0.9% NaCl).

However, this system has an elastic silicone diaphragm which permits a variable volume of RBCs to be processed, i.e. it does not require a set volume of RBCs for processing to take place. The elastic silicone diaphragm changes shape and size during processing so that the machine delivers an end product of variable volume with a fixed haematocrit (Hct). The variable volume disk system will process 100ml of reservoir contents at a time. If the volume of RBCs being drawn into the disk from the reservoir is under 15mls, the system will concentrate several batches of blood before washing. This system is therefore more advantageous for procedures where lower volume blood losses occur or during long procedures where the blood loss is constant and slow.

6.3 Continuous Rotary System

Figure 9. Continuous Rotary System



The continuous rotary system works by continuously removing the supernatant and concentrating and washing the RBCs. It requires only a very small volume of blood loss to process, however, this does not automatically mean processing should progress. The decision to process should always be made on an individual patient basis.

6.4 Stages of the Process

Opposite (Figure 9) is a description of each of the three main processing stages of the ICS process. The fixed and variable volume systems follow a pattern similar to that described below. In the continuous rotary system, washing, separation and reinfusion take place concurrently.

Figure 10. Stages of the Process

1 - Collection

Blood is aspirated and mixed with anticoagulant through an aspiration and anticoagulation (A&A) line, into a collection reservoir. The collection reservoir contains a filter that removes clots and other gross particulate matter.

2 - Processing

a. Separation

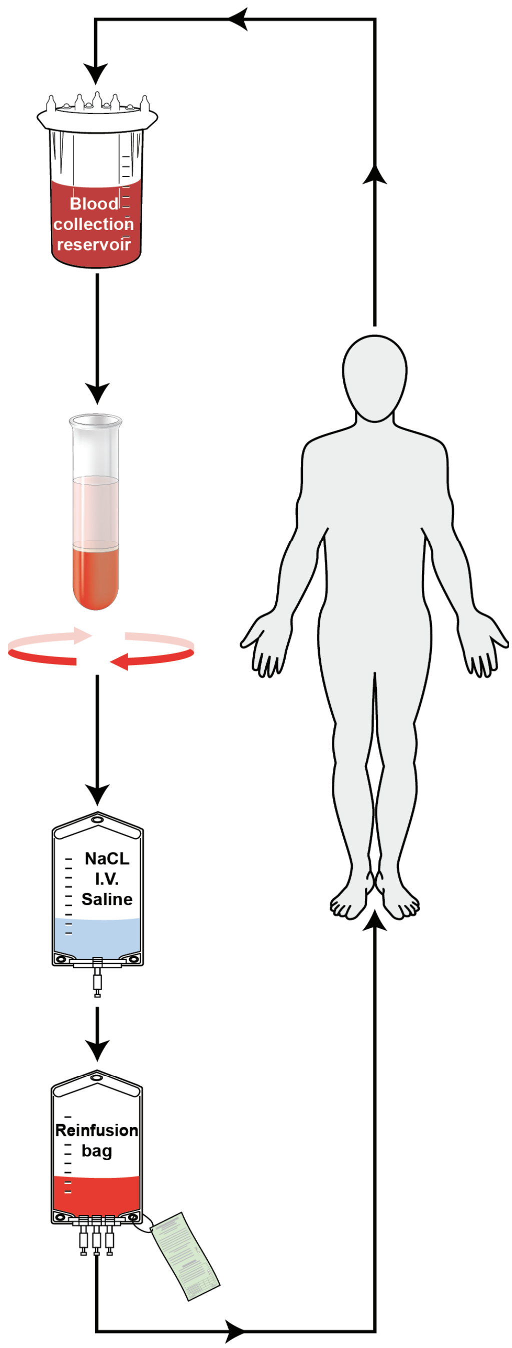
The reservoir contents are pumped/drawn into a spinning centrifuge system. The RBC component is retained within the bowl while the lighter components are forced out into a waste line. As the reservoir contents continue to enter the system and separate, the Hct within the system increases.

b. Washing

In some systems, optical sensors are positioned to detect a precise Hct during automatic mode. When this Hct is reached, the machine trips into the wash stage. IV normal saline (0.9% NaCl) is pumped into the spinning centrifuge system, passing through the heavier RBC component and out into the waste line displacing the remaining waste products (anticoagulant, cell debris, free haemoglobin, plasma etc.).

3 - Reinfusion

The end product of washed, packed, RBCs, suspended in IV normal saline (0.9% NaCl) is pumped into a bag ready for reinfusion.



Most systems have a minimum wash volume recommended by the manufacturer. It is not advisable to decrease the wash volume below this level.

It is advisable to increase the wash volume for procedures where there is a high risk of contamination of salvaged blood, e.g. obstetrics and orthopaedics. See Section 9 for further details.

ICS can reduce and sometimes eliminate the need to transfuse allogeneic (donor) RBCs. In cases where large blood loss occurs, patients receiving ICS may still become depleted of clotting factors and platelets. In such cases transfusion of allogeneic (donor) components such as fresh frozen plasma (FFP), platelets or cryoprecipitate may be required.

Key Points

- The key stages of ICS are:
  - Collection
  - Processing (cell separation and washing)
  - Reinfusion
- ICS produces an end product of packed RBCs suspended in IV normal saline (0.9% NaCl) solution.
- Where large blood loss occurs, transfusion of allogeneic (donor) blood products may be required.

Further Reading

- UK Cell Salvage Action Group (UKCSAG) – Policy for the provision of Intraoperative Cell Salvage (available to download at *www.transfusionguidelines.org.uk*)
- American Association of Blood Banks – Standards for Perioperative Autologous Blood Collection and Administration 6th Edition (ISBN: 9781563958953)
- Manufacturers' ICS Machine Specific Guidance

Self-Directed Learning

What system(s) of ICS are in use in your hospital?

How many ICS machines do you have in your hospital?