

Section 8

Practicalities – Blood Collection

Aim

- To introduce the basic theory and principles of collecting blood for Intraoperative Cell Salvage (ICS)

Learning Outcomes

- To identify the equipment used for blood collection and describe the function of each component
- To describe the steps required in preparing for and commencing blood collection
- To name the two main types of anticoagulant used in ICS, describe their function and mechanism of action
- To describe methods of maximising blood salvage
- To identify areas for potential problems during blood collection

Introduction

Whilst the practical set up of the equipment for the blood collection phase of ICS is specific to the machine in use, the basic theory and principles are the same.

During the blood collection phase of ICS, blood lost during surgery is aspirated from the surgical field, mixed with anticoagulant to prevent clotting, filtered to remove large particulate debris and stored in a collection reservoir ready for processing.

8.1 Decision to Collect Blood

The decision to collect blood is often based on a number of factors including:

- The anticipated blood loss for a particular surgical procedure
- Patient has risk factors for bleeding
- The presence of low preoperative haemoglobin
- Patient's religious or other objection to receiving allogeneic (donor) blood



Collect Only – In situations where it is difficult to predict if the blood loss will be large enough to be processed, it's good practice to set the ICS system for "collect only" whereby only the equipment required for blood collection is prepared. The processing set can be loaded later if a sufficient volume of blood has been collected for processing.

8.2 Equipment

The equipment listed in Table 3 is required for blood collection.

Table 3. Blood Collection Equipment

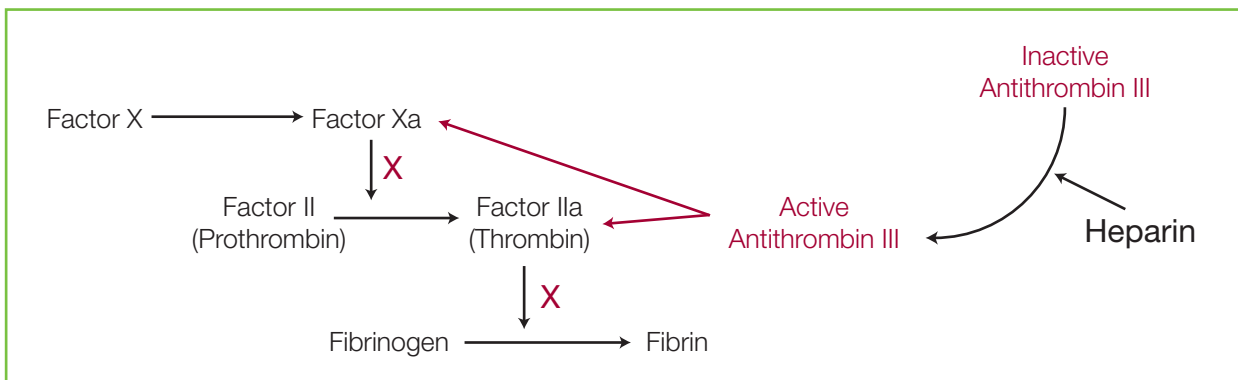
Equipment	Function
Anticoagulant (heparin saline (30,000iu/l) or Citrate (ACD-A))	To prevent clotting of salvaged blood.
Aspiration & anticoagulation line (A&A line) machine specific/sterile	Dual lumen suction line that delivers anticoagulant to the point of blood collection within the surgical field, and aspirates blood and anticoagulant away from the surgical field into the ICS system. The design of the A&A line prevents anticoagulant entering the surgical field.
Collection reservoir machine specific	Holds collected blood prior to processing. Contains a filter to remove large particulate debris (clots, bone fragments etc).
ICS machine or drip stand with collection reservoir bracket	Holds the collection reservoir in position throughout the procedure.
Vacuum source	Connects to the collection reservoir allowing aspiration of blood from the surgical field. Some machines have an integrated vacuum, others must be attached to a separate suction unit or the theatre wall suction.
Suction tip (wide bore/single lumen) sterile	Attaches to A&A line to allow aspiration of blood within the surgical field.
Suction tubing (standard theatre supplies)	Used to connect the vacuum source to the collection reservoir.
Autologous transfusion label	Identifies the blood as autologous, belonging to a particular patient and enables the recording of procedure specific details.

8.3 Anticoagulant

To prevent clotting, the aspiration and anticoagulation line (A&A line) delivers anticoagulant to the point of collection within the surgical field. Blood aspirated from the surgical field mixes with the anticoagulant as it enters the A&A line and is therefore anticoagulated before it enters the collection reservoir. If the rate of flow of the anticoagulant is insufficient, the salvaged blood will clot. This may result in contamination of the processed blood and/or may prevent processing. Types of anticoagulant used are:

- Heparin saline:
 - 30,000iu heparin/1,000ml intravenous (IV) normal saline (0.9% NaCl)
 - Heparin works by activating Antithrombin III which in turn *inactivates* both Factor Xa and Factor IIa (Thrombin) in the coagulation cascade (Figure 11). This prevents the conversion of Fibrinogen to Fibrin and the formation of clots.
 - The recommended ratio is approximately 1:5 e.g. 20ml of anticoagulant to 100ml of blood (check your machine manufacturer recommendations)

Figure 11. Heparin Mechanism of Action



Heparin anticoagulant – will be ineffective if the patient suffers from Antithrombin III deficiency. It is recommended that a citrate anticoagulant is used for these patients.

- Acid citrate dextrose anticoagulant (ACD-A):
 - Citrate based anticoagulant
 - Pre-prepared
 - Citrate based anticoagulants work by binding to free calcium in the blood. Calcium is a required cofactor in the activation of clotting factors; the action of the citrate removes calcium from the coagulation cascade, therefore preventing clot formation by inhibiting the coagulation cascade.
 - The recommended ratio is approximately 1:7 e.g. approximately 15ml of anticoagulant to 100ml of blood (check your machine manufacturer recommendations)

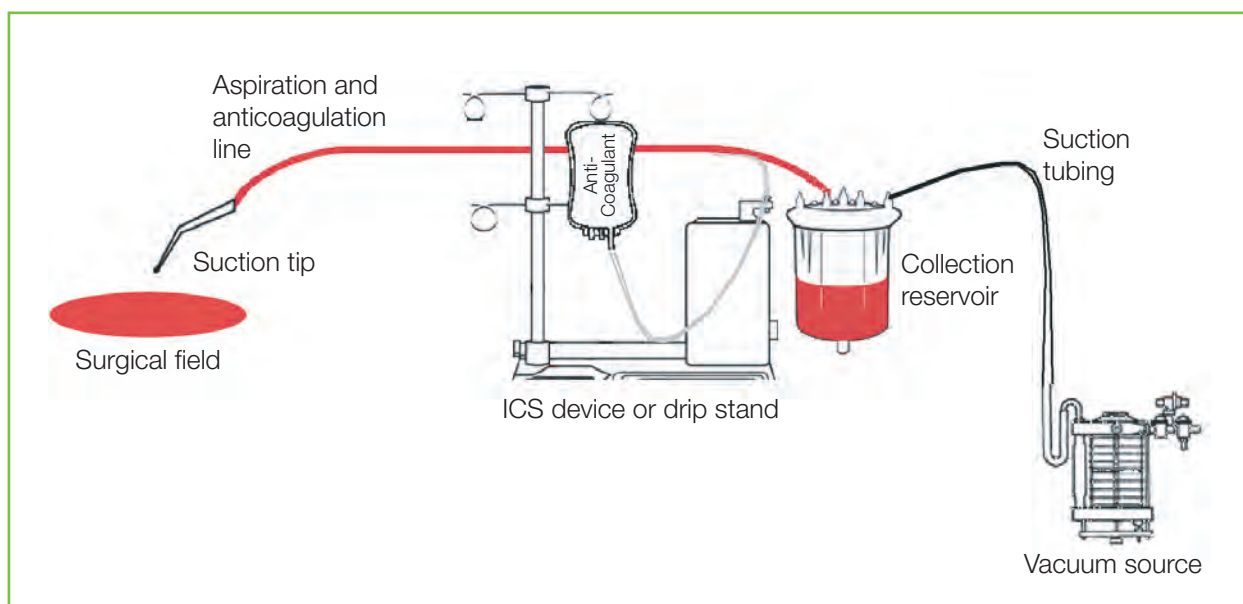


Citrate anticoagulants – fluids containing calcium e.g. Hartmann's, (if used for irrigation) may inhibit citrate based anticoagulants and should be avoided.

The typical (minimum) flow rate for anticoagulant is around 45-60 drops per minute for ACD-A and around 60-80 drops per minute for heparin saline. The anticoagulant flow rate may need to be increased during the procedure to accommodate increased levels of bleeding, this can then be returned to the minimum flow rate once bleeding is under control. Minor adjustments to the flow rate of the anticoagulant may be necessary throughout the duration of the procedure to accommodate varying levels of bleeding.

8.4 Preparation of Equipment for Blood Collection

Figure 12. "Collect Only" Set Up



The set up of the blood collection equipment for ICS is represented in Figure 12. As discussed earlier in this section, the practical set up of the equipment for ICS is specific to the machine in use. However, the basic principles and theory are the same. The main steps in the preparation of the blood collection equipment are outlined below. Clean/aseptic technique should be used as appropriate and protective clothing should be worn in accordance with local policy.

A&A Line/Suction Tip

- Pass aseptically to the scrubbed person within the sterile field.
- Ask them to attach a large bore/single port suction tip to the A&A line.



Suction Tip – to minimise damage to the red blood cells (RBCs) being aspirated, a wide bore (minimum 4mm), single lumen suction tip e.g. Yankauer sucker, should be used.

Anticoagulant

- Aseptically add 30,000iu of heparin to 1,000ml of IV normal saline (0.9% NaCl) and label clearly with an appropriate “drugs added label” or select a bag of pre-prepared citrate anticoagulant. In both cases check the expiry date of the products before use.
- Hang the anticoagulant on the drip stand on the machine or the drip stand with the collection reservoir bracket on if the machine is not available.

Collection Reservoir/Autologous Transfusion Label

- Load the collection reservoir into the bracket on the machine or drip stand.
- If appropriate (see manufacturer’s instructions) **clamp off the port that leads to the processing line.**
- Enter the patient’s details (from the patient’s identification band) onto the autologous transfusion label (Appendix 3) and attach it to the collection reservoir.



Labelling the collection reservoir – to avoid errors in patient identification, an autologous transfusion label should be completed at the patient's side, at the start of *blood collection*. The patient's details should be taken from the identification band attached to the patient. The label should be securely attached to the collection reservoir. If a processing set is subsequently loaded into the machine (see section 9), the autologous transfusion label should be transferred to the reinfusion bag immediately, or a new label completed and attached to the bag.

**Vacuum Source/
Suction Tubing**

- Attach the suction tubing to the vacuum source either on the machine or the theatre wall suction, making sure there is a secure connection.
- Attach the other end of the suction tubing to the appropriate port on the collection reservoir (see manufacturer's guidelines).

Connect A&A Line

- Prior to the start of the operation, ask the scrub person to pass the spiked end of the A&A line out of the sterile field.
- Attach the wide bore line to the appropriate port on the collection reservoir (see manufacturer's guidelines).
- Close the roller clamp on the small bore line and spike the line into the port on the anticoagulant bag.

Turn on Vacuum

- Turn on either the machine vacuum, (if available see manufacturer's guidelines), or the wall vacuum source.
- Regulate the vacuum to approximately -100mmHg to -150mmHg (follow your manufacturer's guidance).



Vacuum Levels – High vacuum levels cause haemolysis (destruction of the RBCs). Maintaining low vacuum levels minimises haemolysis and maximises the red blood cells available for reinfusion.

Prime A&A Line/ Collection Reservoir	<ul style="list-style-type: none"> • Fully open the roller clamp on the A&A line. • Allow approximately 100ml – 150ml of anticoagulant to run through the line to prime the collection reservoir.
Regulate Anticoagulant Flow	<ul style="list-style-type: none"> • Regulate the flow of anticoagulant to approximately one drop per second.
Begin Blood Collection	<ul style="list-style-type: none"> • Inform the surgical team that blood collection can begin. • Record the time blood first enters the collection reservoir.



Patients with religious requirements – the set up of ICS equipment for patients with religious requirement may differ. The requirements should be discussed with the patient prior to use, and all relevant staff should be made aware of these requirements. Further information can be found in Appendix 2.

8.5 Blood Collection

During the blood collection phase, it may be necessary for the operator to make minor adjustments to the system:

- Regulating the vacuum – it may become necessary during periods of high blood loss to increase the level of the vacuum at the request of the surgical team. The vacuum should be returned to a standard level, (approximately –100mmHg to –150mmHg) as soon as the bleeding is under control. This will minimise damage to the RBCs.
- Regulating the anticoagulant flow – the flow rate of the anticoagulant must be regulated depending on the level of bleeding. Insufficient anticoagulant will result in the system clotting off.
- Monitoring the volume of blood loss – when using a “collect only” system, the cell salvage operator must decide if it is appropriate to process the blood based on the volume of blood collected (see Section 9).



IV Grade fluids – Remember, anything that is aspirated from the surgical field could potentially go back into the patient’s circulation. Only IV grade fluids should be aspirated into the ICS system. To avoid contaminating the ICS blood, the standard theatre suction should be used for aspirating when non-IV substances are being used within the surgical field. e.g. orthopaedic cement, betadine, antibiotics not licensed for IV use etc.

8.6 Maximising Blood Collection

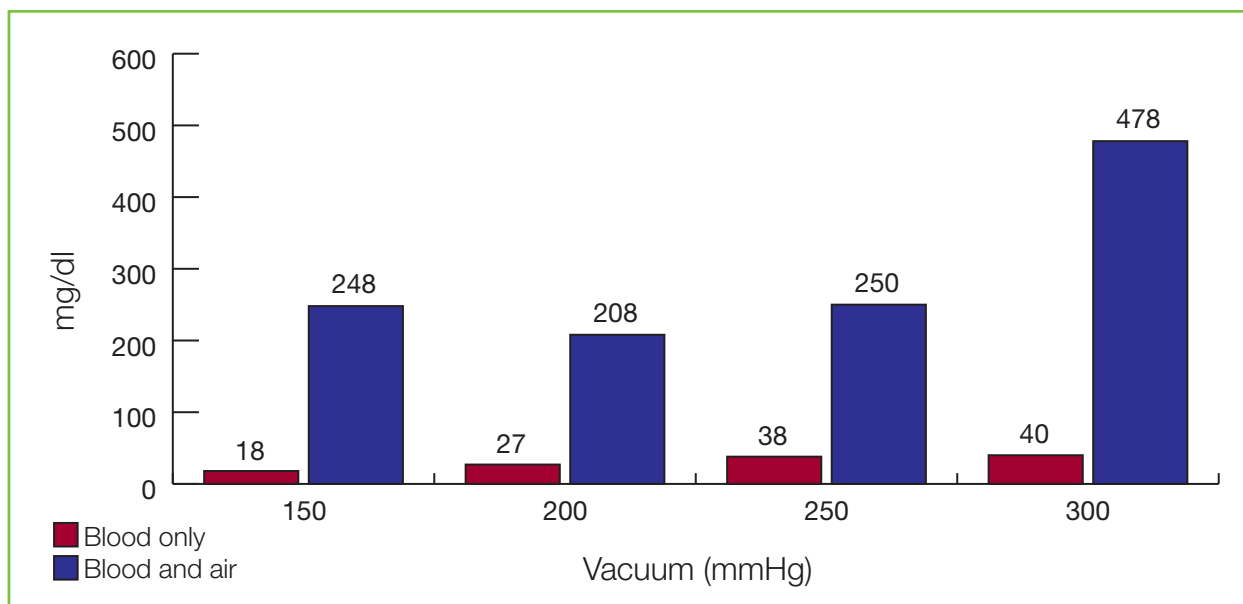
There are several techniques that can be used to maximise the volume of RBCs available for reinfusion. These include:

- Low vacuum level – Maintaining a low vacuum level minimises haemolysis, and therefore maximises the RBCs available for reinfusion. High vacuum levels cause RBC haemolysis, which can be measured by the concentration of plasma (free) haemoglobin (haemoglobin that has been released from haemolysed RBCs).
- Suction technique – where possible, the suction tip should be immersed in the blood and not skimmed across the surface of tissues or pools of blood. Skimming results in a large quantity of air mixing with the aspirated blood, this air interface causes haemolysis and therefore reduces the number of viable RBCs available for reinfusion.

Graph 1 (below) shows plasma haemoglobin at different vacuum levels and using two types of suction technique. The graph demonstrates that when blood only is aspirated (i.e. when the suction tip is immersed in a pool of blood), even high vacuum levels do not result in excessive RBC haemolysis. This supports increasing vacuum levels during excessive bleeding.

However, when blood and air are aspirated, as occurs naturally during most of the ICS process, even low vacuum levels result in excessive haemolysis and therefore reduces the available RBCs for reinfusion.

Graph 1. Changes in Plasma Haemoglobin from Baseline Measurements¹



- Suction tip – as already mentioned, a wide bore, single lumen suction tip minimises damage to the RBCs during collection
- Swab washing – see below

8.7 Swab Washing

Swab washing (Figure 13) allows blood that would normally be lost in swabs to be salvaged during ICS and can significantly increase the volume of RBCs for reinfusion.

- Equipment:
 - Sterile bowl
 - 1,000mls IV normal saline (0.9% NaCl)

Figure 13. Swab Washing



Swabs are placed in a bowl, within the sterile field, containing 1,000mls IV normal saline (0.9% NaCl). The swabs are left for approximately five minutes and are then gently (to avoid damaging the RBCs) squeezed out. The swabs are then disposed of as per department protocol. At the end of the procedure (or sooner if necessary) the swab wash is suctioned into the ICS reservoir and processing is undertaken as normal (see section 9).

In high blood loss procedures, it may be appropriate to suction the swab wash into the ICS reservoir before the end of the procedure, to allow the blood to be processed and returned to the patient. Once the contents of the bowl have been aspirated into the collection reservoir, a further 1,000mls of IV normal saline (0.9% NaCl) should be added to the sterile bowl to allow swab washing to continue.



Ensure the swab wash bowl is maintained within the sterile field.

Ensure no substances not intended for IV use enter the swab wash bowl e.g. Betadine soaked swabs.

8.8 Troubleshooting

As with any technical procedure, there is a potential for problems to arise during the process, e.g.

- Loss of suction:
 - Check the vacuum source
 - Check the suction tubing is securely connected to the vacuum source and the collection reservoir
 - Check the A&A line is securely connected to the collection reservoir
 - Check the A&A line has not been clamped or otherwise obstructed
- Clotting in the collection reservoir:
 - Check the anticoagulant is still flowing
 - Increase the anticoagulant flow rate
 - If excessive clotting has occurred it may be necessary to change the collection reservoir. This can be difficult and will result in a loss of ICS while the problem is solved, and a loss of the blood that has been collected up to that point. Therefore, this should only be undertaken as a last resort.
- Contamination with non-IV substances:
 - Contamination of the salvaged blood with substances not intended for IV use should be discussed with the lead clinician taking responsibility for ICS in the procedure, (normally the lead anaesthetist, however, in some cases it may be the lead surgeon). A clinical decision on how to proceed should be made by this lead clinician. A list of potential contaminants and their associated problems can be found in the UK Cell Salvage Action Group document “Technical Factsheet 9 – Contraindications to ICS”².
 - The decision to use blood that is potentially contaminated with bacteria, amniotic fluid or malignant cells should be made by the clinicians caring for the patient, taking into account the latest evidence and consideration of the risks and benefits of proceeding for the individual patient.

8.9 Documentation

The documentation required during the blood collection includes:

- Autologous transfusion label (Appendix 3)
- ICS data form (Appendix 4)

Key Points

- The main equipment for blood collection includes an A&A line, a collection reservoir and anticoagulant.
- The operator must maintain awareness throughout the procedure in order to prevent errors occurring.
- In order to maximise blood collection, a number of techniques can be used in conjunction with one another e.g. low vacuum levels, swab washing and suction technique.

References

1. Gregoretti, S. (1996) Suction-Induced Haemolysis at Various Vacuum Pressures: Implications for Intraoperative Blood Salvage. *Transfusion*; 36:57-60
2. UK Cell Salvage Action Group (2008) Technical Factsheet 9 "Contraindications to ICS". *Better Blood Transfusion Toolkit* www.transfusionguidelines.org.uk

Further Reading

UK Cell Salvage Action Group Publications.

The following publications are available to download at:
www.transfusionguidelines.org.uk

- Policy for the provision of Intraoperative Cell Salvage
- Technical Factsheets
 - 1 – Swab Washing
 - 2 – Anticoagulation
 - 3 – Blood Collection
 - 6 – Use of ICS in Jehovah's Witness Patients

Other

- American Association of Blood Banks – Standards for Perioperative Autologous Blood Collection and Administration 3rd Edition
- Manufacturer's ICS Machine Specific Guidance