Blood Collection and Storage

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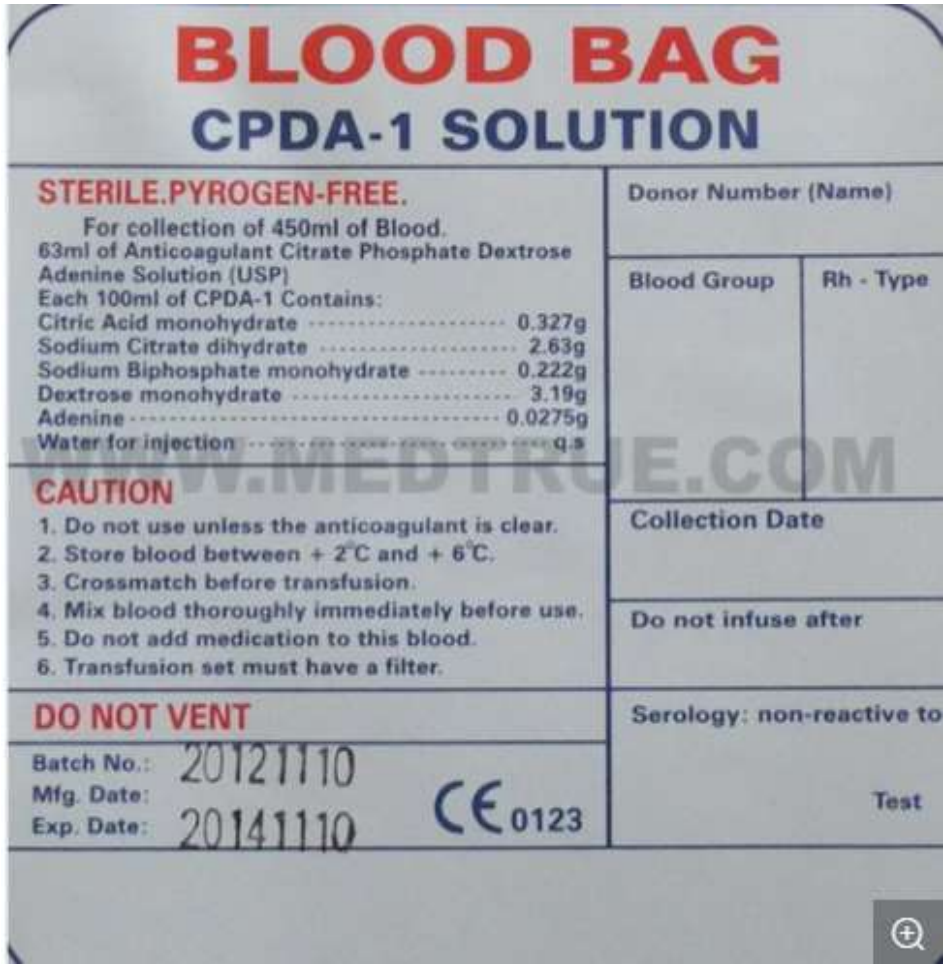
Introduction…

- Processes in blood component preparation is very important to ensure that the quality of blood product is maintained and it can improve the haematological status of the patient after transfusion.
- Blood components may be collected and prepared correctly, but if anticoagulant and preservative solutions are not suitable, or storage conditions not well managed, then the components transfused will not achieve the quality goal.
- Anticoagulants and preservatives initially prevent clotting and thereafter maintain cell viability and function during storage. Storage conditions relate largely to the maintenance of temperature from the time of collection, through processing, testing and labelling and transportation, up to the point of issue for transfusion into a patient. This is known as “cold chain management”.
- Blood is of a fragile nature and components should be handled with due care; mechanical trauma is detrimental to their viability and functionality and rough handling may also damage collection bags.
- As components are usually administered in hospital wards or operating theatres – areas that must be kept clean – it is important to store and transport blood and components under stringently hygienic conditions to ensure that when they reach the patient, they are visually presentable and free of any sign of soiling.

Anticoagulant-preservatives

- Composition of anticoagulant-preservatives

1. Sodium citrate is a calcium-chelating (binding)agent that interferes with the calcium-dependent steps in the clotting cascade and prevents coagulation.
2. Dextrose supports the generation of adenosine triphosphate (ATP) and provides nutrients that are required by the red cells.
3. Citric acid is used in conjunction with sodium citrate and dextrose to make the anticoagulant solution called acid citrate dextrose (ACD). This was one of the earliest anticoagulants used for blood collection and storage. The acidic pH does not maintain 2,3 BPG levels and it is no longer commonly used, as better solutions are now available.



4. Sodium phosphate, when used in conjunction with citric acid, sodium citrate and dextrose, comprise the anticoagulant citrate phosphate dextrose (CPD), which is in common use in conjunction with red cell additive systems. CPD has a more alkaline pH and maintain 2,3 BPG levels better than ACD.
5. CPD to which adenine (A) is added, becomes CPDA-1 (the ‘1’ signifies the formula used) and improves the synthesis of ATP. CPDA-1 is usually used when the collected donation is to be stored as whole blood.

Volume of anticoagulant

- The volume of anticoagulant required to prevent clotting and preserve red cells is dependent on the volume of blood taken from the donor.
- Some blood collection bags are designed for collection of 500mL blood and contain 70mL anticoagulant; others are designed for 450mL collections and contain 63mL anticoagulant.
- If smaller quantities of blood are to be drawn, then the volume of anticoagulant is reduced proportionately.

Adenosine triphosphate (ATP)

- Energy rich compounds (such as glucose or dextrose) are adsorbed into the cells, and are metabolized by enzymes to release their potential energy by a process called glycolysis.
- This energy is stored in a form that the cells can utilize, known as ATP.
- During component shelf life, ATP levels drop, but ATP-reduced red cells are transfused, ATP is regenerated and normal energy metabolism restored.

2,3 biphosphoglycerate (2,3 BPG)

- 2,3 BPG affects the ability of haemoglobin to release bound oxygen.
- When 2,3 BPG levels drop during storage (they fall to zero in about 2 weeks), the affinity of haemoglobin for oxygen increases proportionately. Therefore, when transfused, these cells cannot readily release oxygen to the tissues where it is required.
- However, once in circulation, stored red cells regenerate 2,3 BPG and normal function is restored within 24 hours.

Red cells additive solutions

- Red cell concentrates (Packed red blood cells) are prepared from whole blood donations collected into CDP are suspended in additive solution for improved storage and shelf life.
- When plasma is removed after the centrifugation of whole blood donations, most of the anticoagulant and nutrients in CPD are removed along with it. At this stage, blood has been effectively anticoagulated so the presence of CPD is no longer required by the red cell concentrate.
- However, the red cells need nutrients to survive, and should also suspended in sufficient fluid to allow for normal flow characteristics.

- Additive solutions (AS) vary in composition depending on the supplier. They are sometimes referred to by their brand names or simply as SAGM (saline, adenine, glucose and mannitol) or AS-1, AS-3, AS-5 and so on.
- The typical composition of an additive solution is as follows:

- Saline is the fluid in which the red cells are suspended to provide the desired flow rate conditions
- Glucose (or dextrose) provides the basic nutrients for glycolysis
- Adenine and mannitol assist in the process of ATP generation

- Volume of additive solution required to preserve red cells during storage varies according to the volume of whole blood donation. Red cells from a donation of 500mL require about 111 mL of additive solution, whereas 450mL donations need 100 mL.

Storage Lesion

- Changes that alter the physiological properties occur in collected blood over time, and this is known as storage lesion.
- Coagulation factor activity (including factor VIII) deteriorates very rapidly in whole blood, particularly after the first 24 hours of storage and is not a suitable product to treat haemostatic disorders.
- Platelets in whole blood lose viability and functionality very quickly and are not suitable source for treatment of patients requiring platelet therapy.
- The red cells increase their affinity for oxygen and lose some viability.
- Leucocytes deteriorate with the release of leucocyte proteases.
- Microaggregates form.
- Potassium is released from the red cells.

Shelf life of blood components

- For red cells, shelf life varies at 4°C ± 2°C according to anticoagulant/preservative and additive solution used. The requirement that determines shelf life is that at least 75% of red cells transfused at the end of the proposed storage period must be in circulation 24hrs after transfusion. This interpret as a shelf life of 21 days for ACD and CPD, 35 days for CPDA-1 and 42 days for CPD replaced with a suitable additive solution.

- For platelet concentrates, shelf life at 22°C ± 2°C is determined by its efficacy when transfused. This may be related to platelet viability and function during storage in the correct conditions of temperature and motion, and is considered to be up to 7 days. Most blood services allocate a 5-day shelf life to limit the increased risk of bacterial growth resulting from the room temperature storage requirement.

Shelf life of blood components

- For plasma, the levels of stable clotting factors (FII, FVII, FIX, FX and fibrinogen) are quite well maintained at 4°C ± 2°C. Labile clotting factors (FV, FVIII)deteriorate to levels that are not useful if not frozen within 24hours of collection. Shelf life of labile coagulation factors is up to 3 years if frozen (colder than -25°C). However, a storage temperature that does not reach -25°C but is colder than -18°C reduces shelf life to 3 months.

Storage temperature specifications

- Whole blood may be stored immediately after collection at the refrigeration temperature of 4°C ± 2°C. Alternatively, it may be placed in a controlled room temperature environment of 22°C ± 2°C.
- The option of 22°C ± 2°C storage up to the first 24 hours after collection is a prerequisite for the production of platelet concentrates. Whatever option is used, after the first 24 hours all whole blood donations must be maintained at 4°C ± 2°C.
- Red cells concentrate prepared from whole blood refrigerated immediately after collection should be replaced at 4°C ± 2°C as quickly as possible after processing, and in total no longer than 1 hour from the time the whole blood was removed from the refrigerator for processing. The centrifuge used to spin the whole blood for separation of red cells concentrate should be set at 4°C.
- Red cells concentrate prepared from whole blood stored at 22°C ± 2°C for up to 24 hours after collection, should be stored at 4°C ± 2°C immediately after processing. The centrifuge used should be set at 22°C.

Design features of blood storage refrigerators and plasma storage freezers

- Very good insulation is required, which minimizes heat transfer from the environment to the contents of the refrigerator/freezer interior. Insulation used for freezers may consist of denser and thicker insulating material than that used for blood refrigerators.
- Good insulation reduces workload placed on the equipment's compressor, making its operation much more efficient and also improving "hold-over" time.
- A longer hold-over time is particularly useful in areas where electricity supply is unreliable, and ambient temperatures are usually high.

- The compressor should use chlorofluorocarbon (CFC)-free gas.
- The motor should have sufficient reserve capacity to cool the refrigeration/freezing compartment efficiently.
- The motor/compressor should be controlled by a sensitive thermostat capable of holding the temperature within the required range for blood, or maintaining a sufficiently low temperature for frozen plasma.
- A fan is used to efficiently circulate cold air within the refrigerator/freezer to ensure that uniform temperature is maintained in all parts of the interior.
- Shelving within the unit should be designed to fit blood trays/crates and may be of a roll-out design for ease of accessibility. The shelving also be perforated and not made of solid sheeting and should be positioned to allow the free flow of circulating air.

- A visual temperature display and an audible alarm should be fitted to notify personnel when the temperature is out of range, or when the electricity supply is cut.
- There should be an automatic temperature recording facility and an interface for attachment to an electronic recording device linked to a computer database.
- The interior and exterior of the refrigerator/freezer should be made of material that is easy to clean, and that will withstand strong detergents and regular cleaning. Stainless steel and aluminium are commonly used but other corrosion resistant metals are also acceptable.
- Some models have double-glazed glass doors to enable viewing of the contents without opening the door. The product temperature is better maintained, and the compressor works more efficiently when the door is opened less frequently.