The evolution of intraoperative autotransfusion devices has continued since the introduction of the Bentley ATS in the early '70s. Since that time, advances in technology have spawned a new generation of systems improving performance and blood handling. Today though, the Fresenius C.A.T.S is the only autotransfusion device on the market utilizing a continuous flow technology; this unique process provides a highly efficient, flexible, user-friendly system with exceptional blood processing capabilities.

The design of C.A.T.S allows continuous processing of shed blood and provides several advantages over traditional bowl systems: minimal blood volume requirements, rapid delivery and early availability of packed red cells (PRC), elimination of fat and a consistently high hematocrit product, as well as the ability to perform plasma sequestration (PSQ). It is a highly versatile system that provides a range of flexibility for users, and can be used in a wide variety of surgeries including cardiac, pediatric, trauma and orthopedic cases.

CONTINUOUS FLOW TECHNOLOGY & WASHING PROCESS

With traditional bowl devices, blood is processed in a discontinuous cycle or batch process. Processing takes place in three distinct phases: fill, wash, and empty, on a unit or “batch” of shed blood. Processing and discharge of red cells are defined by the size of the bowl. C.A.T.S differs from traditional bowl systems in that all processing steps take place on a continuous basis as the individual cells flow through the washing chamber via a centrifuge. This process ensures a consistently high hematocrit with efficient washout of plasma and other cellular components in all cases. Moreover, there is never any residual blood volume.

There are three internal pumps that drive the continuous flow process. The blood pump transports blood from the shed blood reservoir to the washing chamber, while the saline pump transports saline into the chamber. The packed red cell (PRC) pump delivers washed packed red cells from the chamber into the reinfusion bag. Due to the continuous process with three independent roller pumps, C.A.T.S facilitates high PRC and blood flow at considerably lower pump speeds compared to bowl systems, where only a single pump performs all three tasks in succession.

The C.A.T.S system uses one set of disposables for all autotransfusion procedures. The disposable set contains a seal less, double spiral washing chamber with ports for incoming blood, waste, saline and packed red cells. The overall process is comprised of three successive stages. The blood pump drives collected blood from the reservoir into the rotating washing chamber, which is driven by a centrifuge. When the centrifuge is running, tubing rotates freely around the wash chamber at a speed exactly half that of the chamber to prevent twisting. Blood cells introduced into the chamber separate at the edge of the spiral channel. As the chamber spins, blood cells flow by gravitational force from the inside to the outside edge of the chamber. During the first separation phase, blood cells flow along the spiral channel and the hematocrit concentrates to approximately 80%. During this phase, the majority of plasma, cellular debris, white blood cells, anticoagulant and other unwanted constituents are removed into the waste bag. It is in this phase that all non-emulsified fat is completely removed. The C.A.T.S system is unique in this respect. Because of the continuous flow nature of processing, red blood cells never remix with waste constituents and contamination with fat can be avoided, thus reducing the risk of fat embolism.

The red blood cells then move through a second washing phase. Here, red cells are resuspended with saline and the hematocrit drops to approximately 15%. The cells will continue along the outside edge of the chamber during a second separation phase, until they reach the outer most edge at the packed red cell (PRC) port where the red cells are reconcentrated to a hematocrit of approximately 65%. The minimum filling volume for the PRC port is 30 mL’s; once this volume is attained, all excess red cells are transferred to the reinfusion bag. Because of the continuous processing cycle, cells will continue to spill off to the reinfusion bag as long as there is shed blood in the collection reservoir. There will never be any residual volume or left over blood.
Furthermore, with a minimum filling volume of 30 mL's of PRC, red cells become available very early in the process and users can be assured of getting a packed red cell product in almost all cases. This is especially important for low volume cases, such as those found with pediatric patients.

During the continuous wash program, the PRC flow is continually monitored and adjusted by the process of blood flow adaptation (BFA). The BFA is an automatic process to compensate for the variation in shed blood hematocrit in the separation process, and ensures a consistently high hematocrit in the output of PRC. In the BFA process, the blood flow rate is continually adapted until the optimum cell through-put is reached. C.A.T.S typically yields a PRC product with a hematocrit above 60%, regardless of the amount of blood processed.

The C.A.T.S System provides a wide selection of fully automated wash programs to use in a variety of cases. Each program differs in regards to the overall processing speed or flow of PRC and the amount of saline used in the wash process. The programs range from an Emergency Wash cycle for maximum speed and output, to a High Quality Wash program for highly contaminated blood products, as found in orthopedic cases. The user also has the option of manually adjusting the PRC flow rates within each program, this allows for maximum wash efficiency and output under all scenarios. Additionally, there are two direct blood transfer programs that can be used in extreme trauma scenarios. Here, blood is transferred directly from the blood reservoir to the reinfusion bag without washing or concentration.

With exceptional processing speed, C.A.T.S can be used in a variety of cases, including emergency situations. In the Emergency Wash program, red cells can be displaced to the reinfusion bag at a rate of 100mL's per minute. Compared to traditional bowl systems, C.A.T.S consistently yields red cells with a high hematocrit with a fast processing speed.

**PLASMA SEQUESTRATION**

Over the past several years, plasma sequestration and component therapy have become a popular and valuable element of blood conservation programs across the country. In plasma sequestration, blood components can be separated into three parts: packed red cells (PRC), plasma (PLS) and platelet rich plasma (PRP), which can be used in several different applications to improve hemostasis or wound healing. The C.A.T.S system affords users the ability to perform this process with a single add-on disposable set while utilizing the same continuous flow technology and washing chamber. The minimum blood volume requirement to perform plasma sequestration is 300mL's. As with autotransfusion, there are several unique advantages with the continuous flow system not found in bowl devices.

By utilizing the same separation technology, the C.A.T.S Plasma Sequestration program yields quality blood components in a timely manner with a highly automated, user-friendly program. One of the key benefits is the ability to give red cells back to the patient very early in the sequestration process. This is especially important during a direct draw procedure where blood is pulled from the patient in several successive stages. Since C.A.T.S requires such a small filling volume, red cells will be pushed off to the reinfusion bag very early in the process and will be available to the patient if needed. Red cell availability is essential for unstable patients when it is crucial to maintain adequate volumes.

In addition to having cells early in the procedure, the C.A.T.S system delivers exceptional blood components. Typically, C.A.T.S produces platelet concentrations three times baseline levels and the average platelet recovery rate is 51% in PRP. Because of the design of the washing chamber and processing principle, the most concentrated platelets are available behind the red cell layer. Users have the option of obtaining a rich, highly concentrated platelet product when smaller volumes of PRP are pulled from the program, such as 20 to 30mL's. This flexibility provides an increasing array of applications where the PRP product can be used. Many institutions have begun to use this process as part of a comprehensive program to improve wound healing in their cardiac operations, as well as orthopedic procedures.

In general, the C.A.T.S continuous flow system provides real benefits that help achieve better outcomes. Clinicians can be assured that no blood is ever wasted and they will always be giving back the best red cell product with a high hematocrit. In the coming year, a new generation of C.A.T.S will be available in the U.S market. This system improves upon the current design and will offer many user enhancements. Look for information from Terumo Cardiovascular Systems in the coming months.

Terumo Cardiovascular Systems is the exclusive distributor of Fresenius C.A.T.S in North America.

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4 Shulman et al, Quality of Processed Blood for Autotransfusion, JECT, Vol 32, March 2000