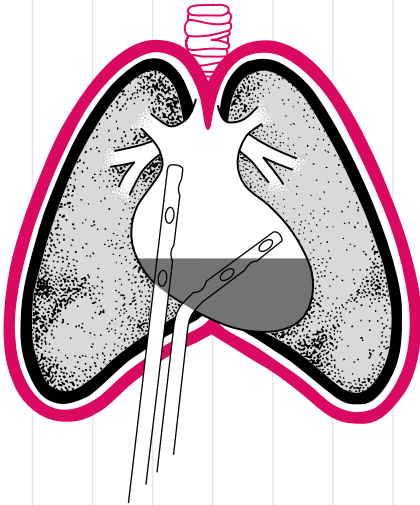


a personal guide to

M A N A G I N G

Chest Drainage

AUTOTRANSFUSION



ATRIUM

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Your personal guide to *Managing Chest Drainage Autotransfusion* is a quick and easy reference to help extend your understanding of unwashed whole blood autotransfusion following open heart surgery and chest trauma, and to help answer questions which may arise from time to time. This ATS Guide is provided as an educational service from Atrium, a world leader in water seal chest drain and autotransfusion technology. This booklet has been prepared as an educational aid only and is not intended to replace any medical or nursing practices, or hospital policies. Due to numerous model types available, it is important to carefully read and follow each corresponding product insert prior to use.

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Introduction

n Making It Simple To Understand

The necessity for blood transfusion is often required during and after surgical procedures, particularly cardiovascular surgery and trauma conditions, due to significant blood loss. Whole blood, which is salvaged postoperatively, can be reinfused in a timely manner, without the need to wash or process the blood into its components, using a standard 40 micron microemboli blood filter. This process of collecting and reinfusing unwashed shed mediastinal blood is the standard for postoperative cardiovascular and trauma patients, and is what chest drainage autotransfusion is all about. Blood transfusions are classified as two types:

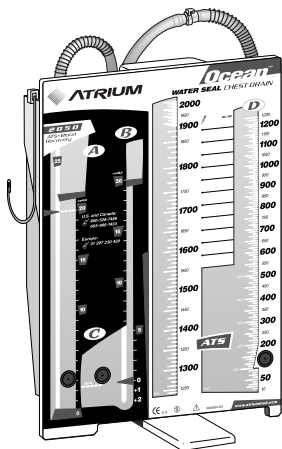
Autologous Blood: The patient's own.

Homologous Blood: Blood transfused from one individual to another of a different genetic make-up. Donor blood, or banked blood, is homologous blood.

Autotransfusion is defined as the collection and reinfusion of the patient's own (autologous) blood. The process of autotransfusion following surgery is often simply referred to as ATS and can be performed with an ATS-compatible chest drain.

Over the past two decades, cardiac surgery nurses have witnessed numerous changes in the practice of blood administration during and after cardiac surgery. In an attempt to minimize transfusion of homologous (banked) blood, healthcare technology has focused on very efficient, low cost ways to conserve a patient's own autologous blood for reinfusion. Understanding the process of collection and reinfusion of chest tube drainage (shed mediastinal blood) following cardiac surgery or trauma conditions is the focus of this guide.

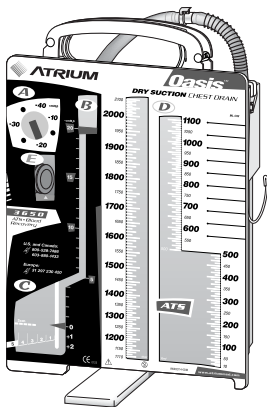
It is our hope that review of this educational aid booklet will enhance your working knowledge of chest drainage auto-transfusion and further familiarize you with the Atrium systems for conducting postoperative ATS.



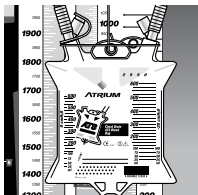
*Ocean™ 2050
ATS chest drain*



*2450
self-filling
ATS bag*



Oasis™ 3650 ATS chest drain



*2550
In-line
ATS bag*

n Customer Service

If a question or need arises for customer service, product information, or to request inservice educational material, we invite you to call or fax Atrium's hotline anytime.

In the U.S.A. 1-800-528-7486
Outside the U.S.A. 603-880-1433
Fax 603-880-6718
www.atriummed.com

The Atrium System

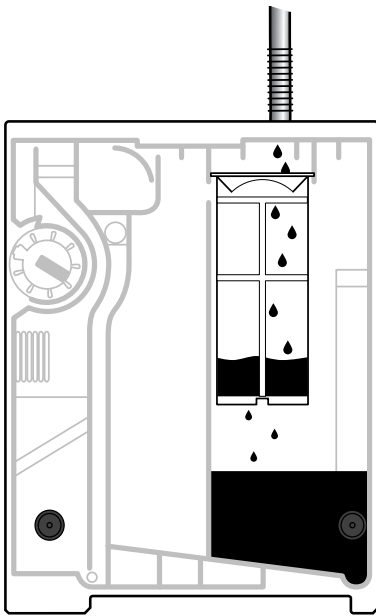
n Flexible Options For Post-Op ATS

Atrium offers the best combination of quality, performance, flexibility, and convenience found in any chest drainage auto-transfusion system. Atrium's ATS chamber water seal chest drains have been carefully engineered to satisfy today's critical need for more cost effective blood management. Each Atrium system provides the OR, critical care, and emergency trauma team complete control of an easily handled chest drain from set up to monitoring even small changes in collection volume. Once a decision has been made to initiate autologous autotransfusion, several options are available for instituting the most effective ATS method specific to the needs of the patient, quickly and cost effectively. Whether for routine chest drainage autotransfusion or for emergency chest trauma applications, Atrium's ATS systems offer unlimited flexibility for prescribing either *continuous pump reinfusion*, convenient *in-line ATS blood bag* infusion, or "post event" blood retrieval with a *self-filling ATS blood bag*.

n Proven Filter Technology

Atrium's Ocean™, Oasis™ and Express™ ATS collection chambers utilize an advanced integral filter design. The large, graduated filter chamber screens out large clots, while quickly and efficiently channeling whole blood through the 200 micron mesh filter. This innovative filter technology helps prevent clumping, aggregation, or adhesion of plasma containing proteins during drainage collection.

The gravity assist filter, together with the automatic high negative pressure protection of the water seal float valve, significantly reduces large pressure gradients which can be damaging to blood cells during collection. Reducing blood cell injury is an important step toward improving any whole blood conservation following surgery.



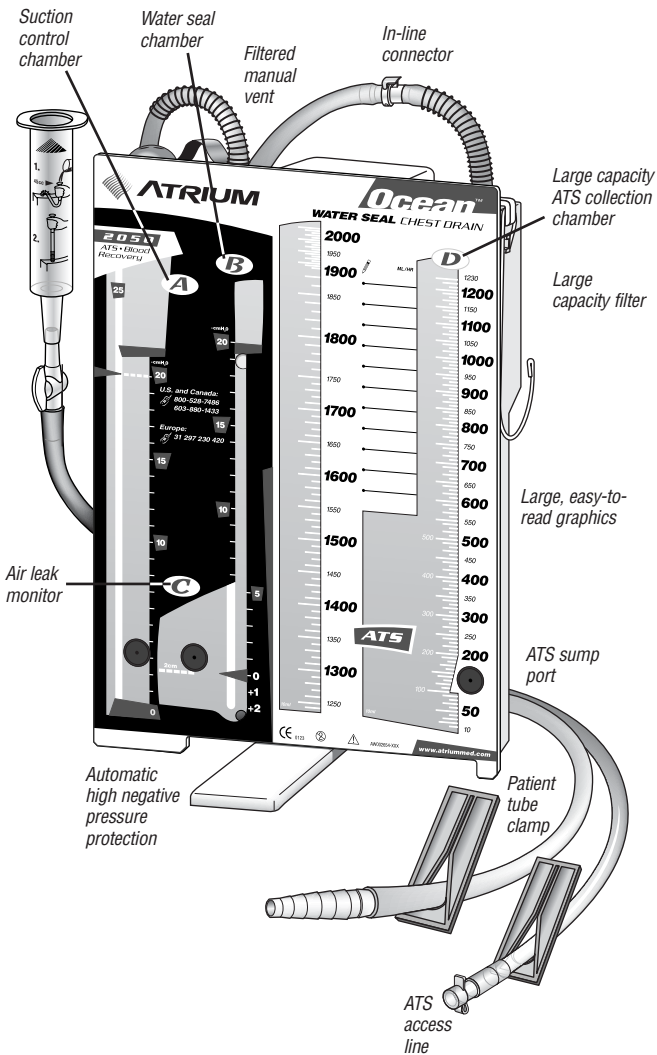
Advanced Filter Chamber Design

- *Enhanced blood cell protection*
- *Large clot capacity*
- *No fluid back-up*

An important safety feature of the filter design allows for drainage to spill over if the filter were to fill up or clot off, preventing possible fluid back-up to the patient. The Atrium ATS system provides for unrestricted collection efficiency under all patient conditions, thus helping reduce the risk of cardiac tamponade due to filter occlusion.

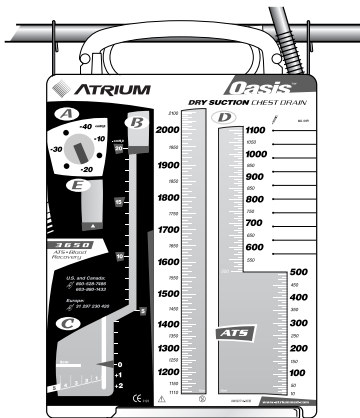
n Ocean™ 2050 ATS System

- n Compact size and familiar water seal operating system sets up in seconds and is convenient to transport.*
- n Large capacity ATS chamber offers enhanced collection capabilities during emergency situations.*
- n Large graduated filter chamber prevents fluid back-up and helps protect integrity of blood cells during collection.*
- n Kink-resistant ATS access line for rapid access to patient drainage.*
- n ATS sump port provides access to entire ATS chamber contents.*
- n Both single and dual ATS models offer unlimited flexibility for prescribing either continuous pump reinfusion, self-filling ATS blood bag infusion or in-line ATS bag infusion.*
- n Large, easy-to-read collection chamber numbers and graduations provide the ultimate in patient drainage assessment.*
- n Advanced float valve design provides automatic high negative pressure protection.*
- n Filtered manual vent offers an additional method for controlling vacuum pressures when connected to suction.*



n Oasis™ Dry Suction Control

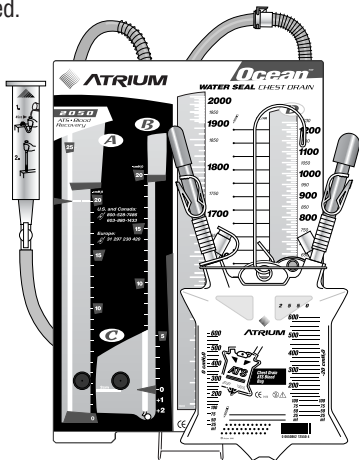
Atrium has continued our commitment to product innovation with the Oasis™ series dry suction chest drains. Atrium Oasis™ chest drains feature a traditional water seal operating system with the enhanced performance and convenience of dry suction control. With pre-packaged water to fill the water seal, set up is fast and convenient. Our advanced, “self-regulating” dry suction regulator automatically adjusts to changes in patient air leaks and fluctuations in hospital wall suction. The ATS chamber has a large integral blood filter, an ATS sump port, and an ATS access line for rapid access to patient drainage. The Oasis ATS model offers unlimited flexibility for prescribing continuous pump reinfusion, self-filling ATS bag infusion, or in-line ATS bag infusion.



n For Models Equipped With In-Line Patient Tube Connectors

For models equipped with in-line connectors, use of an Atrium in-line ATS bag, either alone or as a back-up to a continuous infusion method, will provide enhanced collection capacity and an alternative ATS collection method during

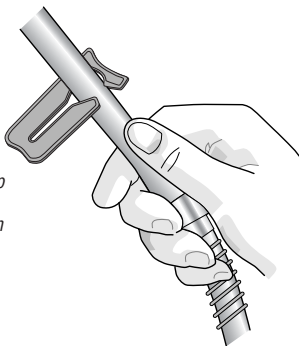
emergency situations. These tamper-resistant locking patient tube connectors provide convenient system disconnection after use or rapid in-line ATS blood bag attachment, when required.



n Patient Tube Slide Clamp

The patient tube slide clamp provided with in-line connector models must remain open at *all times* during system operation. It is recommended to move the patient tube clamp next to the in-line connector (closer to chest drain) for set up convenience and routine visual check. ***Do not keep patient tube clamp closed when system is connected to patient. Tube clamp must be closed prior to in-line connector separation.***

Keep clamp open at all times when system is connected to patient.



Continuous ATS With A Blood Compatible Infusion Pump

n Advantages Of Continuous ATS

When routine autotransfusion is prescribed following cardiac surgery, “continuous” or “closed loop” ATS via a blood compatible infusion pump offers distinct advantages to the patient, nursing staff, and hospital when compared to traditional in-line ATS blood bag methods. First, a continuous ATS reinfusion set up remains a “closed” system, which minimizes the risk of nurse exposure and helps reduce the risk of infection. A closed ATS system reduces the potential of contamination by eliminating repeated disconnections for ATS bag replacement and there is never a need to clamp off the patient tube or interrupt patient drainage. There is significantly less operator exposure to blood with a closed ATS system, and therefore, less potential contamination of nursing personnel.

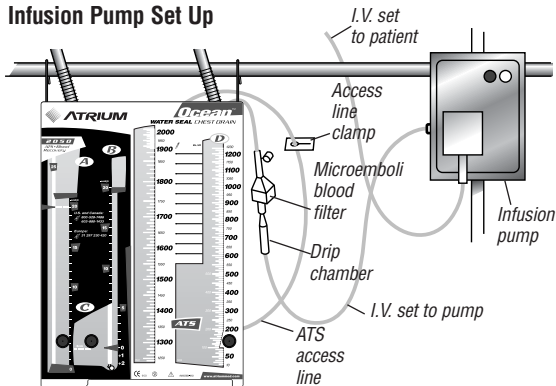
The concept of reinfusing blood back to the patient on an hourly, continuous basis is quite different than allowing collected blood to sit at room temperature in an ATS bag over a three-to-five hour period and then reinfusing it back to the patient all at once. Although both techniques are deemed acceptable, many clinicians believe that reinfusing the patient's blood back in a more consistent, timely fashion can contribute to improved patient stability during and following ATS.

A continuous autotransfusion technique saves time, money, and waste by eliminating the need for a new ATS blood bag, microaggregate blood filter, and I.V. set for each infusion. Many hospitals have experienced significant reductions (as much as 50%) on their annual chest drain/ATS budgets by converting from in-line ATS to continuous ATS. Continuous reinfusion via a blood compatible infusion pump can also

save valuable nursing time in a busy ICU. Once the pump and I.V. circuit are set up, it becomes **automated ATS**. Precise drainage readings are made from a rigid collection chamber with calibrations of 10ml vs. conventional ATS blood bags which are calibrated in 25ml increments. Depending upon the ATS bag design, drainage readings can fluctuate greatly under varying vacuum conditions with in-line ATS bags.

Implementing a change in ATS technique does require a certain learning curve. However, most critical care nurses are already familiar with infusion pumps and can quickly become skilled at administering continuous ATS. Many clinicians agree that continuous ATS is an easy, accurate, and cost effective method for hospitals practicing *routine* autotransfusion after cardiac surgery.

Infusion Pump Set Up



n Infusion Pump Requirements

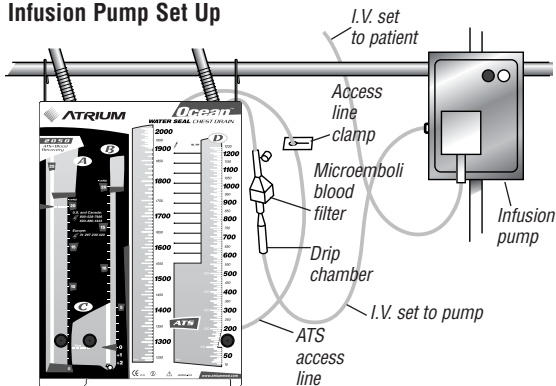
For direct reinfusion of shed autologous blood via a blood compatible infusion pump, a microemboli blood filter and non-vented, blood compatible I.V. administration set must be used. ***Please refer to all pump manufacturer's directions for use, warnings and cautions, prior to use.***

n Non “Self-Priming” Infusion Pumps

For non self-priming infusion pumps, the filter and I.V. set can be primed by aspirating air out of the I.V. circuit with a three-way stopcock and syringe or pre-primed with saline prior to attachment to the blood filter. Most self-priming infusion pumps do not require priming the I.V. set with saline. Non self-priming pumps can be used by manually priming the ATS access line, filter, and I.V. set by the following manner. Begin by clamping off the ATS access line. Drape the access line around the patient tube or metal hanger prior to filter spiking. Remove the spike port cap and insert a microemboli blood filter using a firm twisting motion. Spike a non-vented blood administration I.V. set directly into the filter. Attach a three-way stopcock to the distal (patient) end of the I.V. set. Next, connect a 60cc luer-lock syringe to the side port of the three-way stopcock and open the free flow setting on the pump cassette, if provided.

Turn microemboli filter in “spike down” position so that blood will flow *up* through the filter and drip chamber. Unclamp access line and I.V. tubing. With a 60cc syringe, slowly aspirate blood from drain, making sure the filter and drip chamber remain upside down. When the drip chamber is approximately 1/4 full with blood, turn the filter and drip chamber right side up (spike up) and continue purging air

Infusion Pump Set Up



from line. When completed, insert the I.V. cassette into the infusion pump.

Commence final priming with the pump by ***purging all in-line air prior to patient connection.*** Failure to position drip chamber in spike up position may result in “air-in-line” pump alarm, requiring I.V. set disconnection from the patient and subsequent repriming of the I.V. circuit. Set the infusion pump to the desired “*volume to be infused*” and “*ml per hour*” rate for continuous autotransfusion.

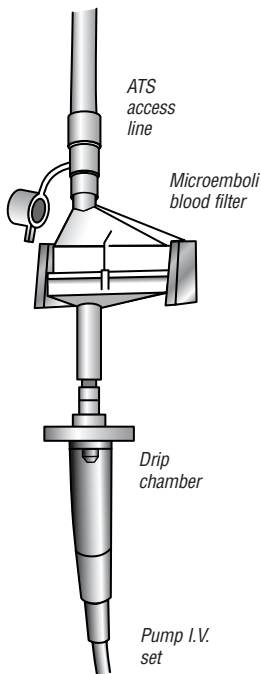
n “Self-Priming” Infusion Pumps

Most self-priming infusion pumps do not require priming the I.V. set with saline. Begin by inserting a microemboli blood filter into the ATS access line and attaching a non-vented I.V. set to the filter. Next, insert I.V. set cassette into the pump and set the infusion pump to priming mode. Open the ATS access line clamp and

commence priming ***until all in-line air is fully purged from the ATS access line, blood filter, and I.V. set.***

When fully primed, position the filter and I.V. set assembly in a *spike up* position by draping the ATS access line around the drain hanger or patient tube as illustrated.

Complete I.V. circuit must be purged of all air prior to patient connection. Set the infusion pump to the desired “*volume to be infused*” and “*ml per hour*” rate for continuous autotransfusion.



n Recording Patient Drainage

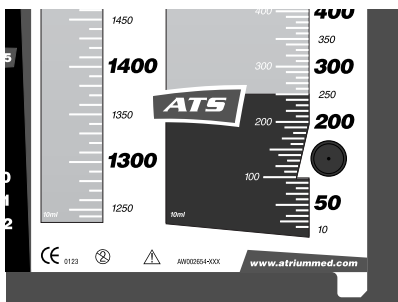
The time and method for tracking and recording patient drainage during continuous reinfusion may vary from hospital to hospital. Please refer to your hospital's protocol for specific guidelines pertaining to time intervals and volume thresholds for ATS.

A common method of tracking patient drainage is to prescribe pump reinfusion on an hourly basis. For this technique, after the microemboli blood filter and I.V. circuit have been fully primed, the infusion pump is programmed to infuse the total available blood volume in the Atrium drain during the next hour. After the initial infusion volume has been completed, the total volume now remaining in the collection chamber can be read directly as the amount the patient has drained over the last hour.

The total volume infused displayed on the pump, if provided, together with the priming volume and the drainage volume currently remaining in the Atrium drain, will indicate the total volume of blood collected.

To determine partial hour or incremental chest tube drainage during continuous autotransfusion, the following formula is suggested:

Total Volume Autotransfused (+) Priming Volume (+) Total Currently in Chest Drain (-) Last Recorded Total Chest Tube Output = Partial Hour or Incremental Blood Loss.



ATS Collection Volume Worksheet

1. Total volume autotransfused from either:

A. Cumulative pump reading, **or**

B. Last recorded ATS total from intake column of flow sheet (+) total infused during **current** infusion setting.

2. Priming volume at initial set-up:

(+) _____

3. Total blood currently in Atrium

drain: (read directly from drain)

(+) _____

4. Last recorded **total** chest tube

output from "chest tube"

column of flow sheet:

(-) _____

Blood loss since last recording

(=) _____

Keeping track of your patient's drainage during continuous ATS is made easier than ever with Atrium's advanced ATS sump port design. Located at the base of the ATS chamber, the sump port provides access to the entire blood contents via a kink resistant ATS access line. The innovative sump design eliminates the need to leave (and account for) excess blood in the collection chamber during continuous reinfusion procedures. Most competitive systems require a minimum of 50ml to remain in the collection chamber at all times (to prevent air from entering the I.V. circuit) which can make partial hour or incremental chest drainage recordings more difficult. Atrium's ATS sump port design allows you to simply program the infusion pump to deliver the total blood volume in the ATS chamber for each infusion. Atrium provides a simple and easy method to track and record patient drainage during a continuous reinfusion mode.

ATS Blood Bag Options

n Self-Filling ATS Bag (2450)

The 2450 ATS bag is a self-filling blood evacuation device for use with Atrium ATS chamber chest drain models. This 700ml capacity PVC blood bag incorporates a low vacuum generating spring assembly. The 2450 ATS bag provides immediate transfer of patient drainage from an Atrium ATS chest drain without patient tube disconnection or interruption of standard chest drainage techniques.

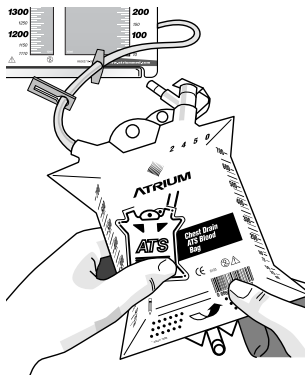
Step 1: Attaching ATS Bag

Prior to attaching the 2450 ATS blood bag, close the chest drain ATS access line clamp and remove the spike port cap. Insert the ATS bag spike into the chest drain ATS access line spike port using a firm twisting motion. To maximize blood transfer efficiency, position the ATS bag below the base of the chest drain.

Step 2: Activating ATS Bag

Once the 2450 ATS bag is connected to the ATS line and positioned below the chest drain, open both clamps. Holding the ATS bag two-to-four inches below the base of the chest drain, gently bend the ATS bag upward where indicated to activate blood transfer. When activated, the self-

filling ATS bag will begin to fill and expand as blood enters from the chest drain. *Do not activate ATS bag prior to connecting to chest drain. If accidentally activated prior to system connection, simply displace air into the chest drain after system connection. (See Displacing Air Space From ATS Bag.)*



Step 3: Disconnecting ATS Bag

Once blood evacuation is complete and the filled ATS bag is ready for disconnection, close both ATS access line and ATS blood bag clamps. To disconnect, remove ATS spike from the ATS access line spike port and insert into the ATS bag spike holder. Recap the ATS access line spike port and position the ATS access line in the holder located on top of the chest drain. Keep ATS access line clamp fully closed at all times when not in use. The 2450 ATS bag is now ready to be handled for reinfusion use. *(See Reinfusion Set Up.)*

Displacing Air Space From ATS Bag

Displacing air by gently squeezing ATS bag will allow more blood volume into the bag. Repeat as necessary until all air is displaced and ATS bag is full.

Filtered Air Vent

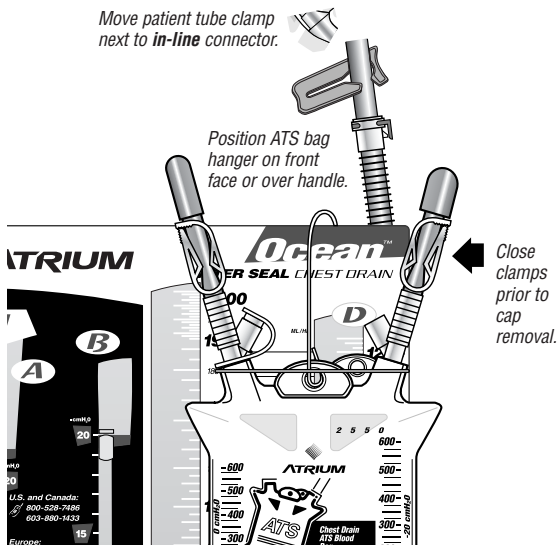
The ATS blood bag incorporates a filtered air vent with tethered plug for reclosure after use. The air vent must be open for all non-pressure infusion procedures (*gravity drip, infusion pump*) and must remain closed for pressure infusion (*hand squeeze, pressure infuser*).

n In-Line ATS Bag (2550)

Atrium's 2550 in-line ATS bag is a compact postoperative ATS collection device for use with Atrium chest drains equipped with in-line patient tube connectors. Atrium's locking auto-connect in-line tubing connectors provide rapid conversion from collection mode to reinfusion mode in seconds.

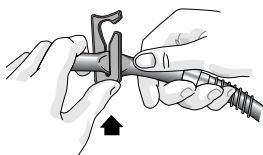
Step 1: Placement Onto Chest Drain Or Bed Rail

Atrium's advanced hanger design provides quick and easy positioning directly onto the front face of the chest drain (as shown) or adjacent bed rail. For added security during patient transit, the hanger can be placed over the chest drain handle. Firmly close both ATS bag clamps prior to connector cap removal.

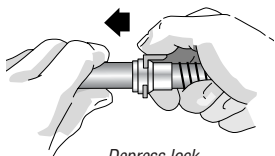


Step 2: To Connect In-Line ATS Bag To Chest Drain

To begin, move the open patient tube clamp next to the in-line connector for convenient system set up and easy visual check. Close the patient tube clamp firmly and separate connector by depressing connector lock.

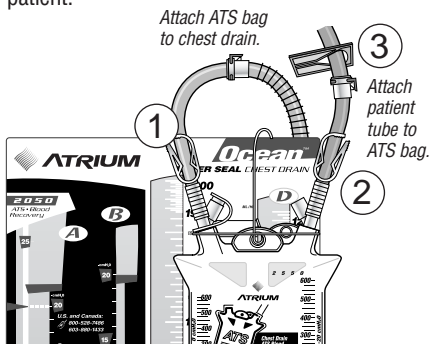


Move clamp next to connector. Close prior to connector separation.



Depress lock to separate connector.

Once separated, remove cap from female ATS bag connector and insert male patient tube connector. Remove second ATS bag cap and insert male ATS bag connector into female chest drain connector. In-line ATS bag is now connected to chest drain and patient.



Open clamps in the above 1-2-3 sequence

Step 3: Open Clamps To Begin Blood Collection

Open both in-line ATS bag clamps prior to opening patient tube clamp to bring ATS bag pressure to proper vacuum level. Open the patient tube clamp after both ATS bag clamps have been opened. All clamps must remain fully open at all times when ATS bag is connected to patient. Patient tube and ATS bag should be free of dependent loops to ensure maximum drainage efficiency. ***Do not leave patient tube clamp closed after in-line ATS bag attachment to patient.***

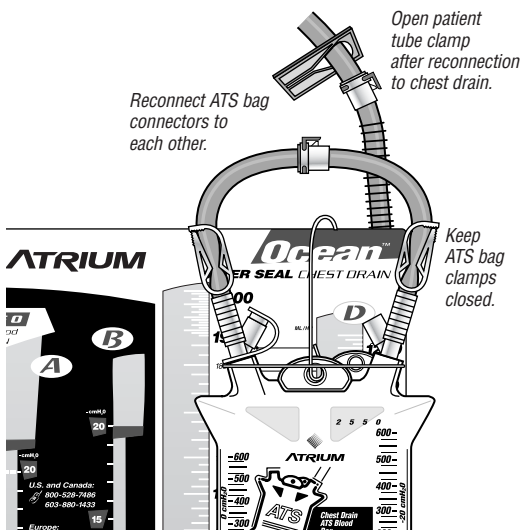
Reading And Recording Blood Volume

The in-line ATS bag deflects slightly under vacuum and is therefore calibrated on one side under vacuum pressure. The opposite side is calibrated for non-vacuum conditions. All fluid level calibrations are in 25ml increments up to a maximum collection volume of 600ml. All ml increments are approximate.

Step 4: To Disconnect In-Line ATS Bag From Chest Drain

To remove in-line ATS bag from the chest drain, securely close patient tube clamp and both ATS bag clamps. Disconnect chest drain side first, then disconnect the patient side connector. Immediately place the male patient tube connector into the female chest drain connector, and open patient tube clamp. Reconnect ATS bag connectors to each other. ATS bag is now ready to be handled for reinfusion use.

Caution: Open patient tube clamp immediately following reconnection to chest drain or new in-line ATS bag. Do not keep patient tube clamp closed during chest drainage or patient transit.



n Reinfusion Set Up

A microemboli blood filter and I.V. blood set are required for *unwashed* blood reinfusion. **Caution: A new microemboli blood filter must be used for each new ATS bag.** Priming of the blood filter and I.V. set is accomplished by the following steps:

1. Prime I.V. blood administration set and microemboli blood filter with sterile saline.
2. After chest drain disconnection, invert ATS bag with spike port pointing upward and remove tethered cap using sterile technique. Insert saline filter spike into ATS bag spike port using a firm twisting motion. Return ATS bag to upright position and place on standard height I.V. pole.
3. Open filtered air vent located on top of ATS bag first, then open the I.V. clamp to complete priming. All remaining air within the I.V. circuit must be evacuated prior to patient connection. Close I.V. clamp when fully primed. I.V. is now ready for patient connection. **Caution: Failure to purge all air from the entire I.V. circuit, prior to patient connection, can result in air emboli.**

n Reinfusion (Gravity Or Pressure Infuser Application)

Follow all hospital protocols for administering autologous whole blood reinfusion for both gravity drip or pressure infuser application:

1. Attach distal end of fully primed I.V. set to patient and open I.V. line clamp to begin patient infusion.
2. For non-pressure infusion, open filtered air vent for maximum flow rate.
3. For pressure infuser application, filtered air vent must remain closed. Maximum ATS bag infuser pressure is 150mmHg. **Caution: Do not reinfuse entire blood contents completely through blood filter and I.V. set, as air emboli can result.**

Anticoagulants

n Anticoagulant Administration

Published reports on autologous whole blood autotransfusion indicate that reversing heparin with protamine to pre-operative levels, or collection of non-heparinized blood following emergency chest trauma, may require a citrate anticoagulant to be added to collected blood to minimize clotting during collection. ACD-A and CPD solutions (Anticoagulant Citrate Dextrose Solution-A or Citrate Phosphate Dextrose Solution, USP) are anticoagulants commonly prescribed at the physician's discretion for autologous whole blood autotransfusion.

When required, citrate ACD-A or CPD solutions should be added directly to the ATS collection system during set-up or simultaneous to blood collection. After appropriate alcohol swabbing of the anticoagulant injection site located on the ATS bag or needleless access port (if available), a 20 gauge or smaller needle can be inserted for administering anticoagulant via syringe or volume control I.V. set. Anticoagulants may also be administered directly through the patient tube by inserting a 20 gauge or smaller needle with syringe.

Please refer to page 38 of this booklet for precautions when administering anticoagulants for autotransfusion.

n What Is The Difference Between ACD-A, CPD, And Heparin?

ACD-A is Anticoagulant Citrate Dextrose, commonly called "citrate." ACD-A is a sterile, non-pyrogenic solution of citric acid, sodium citrate, and dextrose in water for injection. ACD-A is intended only for use with ATS collection devices and must be thoroughly mixed with blood during collection, prior to infusion.

ACD-A is the anticoagulant of choice for intraoperative, postoperative, and posttraumatic autotransfusion techniques because:

- It's been reported that ACD-A can provide a slightly lower pH blood/anticoagulant mixture, which is consistently advantageous for whole blood platelet preservation.
- It has also been reported that with ACD-A, more viable platelets may be returned to the patient than non-citrated blood.
- ACD-A helps reduce clotting from blood cell aggregation in the ATS unit and may help reduce plugging of the microemboli blood filter and I.V. line during reinfusion.

CPD is a sterile, non-pyrogenic solution of Citrate Phosphate Dextrose in water. CPD is intended for use for anticoagulating banked blood and it may also be used with ATS collection devices.

Heparin is used extensively during surgical procedures such as open heart surgery. Heparin is a systemic anticoagulant with a much longer half-life in the body compared to ACD-A or CPD.

n How Do Anticoagulants Work?

Heparin and citrate solutions work through different mechanisms to prevent clotting during collection. ACD-A and CPD are *local* anticoagulants unlike heparin which is a *systemic* anticoagulant. ACD-A works by binding with the calcium ion, preventing the protein fibrinogen from converting into insoluble fibrin, which would cause the blood to clot. Because citrate binds only with calcium, it anticoagulates only the blood it is collected with. Simply stated, ACD-A prevents blood cells from sticking to each other, preserving the integrity of the blood cell membrane. Once the anticoagulated blood is infused, citrate is rapidly metabolized by the liver. Due to the tremendous amounts of calcium in our bodies, the small amount of citrate normally prescribed for use with post-op ATS drainage systems generally has little or no effect on the patient systemically when infused at proper doses.

n ACD-A Dosage Recommendations

Anticoagulant Citrate Dextrose Solution-A acts by binding free calcium in blood, provides a lower pH that is considered advantageous for platelet preservation, and is known to help reduce clotting in instances of rapid blood loss.

Blood Volume Expected	(For 1:7) Add This Amount ACD-A	(For 1:20) Add This Amount ACD-A
Low Volume 140-250ml	20-35ml	7-12.5ml
Incremental Volume Over 250ml	For each 100ml of collected blood add 14ml ACD-A	For each 100ml of collected blood add 5ml ACD-A
Moderate to Medium Volume 250-500ml	40-70ml	12.5-25ml
Large Volume 500-1000ml	70-140ml	25-50ml

Dosage ratios are approximate

Blood To ACD-A Ratio Chart

Total ACD-A In Drain	Blood Volume	Total Volume (ACD-A & Blood)	Ratio
40ml	280ml	320ml	7:1
40ml	320ml	360ml	8:1
40ml	360ml	400ml	9:1
40ml	400ml	440ml	10:1
40ml	440ml	480ml	11:1
40ml	480ml	520ml	12:1
40ml	520ml	560ml	13:1
40ml	560ml	600ml	14:1
40ml	600ml	640ml	15:1
40ml	640ml	680ml	16:1
40ml	680ml	720ml	17:1
40ml	720ml	760ml	18:1
40ml	760ml	800ml	19:1
40ml	800ml	840ml	20:1

n CPD Dosage Recommendations

Anticoagulant Citrate Phosphate Dextrose Solution can be added at the discretion of a physician at a control dosage of 14ml CPD solution per 100ml of collected blood; i.e., *70ml CPD/500ml blood*. When required, it is recommended a volume control I.V. set be used with all 500ml CPD anticoagulant solution containers.

Caution: Anticoagulant therapy and dosage recommendations are at the discretion of a physician, and should be monitored carefully during and after patient reinfusion.

Principles Of Blood Recovery

n History Of Autotransfusion

The concept of collecting and returning one's own blood is not new. Autotransfusion was first reported back in 1818 by Dr. James Blundell, an English physician, when he collected and reinfused blood lost by a woman during childbirth. It was first reported in the United States in 1917 by Dr. D.C. Lockwood. However, autotransfusion was rarely practiced prior to the mid-1970's, when the number of cardiac surgical procedures increased significantly, extending the nation's demand for blood. Concern over blood shortages, infection, and transfusion-transmitted diseases rekindled an interest in autologous transfusion and inspired numerous studies documenting the safety and efficacy of reinfusing the patient's own shed mediastinal blood after open heart surgery. This extensive research is what prompted Atrium to develop products that would make the process of collecting and reinfusing the patient's own blood safe, cost effective, and easy to use. As the epidemic of the acquired immune deficiency syndrome (AIDS) progressed through the 1990's and the risks associated with receiving donor blood transfusions increased, whole blood autotransfusion became routine procedure at many hospitals around the world. Today, current market data suggests that unwashed chest drainage continues to be a major adjunct to many medical centers' blood conservation techniques following open heart surgery and mediastinal chest trauma.

More recently, healthcare reform has forced many hospitals to control costs which has prompted many discriminating clinicians to focus on more efficient, flexible, and cost effective methods of conserving the patient's own blood for later infusion. This progressive attitude toward ATS has actually helped strengthen Atrium's position as a world leader and innovator in blood salvaging technology due to the efficiency, flexibility, and cost effectiveness of our chest drainage autotransfusion systems. Atrium offers multiple options for conducting chest drainage autotransfusion to fit any hospital's blood conservation needs. In addition, Atrium's large capacity collection systems and advanced blood filtration technology provide maximum patient protection during episodes of heavy blood loss.

n Blood Conservation Techniques

There are many blood conservation techniques that are designed to reduce the use of homologous blood. Most medical centers today that have large cardiac surgery programs or active trauma centers have instituted some form of blood conservation program aimed at minimizing the patient's exposure to homologous blood. Autologous blood recovery methods are currently classified into four categories, and it is quite common for hospitals to use a combination of these techniques as part of their comprehensive blood conservation program.

Pre-Deposit Autologous Donation. This autotransfusion technique permits the patient to donate their own blood a few weeks prior to elective surgery. If the patient requires a blood transfusion, either during or after the surgical procedure, it is readily available. If this blood is not needed at the time of the surgery, it can subsequently be tested and approved as donor blood.

Continued . . .

Intraoperative ATS. This technique collects and reinfuses blood aspirated from the wound during a surgical procedure. The salvaged blood can then be washed prior to reinfusion or administered through a filter without being washed.

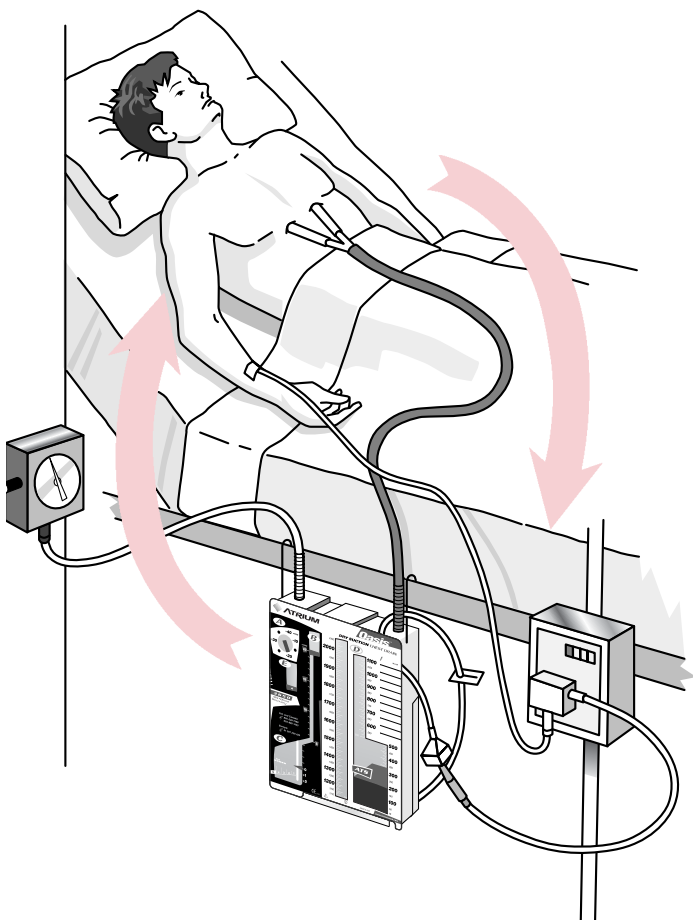
Postoperative ATS. Blood shed postoperatively can be salvaged from body cavities, joint spaces, and other closed operative sites. Today's chest drainage systems provide a safe, simple, and cost effective means of returning unwashed shed mediastinal blood following cardiac surgery back to the patient.

Trauma Emergencies. Patients who experience trauma to the heart or a major blood vessel are subject to severe bleeding into the chest cavity. Blood which is shed into the chest cavity due to trauma injury or a penetrating chest wound can be harvested and reinfused with no delay for typing or cross-matching.

Atrium manufactures a complete family of standard water seal and dry seal chest drains which offer flexible options for autotransfusion following cardiac and thoracic surgery, and chest trauma. Atrium's chest drainage autotransfusion systems are most appropriate for procedures where blood loss is considered suitable for reinfusion and it is not necessary to wash and pack red blood cells. Hospitals actively practicing blood conservation and using postoperative chest drainage ATS techniques will find Atrium's blood recovery ATS systems an integral adjunct to their current blood conservation program.

Whether for routine chest drainage autotransfusion, or for emergency chest trauma applications, Atrium's ATS systems offer unlimited flexibility for prescribing either continuous pump reinfusion, convenient in-line ATS blood bag infusion, or "post event" blood retrieval with a self-filling ATS blood bag.

Continuous ATS Infusion Pump Set Up



A continuous infusion pump method provides uninterrupted patient drainage and is referred to as a closed ATS set up. Continuous ATS is also a convenient whole blood autotransfusion method for mediastinal drainage immediately following open heart surgery and/or chest trauma.

Advantages Of Autotransfusion

There are many advantages that autologous blood transfusion can offer to the patient, the hospital and the community. Probably the single most important benefit of autotransfusion is that it provides immediate fluid replacement with less dependence on banked homologous blood transfusion. Although the potential risks associated with homologous blood transfusion are considered to be low, they include allergic and febrile reactions, infection, alloimmunization and, more importantly, risk of transfusion-transmitted diseases such as non-A, non-B Hepatitis and the human immunodeficiency virus (HIV). Autologous autotransfusion helps reduce the risk of disease transmission, and helps conserve banked (homologous) supplies. Additional benefits of autologous transfusion include:

- Convenient and immediate availability.
- Assured compatibility reduces the risk of technical or clerical errors associated with typing or cross-matching of banked homologous blood.
- Eliminates transfusion reactions.
- Compatible blood temperature, depending on technique.
- Addresses special blood needs; i.e., religious objections to receiving homologous blood transfusion, and rare blood types.
- Potential cost savings to the hospital and patient.
- Can provide psychological benefits for patients when they know they are receiving their own blood.

n The Role Of 2,3-DPG

The main function of red blood cells (RBC's) is the transport of oxygen and carbon dioxide. This process is made possible by a protein molecule found in the red

cell called hemoglobin, or HgB. Hemoglobin's primary function is to carry oxygen from the lungs, release the oxygen to tissues and organs, and carry carbon dioxide from the tissues back to the lungs.

There is a high energy molecule found in red cells, known as 2,3-Diphosphoglycerate (2,3-DPG), which is bound to hemoglobin and is an important regulator of the affinity of hemoglobin for oxygen. The role of 2,3-DPG is to lower hemoglobin's affinity for oxygen so that it releases oxygen to the tissues more easily. Without 2,3-DPG, hemoglobin has a limited ability to release oxygen to the tissues.

So why is this important? Well, the discovery of 2,3-DPG and its role, has provided clinicians with new insights about the infusion of stored (banked) blood versus fresh autologous blood which is salvaged during and after surgery. It is known that stored blood has very low levels of 2,3-DPG (approximately 6%). This could potentially be a serious situation for patients receiving large quantities of stored blood, because the amount of oxygen released to the tissues is then minimal. It has been reported that transfused cells depleted of 2,3-DPG may regain only half their normal level back in a 24-hour period, and this may not be rapid enough for a patient already compromised from significant blood loss, or a patient that is severely ill.

Autologous blood which is collected and transfused intraoperatively and postoperatively, on the other hand, may have higher levels of 2,3-DPG (100%) which can potentially allow hemoglobin to release oxygen to the tissues more easily.

It is important to note that both banked blood and autotransfused blood each have distinct advantages and disadvantages. However, the fact that autotransfused whole blood can contain higher levels of 2,3-DPG is clearly one advantage that autologous transfusion may offer over banked blood.

n Defibrination

Under certain conditions, shed blood has been reported to be sufficiently defibrinated due to prolonged exposure to wound surface tissue, rendering pooling blood resistant to further clotting. Defibrination simply means that fibrin, a clotting agent, is removed from the blood. Natural defibrination of blood is dependent upon many variables including, but not limited to: length of surgical procedure, rate of blood loss, intraoperative heparinization, postoperative heparin reversal with protamine, and the patient's intrinsic ability to clot.

Under normal (slow) bleeding conditions, where shed blood has been affected by prolonged contact with an internal body surface and has been sufficiently defibrinated, the blood may not clot during collection and, as a general rule, anticoagulation is not required. However, when rapid or massive blood loss can be expected, an effective dose of “citrate” anticoagulant is recommended to help minimize clotting during such conditions.

Caution: Anticoagulant therapy and dosage recommendations are at the discretion of a physician and should be monitored carefully during and after patient reinfusion.

n Comparison Of Banked And Autotransfused Blood

As previously discussed, concern over blood shortages and the risks associated with homologous blood transfusion pushed autotransfusion into the spotlight during the late 1970's and early 1980's. Much of the research which was done at that time focused on the hematology of autotransfusion. The following chart compares autotransfused (autologous) blood versus donor or banked (homologous) blood. It is important to note that both autologous and homologous blood transfusions offer advantages to the patient and neither is considered perfect.

Clinical Considerations Of Autologous ATS*

Blood Elements	ATS (Autologous) Blood	Banked (Homologous) Blood
• Hematocrit (% of RBC's)	22% to 30%	41% to 45%
• Life span	Normal	Decreased
• Platelets	15,000-67,000 Varies with patient status. Become viable after infusion.	0 Depleted of viable platelets.
• 2,3-DPG (oxygen releasing enzyme in blood)	100% Ensures normal delivery of oxygen to the tissues.	6%
• Fibrinogen	Will not clot with normal slow bleeding due to defibrination in chest cavity.	More normal clotting as defibrination does not occur. However, anticoagulant prevents clotting.
• Clotting factors	Near normal levels.	Lower than normal levels.
• pH	7.4 (normal)	6.3 (acidotic)
• Anticoagulants	Not usually due to defibrination. Judgment call for rapid bleeders.	CPD (1:7 ratio)
• Typing and crossmatching	No	Yes

*See references

Autotransfusion Precautions

n Nursing Responsibilities

All hospital protocols for blood handling, anticoagulant administration, autologous whole blood autotransfusion, pressure infusion of blood, disposal handling, and infection control should be carefully followed.

n Contraindications For Autotransfusion

Evacuation of collected contents for purposes of reinfusion is contraindicated in the presence of one or more of the following clinical intraoperative or postoperative conditions:

- Coagulopathy or D.I.C.
- Pericardial, mediastinal, or systemic infection or infestation.
- Pulmonary and respiratory infection or infestation.
- Presence of malignant neoplasm.
- Enteric contaminated thoraco-abdominal cavities.
- Intraoperative thoracic or mediastinal cavity use of topical thrombin, microfibrillar hemostatic agents, or providine-iodine gels or solutions.

n Maximum Blood Storage Time

Collected blood should not remain in the chest drain or ATS blood bag collectively for more than six hours prior to autotransfusion. **It is recommended that unwashed collected blood be reinfused immediately or on a continuous basis not to exceed six hours from initial collection.**

The Standards of Blood Banks and Transfusion Services manual produced by the Committee on Standards, American Association of Blood Banks (twenty-first edition, 2003), states that the transfusion of shed blood collected under postoperative or posttraumatic conditions shall begin within six hours of initiating the collection. These published standards on the collection and storage of autologous blood indicate that all blood components suffer some form of damage during prolonged storage. Atrium suggests that the most recent published standards be referred to for specific information with regards to blood handling, anticoagulants, storage conditions, and maximum storage times.

n Adverse Reaction

Adverse reactions such as coagulopathy, D.I.C., blood trauma, and particulate/air embolism have been reported to occur during and after autotransfusion of shed mediastinal/pleural blood from surgery and chest trauma. (See *References.*)

n Air Embolism Precautions

Failure to purge all air from the complete I.V. circuit prior to patient connection can result in air emboli. Do not reinfuse entire ATS chamber or ATS bag contents completely through microemboli filter and I.V. set, as air emboli can result.

n Blood Filter Requirements/Precautions

For any procedure requiring reinfusion of unwashed shed blood, a *microemboli blood filter* suitable for autotransfusion must be used. A standard 40 micron blood filter traps clumped cells, debris, and coagulated protein. A new microemboli filter must be used for each new ATS bag.

Please refer to manufacturer's directions for use, warnings and cautions for microemboli filters, prior to use.

n Anticoagulant Precautions

For emergency chest trauma or when a hospital's autotransfusion protocol suggests use of an anticoagulant such as citrate or heparin, anticoagulant should be added directly to collected autologous blood during collection. Anticoagulant therapy and dosage recommendations are at the discretion of a physician, and should be monitored carefully during and after patient reinfusion.

Citrate toxicity must always be considered when administering ACD-A solution medications. Therefore, a maximum dosage ratio of 1:7 or less of ACD-A to blood is recommended (1:7-1:20). Infusion dosage ratios of greater than 1:5, as a result of a partially blood-filled chest drain or blood bag with too much ACD-A or CPD added, should be avoided and not infused.

Rapid infusion of citrate anticoagulated blood has been reported to cause citrate toxicity and myocardial depression. Indications of such reactions are identified by tingling sensations around the mouth, stomach cramps, and possible arrhythmia. Federal U.S.A. law requires that citrate solutions (such as ACD-A, CPD, or heparin) may not be dispensed without a prescription.

n I.V. Blood Set Precautions

A non-vented blood compatible I.V. administration set is required for reinfusion. All air within the I.V. circuit must be evacuated prior to patient connection. Failure to purge all air from the entire I.V. circuit prior to patient connection can result in air emboli. Please refer to manufacturer's directions for use, warnings and cautions for I.V. blood administration sets.

n Infusion Pump Precautions

Please refer to manufacturer's directions for use, warnings and cautions for blood compatible infusion pumps prior to use with any blood collection device.

Autotransfusion References

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Troubleshooting Guide

Q During rapid blood loss conditions, is it normal for the filter chamber in the Ocean™ 2050, Oasis™ 3650 or Express 4050™ ATS chamber models to fill with clot?

A When rapid or massive blood loss is encountered, blood may not be allowed to pool in the chest long enough to become sufficiently defibrinated. In general, the more rapid the bleeding, the more clotting you can expect to see. The purpose of the filter chamber is to screen large blood particulates during collection. The filter chamber has a large 300ml filtering capacity and is calibrated to give you useful diagnostic information about your patient's condition. An important safety feature of Atrium's advanced filter chamber design is that it can allow drainage to spill over in the rare event that the filter chamber would fill up or clot off, preventing any possible fluid to back up the patient tube. The Atrium system provides unrestricted patient drainage under all patient conditions, thus helping reduce the risk of cardiac tamponade. When rapid or massive blood loss can be expected, an effective dose of "citrate" anticoagulant is recommended to help minimize clotting in the chest drain during such conditions.

Q In the event that the filter does fill up with clot and drainage starts to spill over into the ATS chamber, can I continue reinfusion?

A Yes. If the blood is considered suitable for reinfusion you may continue ATS. The spill over safety feature of the filter chamber does not preclude ATS because a microemboli blood filter, which must be used during reinfusion, will screen out any harmful particulates to the patient. However, during episodes of heavy blood loss, you can anticipate a fair amount of clotting and

accessing the blood for subsequent reinfusion from the ATS chamber or ATS bag may be difficult. If rapid or massive blood loss can be expected, an effective dose of citrate anticoagulant is recommended to help minimize clotting and enhance ATS efficiency during such conditions.

Q What should I do if the patient's rate of bleeding exceeds the maximum infusion pump rate setting?

A For clinical situations where blood loss is massive or for emergency chest trauma, use of either an Atrium 2450 self-filling ATS bag or 2550 in-line ATS bag will provide a more rapid infusion technique as compared with a continuous infusion pump method. Use of multiple ATS blood bags will accommodate larger blood volumes, faster than an infusion pump set at a maximum infusion rate. The rate of gravity reinfusion from an ATS bag is equal to or faster than many infusion pumps. Hence, the use of Atrium's flexible ATS systems may provide the most efficient means for conducting hospital-wide chest drainage ATS.

Q What should I do:

n **When an "air-in-line" pump alarm sounds?**

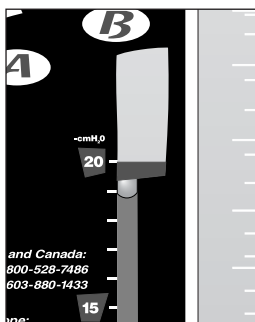
A Make sure that you are using a non-vented blood administration set. Check to see that all connections are air-tight including the filter spike and any luer-lock connections. Failure to position drip chamber in a spike up position may result in an "air-in-line" pump alarm. An alarm may also result if the "total volume to be infused" setting on the pump exceeds the total volume of blood in the Atrium chest drain. After you locate and correct the source of air in the I.V. circuit, commence priming until all in-line air is fully purged from the I.V. circuit and reset the infusion pump for continuous autotransfusion. Failure to purge all air from the complete I.V. circuit can result in air emboli.

n When an “occlusion” alarm sounds?

A First, check to see that all clamps are open and there are no kinks in the tubing. During continuous ATS, the infusion pump is “pulling” against both negative pressure in the chest drain and gravity. To minimize the force of gravity, the infusion pump should be placed low on the I.V. pole at approximately the same level as the drain. It is also recommended to set the pressure (psi) setting on the pump to the “maximum” or “high” setting. If these steps are taken and the occlusion alarm persists, it may indicate that clotting has occurred somewhere in the I.V. circuit, i.e., the ATS sump port, ATS access line, microemboli blood filter, or I.V. blood set. Under certain conditions, shed blood has been reported to clot during ATS collection which requires a medical decision whether to continue or discontinue autotransfusion, or add an anticoagulant such as ACD-A or CPD to reinstitute patient reinfusion.

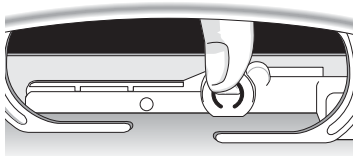
Q What causes the blue water in the water seal column to gradually rise to the top during continuous ATS use?

A The water seal column is a diagnostic manometer for monitoring your patient’s intrathoracic pressure. When blood is removed from a closed chest drainage system, due to the ongoing mechanical action of the infusion pump, intrathoracic pressures temporarily increase, causing the blue water to momentarily rise in the water seal column. The rate at which the water seal will rise is dependent upon the volume and rate of blood



being removed from the ATS chamber during reinfusion, versus the volume and rate of patient drainage entering the ATS chamber. For example, for every 3ml infused to the patient, the water seal will rise approximately 1cm, assuming there is *no* drainage coming into the ATS chamber. However, if the patient drains 3ml for every 3ml infused, you would notice virtually no change in the height of the water seal column. Hence, when the volume of blood being removed from the chest drain during continuous reinfusion exceeds the volume of drainage entering the drain, it is normal to observe a gradual rise in the water seal column. The height of the water column and patient pressure can be immediately reduced by temporarily depressing the filtered manual vent located on top of the drain until the water column lowers to the desired level. It is not recommended to lower water seal column when suction is not operating or when patient is on gravity drainage.

If vacuum pressures greater than $-20\text{cmH}_2\text{O}$ on gravity or $-40\text{cmH}_2\text{O}$ on suction were to occur for an extended period of time during autotransfusion, the automatic *controlled* release design of Atrium's float valve will allow the water seal to release automatically, lowering the blue water to a normal, safer vacuum pressure level.



Manual high negativity vent

Q Why does the blue water rise to the top of the water seal column during 2450 self-filling ATS bag use?

A The 2450 ATS bag is a self-filling blood evacuation device for use with Atrium ATS chamber chest drain models. This 700ml capacity PVC blood bag incorporates a low vacuum generating spring assembly which serves to initiate immediate transfer of patient drainage from the ATS chamber without patient disconnection or interruption of standard chest drainage techniques. As discussed in the previous question, when blood is removed from a closed chest drain system, intrathoracic pressures temporarily increase, causing the water to momentarily rise to the top of the water seal column. This principle applies also to the 2450 bag, the only difference being the *rate* at which the blood is evacuated. The 2450 self-filling ATS bag provides rapid access to patient drainage for STAT blood recovery needs. Atrium's advanced water seal float valve, located at the top of the water seal column, has been carefully engineered to accommodate rapid, safe blood evacuation from an Atrium chest drain. When the 2450 bag is activated, water will rise to the top of the water seal float valve causing the ball to "seat" up against a curved valve seat. Water passes through the valve to allow the water seal to release automatically, which generally takes place within 10-12 seconds of bag activation. The benefit of Atrium's advanced *controlled* release float valve design is that it enables all thoracic patients to draw as much intrathoracic pressure as they may require during each respiratory cycle. It further protects the patient against prolonged exposure to vacuum pressures due to milking or stripping patient drainage tubes, or removal of the blood from the ATS chamber during autotransfusion.

Q In order to prevent an “air-in-line” pump alarm during continuous reinfusion, is it necessary to leave 50ml of blood in the ATS chamber at all times?

A No. Atrium’s ATS sump port, located at the base of the ATS chamber, provides access to the *entire* blood contents via a kink-resistant ATS access line. This innovative ATS sump design eliminates the need to leave excess blood in the ATS chamber during continuous reinfusion, so keeping track of your patient's drainage is made easier than ever. However, care should be taken not to program the I.V. pump to infuse more than the total blood volume currently in the ATS chamber. Failure to do so may result in an “air-in-line” pump alarm, requiring subsequent repriming of the I.V. circuit.

Q What should I do if the 2450 self-filling bag does not fill completely after activating blood bag?

A Any remaining air in the ATS bag can be easily displaced back into the chest drain by gently squeezing the ATS bag. This procedure is quite normal and will allow more blood volume to transfer from the ATS chamber directly into the self-filling ATS bag. Repeat as often as is necessary until all air is displaced and the ATS chamber volume has been transferred into the ATS bag.

Q In the event blood reinfusion does not appear to be flowing freely into the patient during gravity (non-pressure) ATS bag reinfusion, what should I check for?

A Make sure the filtered air vent located on top of the Atrium ATS bag and all I.V. line clamps are open to maximize flow into the patient. It is also important to periodically check the ATS bag during patient reinfusion for any signs of intra-ATS bag clotting by gently tipping the ATS bag to one side to observe any clot formation.

Q What do I do when clotting within the ATS bag occurs during patient reinfusion?

A Under certain conditions, shed blood has been reported to clot during ATS collection. If you observe clot formation in the ATS bag during reinfusion, unfortunately, it may be too late to do anything about it. Adding citrate ACD-A anticoagulant to the bag will reduce any *further* clotting, however, it will not lyse, or break up clots which have already formed. In this situation, you can try gently manipulating or tipping the ATS bag to one side. This will often move clot formation away from the spike port area and improve blood reinfusion to the patient.

Q If there is approximately 200ml of drainage volume in the ATS chamber and 40ml of that volume is ACD-A, is it okay to go ahead and reinfuse the blood?

A No. This particular situation results in an infusion dosage ratio of approximately 1:4 (one part ACD-A to 4 parts blood). Citrate toxicity must always be considered when administering ACD-A solution medications. Therefore, a maximum dosage ratio of 1:7 or less of ACD-A to blood is recommended (1:7 to 1:20). Infusion dosage ratios of greater than 1:5, as a result of a partially blood-filled chest drain with too much ACD-A or CPD added, should be avoided and not infused. A convenient blood to ACD-A ratio chart is provided on page 27 of this guide.

Notes





CUSTOMER SERVICE

If a question or need arises for customer service, product information, or to request inservice educational material, we invite you to call or Fax Atrium's hotline anytime.

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