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Redo-Cardiac Surgery Without Blood Transfusion in Adult Jehovah's Witness Patients - A Single Surgeon's Experience

Manuel R. Estioko, MD

Knowledge and Compassion
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Redo-Cardiac Surgery Without Blood Transfusion in Adult Jehovah's Witness Patients - A Single Surgeon's Experience

Manuel R. Estioko, MD

In primary or first time cardiac surgery, it takes just several minutes for the surgeon to open the chest by median sternotomy (cutting the breast bone). The anatomic landmarks are intact, which allows the surgeon to perform the heart operation without a lot of difficulty. In fact, many operations have been performed without blood transfusion. Some patients later require a repeat operation—redo-surgery, for example redo-valve replacement or redo-coronary artery bypass graft (CABG). Redo-surgery presents added challenges. Adhesions or scars develop as a natural consequence of the body healing, and the heart is often encased by scars and attached intimately to surrounding vital structures. Repeat median sternotomy is the usual access to the heart. This procedure has to be done very carefully because the heart is just underneath the sternum. Opening the chest may take 30 minutes to an hour or more, depending on the severity of adhesions. Careful dissection is continued to free the heart before proceeding with the planned operation, which adds to the operative time. Therefore, redo-operation is a much more involved operation, with higher risk of potential bleeding and complications.

Is it possible to do redo-cardiac surgery without blood transfusion? This report of a single-surgeon experience is important, since there are no large-series reports on this subject specifically involving Jehovah's Witness patients, who for religious reasons absolutely do not accept blood transfusion.

This article has two parts. Part A—Clinical Report: Outcomes for forty-two (42) adult Jehovah's Witness patients undergoing redo-cardiac surgery; and Part B—How To do It. The surgical principles and techniques employed are discussed and recommendations are suggested.

Part A: Clinical Report

Forty-two (42) adult Jehovah's Witness patients were reoperated. All the previous heart surgeries were by median sternotomy. There were twenty-eight (28) male and fifteen (15) female patients. The age range was thirty-three (33) to seventy-six (76) years. Thirty-one (31) of the cases were valve operations: twenty-three (23) single valve replacements and eight multiple valves. Of the multiple valves, five (5) were double valves—mitral valve replacements (MVR) and aortic valve replacements (AVR) and three were triple valves —MVR and AVR and tricuspid valve repairs (TVr). There were ten (10) redo-CABG. Six (6) patients had third-time operations. One of these had resection of the ascending aorta and Dacron graft repair for increasing size aneurysm, six cm in transverse diameter. This patient had the first aortic valve repair as a youngster because of a stenotic valve, followed years later with AVR. These operations are summarized in the following table:

Redo-Cardiac Surgery
n = 42

Valve replacements	23
Mitral = 11 Aortic = 11 Tricuspid = 1	
Double valve	5
Triple valve (MVR, AVR, TVr)	3
Redo CABG	10
Asc. aorta aneurysm repair	1

Results

All the redo-surgery patients survived their operations except one. The 30-day mortality rate is 2.3%. The patient who did not make it expired 22 days after surgery because of complication of CVA (cerebro-vascular accident) unrelated to blood loss or anemia. There was no significant bleeding encountered in the entire series.

PART B: How To Do It

This section points to essential medical and surgical principles and describes the important details of surgical technique and strategy. In addition, the author emphasizes things to avoid that may contribute to bleeding and blood loss. Recommendations are suggested.

General Considerations:

All the patients in this report declined blood transfusion by reason of their religion; they were Jehovah's Witnesses. Their decision was Bible-based and was not negotiable. The five major blood products that were not acceptable included: whole blood, plasma, red blood cells, white blood cells and platelets. Minor blood fractions, like coagulation factors, were considered a matter of conscience and most of the patients accepted them. Special informed consent forms were signed and witnessed. Face- to-face discussions between patient and surgeon were held two times or more. A close member or members of the family were encouraged to join in and all questions were answered to the patient's satisfaction. These patients were well informed, most cooperative and very grateful.

The surgeon agreed to treat the patients with the above blood restriction. All the members of the surgical team including the anesthesiologist had agreed to this and all were committed to the goal of surgery without blood transfusion. The surgeon provides strong leadership (captain of the ship) since he has the ultimate responsibility to the patient.

Cardiac surgery without blood transfusion was viewed as a total management approach that involves the three phases of care: preoperative, intraoperative, and postoperative.

Preoperative Care:

- Appropriate surgical indication and timing of the operation.
- Maintain and optimize hemoglobin concentration
- Exclude bleeding problems.
- Associated medical conditions (comorbidities) are stabilized.

Anemia is the most important single predictor of blood transfusion in surgery. The additional blood loss during surgery worsens the anemia. None of our patients had preoperative anemia, all had normal levels of hemoglobin and hematocrit.

Intraoperative Care:

Primary Goals in Surgery:

A. Limit Blood Loss
   Limit blood loss with meticulous surgical techniques
B. Avoid Coagulopathy
   Optimize hemostasis and avoid excessive hemodilution

Meticulous surgical techniques with minimum blood loss

- Surgical team carefully plans the operation with all the details.
- Careful hemostasis during every step of the surgery.
- Use tools appropriately, i.e. electrocautery, suture, ligature, Argon Beam Coagulator (ABC), hemostatic glues and other preparations.

- Surgical team works efficiently, not hurriedly.

Limiting blood loss during surgery is mainly related to meticulous surgical technique and therefore this job is the primary responsibility of the surgeon. The technique is characterized by surgical precision and efficiency (no delays or wasted motions) while doing the operation with careful hemostasis during every step of the procedure. When this is practiced every time, it becomes a second nature to the surgeon and actually shortens the operative time. Good exposure and visualization are essential. All bleeders and potential bleeding situations are cared for without allowing anything to chance. Particular care is directed to working in the back of the heart where the exposure may be limited. Recheck and control of bleeders are performed while the patient is still on bypass and/or before decannulation. Lifting the heart to look for a bleeder at the end of the procedure may cause hemodynamic instability in the recovering heart. The "method is everything" which means details and more details. Here, experience makes a difference.

Repeat Median Sternotomy:

In preparation for the operation, the surgeon reviews the X-rays and CT scan of the chest (preferably a 64-slice scan) to evaluate the proximity of the heart to the sternal bone and plan his surgical approach in cutting the bone and dissecting the heart. The surgeon figures out the anatomic considerations by correlating the patient's chest anatomy. As previously mentioned, the heart is often adhered intimately to the sternum, so care should be exercised and more so in the presence of an enlarged heart. A semi-circular blade electric saw is used very carefully. Once the bone is cut, one side of the bone at a time is now lifted gradually and dissection of the cardiac structures is done patiently with utmost care. Enough dissection is carried out to be able to: 1) insert the sternal retractor 2) cannulate for the cardiopulmonary bypass and 3) accomplish the planned operation. It is not necessary to free the whole heart. To avoid bleeding when there is a truly difficult area of exposure, cardiopulmary bypass maybe started as an option for safety. On the other hand, too early start of the bypass prolongs bypass time, which is not desirable.

Cardiopulmonary Bypass and Cardioplegia:

Cardiopulmonary bypass supports the entire patient during the period when the actual work in the heart is being done. The system is efficient to maintain controlled flow, adequate pressure and perfusion to the tissues of the body with optimum oxygenation. To fulfill these requirements, the bypass system we use has the following features: 1) efficient, small prime membrane oxygenator, 2) centrifugal pump, 3) small prime, 800 ml total volume of whole system including tubings. The small total prime volume avoids excessive hemodilution. An experienced and knowledgeable perfusion team is an essential part of the team.

Myocardial protection: One of the greatest advances in cardiac surgery in recent years is in the improvement of myocardial protection with use of cold Potassium (K) cardioplegia. This prevents heart muscle injury during the anoxic period of the operation (aortic cross clamp). At this time, the heart muscle is not getting the usual flow of blood and oxygen. Good myocardial protection allows safe operation since the heart recovers well even with the patients with very poor cardiac function with low ejection fraction (EF). The cardioplegia we use, called Microplegia using the Quest Myocardial Protection System (Quest MPS, Atron Corporation, Allen, Texas), has unique advantages: it provides excellent myocardial protection as well as good control of hemodilution. Essentially, Microplegia consists of cold solution of small volume high concentration of K delivered using the fluid from the bypass circuit as the vehicle. The Microplegia is delivered antegrade via the coronary arteries and retrograde via the coronary sinus about every 15 minutes. One important detail that ensures good perfusion of the myocardium is to monitor the retrograde coronary perfusion pressure, which is maintained at 30-40 mm Hg

Total microplegia fluid infusion throughout the whole operation is only about 100 to 150 ml, because the diluent for the very high K concentration used is coming from the cardiopulmonary circuit, made possible by the highly sophisticated mixing function and pump delivery of the Quest MPS. Therefore, no additional fluid is needed, which is a novel idea. In contrast, the standard/conventional way of using cardioplegia by most cardiac surgeons involves using cardioplegia solutions prepared beforehand in one-liter bottles of saline solution with a small dose of Potassium; about three to five liters (1000 ml per bottle) are given for myocardial protection, further aggravating the hemodilution, with adverse effect on the patient's coagulation function (highly diluted blood does not clot well).

Blood Pump for Microplegia Delivery (Quest MPS)

What is Microplegia? Cold solution of very small volume, high concentration K+ (depolarizing agent) with Magnesium is delivered to the myocardium using undiluted blood from Cardiopulmonary Bypass as the vehicle.

Avoiding Excessive Hemodilution and Coagulopathy:

Avoiding coagulopathy is a complex subject and is not well understood by many. There is a basic and fundamental biological truth that has to be considered at all times, that is, the human blood is meant to be in its natural environment inside the blood vessels which have a surface lining that is biologically active and friendly to the blood. This lining promotes smooth flow as blood travels through the vessels throughout the entire circulatory system. Once the blood is exposed outside to foreign surfaces there are abnormal changes and degradations to its elements affecting its functions. The use of cardiopulmonary, pumps, tubings, cell savers, suctions, other invasive procedures do just that. Therefore, the less and shorter we use these, the better for the blood. It is important to understand the specific factors during surgery that may contribute to bleeding problem and should be avoided. The following should be avoided and some solutions are suggested:

1. Excessive hemodilution: Hemodilution becomes excessive when there is uncontrolled use of the many fluid sources during the operation, such as: IV fluids by the anesthesiologist, cardiopulmonary bypass prime, cardioplegia solution, fluids given by the perfusionist and additional volume given in the maintenance of BP. The cumulative fluid drops the hematocrit significantly which is not really due to blood loss. Excessive fluid administration also dilutes the patient's coagulation factors causing impairment of the clotting mechanism, leading to a bleeding tendency that is referred to as "dilutional coagulopathy". The solutions to this problem are: a) restrict fluid administration by the anesthesiologist and perfusionist, b) small cardiopulmonary bypass prime, c) microplegia myocardial protection technique with the use of the Quest MPS, which has a major impact on limiting cardioplegia fluids, d) use of

pharmacologic agents and drugs necessary for hemodynamic stabilization instead of volume administration. Often, vasodilatation is the cause of blood pressure decline rather than true hypovolemia. Of course, hemodynamic stability and optimal tissue perfusions should always be maintained.

2. Procedures that have adverse effects on the blood and coagulation factors: a) spillage of blood in the pericardium and surgical field, b) excessive use of high-pressure suctioning in both cardiotomy and cell saver suckers, c) too much use of ice saline irrigations in the surgical field. All these contribute to adverse effects on the blood coagulation mechanism. Solutions to problems are: a) avoid spillage of blood in the surgical field, b) set the cardiotomy and cell saver negative pressure suctions to the minimum, c) minimize irrigation in the field, d) avoid over-reliance on cell salvage. The truth is, if meticulous surgical technique is used and fluids are controlled, there is not much to salvage, due to minimized blood loss and improved hemostasis.

3. Prolonged cardiopulmonary bypass and operative times. Examples: surgical delays; extended cooling and rewarming times when deep hypothermia is utilized. Mild to moderate hypothermia is preferred.

If you follow the above suggestions, you will achieve superior outcomes. This approach enables the surgeon to avoid the faulty thinking or habits epitomized by the philosophy: "Do not worry about the fluids, we can do hemococentration," or "Do not worry about those bleeders, the cell saver will take care of it."

The Anesthesiologist;

The anesthesiologist is the other vital player in the OR who works closely with the surgeon and the perfusion team. He is responsible for hemodynamic monitoring and oxygenation throughout the course of the operation. He puts in the monitoring lines, which include arterial line, central venous line (CVP), and Swan-Ganz catheter prior to induction of anesthesia and endotracheal intubation. He also performs transesophageal echocardiogram (TEE) at certain parts of the operation to evaluate cardiac function and verifies the position of the coronary sinus catheter that monitors the pressure during retrograde cardioplegia delivery. In addition, he administers necessary fluids, drugs like Heparin, and later Protamine, and other needed cardiovascular medications.

The anesthesiologist, surgeon, perfusionist and nurses must communicate well throughout the course of the operation especially on issues of monitoring, hemodynamic parameters, oxygenation, volume/fluids and drug use.

One other procedure requiring the anesthesiologist to be skilled in bloodless techniques is the practice of acute normovolemic hemodilution (ANH). The anesthesiologist removes a unit or two units of blood (calculated amount depending on the patient) in a proper storage bag prior to Heparin and cardiopulmonary bypass. The removed blood is kept in continuity with the patient's cardiopulmonary bypass circuit, but not in continuous flow; it has all the coagulation factors intact. It is returned to the patient at the end of the operation for improved hemostatic function. In addition, the returned blood increases the patient's hemoglobin and hematocrit. This is a very important procedure, when property utilized, in the overall strategy for avoiding blood transfusion.

It is desirable to keep lower BP by using drugs during the periods of sternotomy and cardiopulmonary bypass cannulation. There is some blood loss during at these maneuvers, which can be decreased by keeping the patient's BP down. The anesthesiologist must control the systolic BP to about 100 mm of Hg during these periods.

Antifibrinolytic Agents: Antifibrinolytic agents are suggested to help improve hemostasis and decrease bleeding using tranexamic acid or aminocaproic acid (Amicar) with similar efficacy. In the past, Aprotinin (Trasylol) had been used but this drug has been discontinued by the Food and Drug Administration (FDA) because of reports of associated increased in mortality and renal dysfunction (Bayer Corporation withdrew the drug in 2008).

Technical Detail in Redo-CABG:

It is important to know the location of a patent Internal Mammary Graft (IMA) to avoid its injury during the reoperation. A CT angiogram and preoperative selective angiogram localize the IMA and show the proximity to the sternum. The IMA should not be injured because it is important to the blood supply to the heart and can also cause bleeding. The surgeon plans and executes his surgical approach accordingly to avoid this problem.

Helpful Technique in Redo-Valve Replacement:

Plan the steps of the operation, avoid unnecessary dissection but with enough good surgical exposure. Practice proper sequencing technique which means doing a step and going to the next seamlessly with efficiency without pausing to admire your work. This helps in cutting down the operative time. Be sure that the valve is properly sized to avoid mismatch. The sutures are precisely placed, the valve is seated properly and the sutures are tied tightly. All suture lines are rechecked several times. Hemostatic glues and sealants may be utilized and were used in some of our patients.

For purposes of Illustration, Here Are Examples of Good Hemostasis*

No blood stains in the white towels (sternotomy incision)

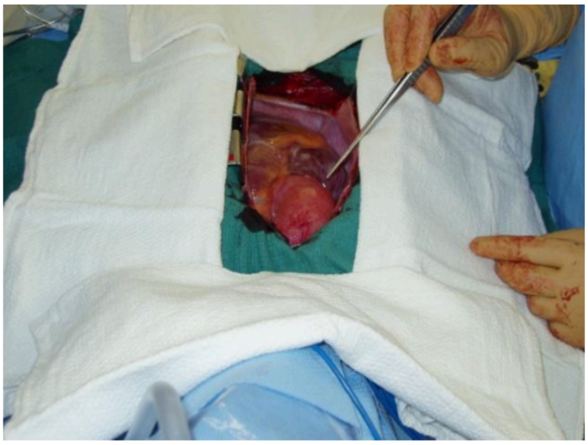

Photo courtesy of Shannon Farmer

Clean surgical field (aortic graft repair)

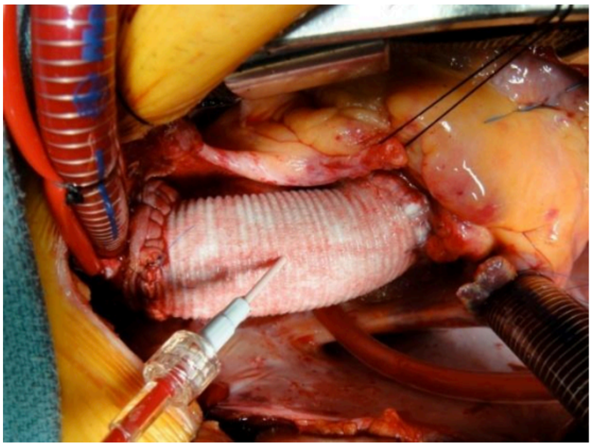

Photo courtesy of Sharo Raissi, MD

Postoperative Care:

- Precise hemodynamic monitoring
- Strict control of BP
- Optimize organ and tissue perfusion and oxygenation

When preoperative and intraoperative care have been properly executed there is minimum blood loss, no bleeding, and the Hb/ Hematocrit levels are adequate at the end of the operation. The recovery will be smooth without any problem. The next step is to pay attention to the details of postoperative care. Precise postoperative Intensive Care Unit (ICU) monitoring with stabilization of the patient are most important. Proper setup and a well-trained nursing staff are must requirements. The arterial BP should be maintained not higher than about 110 mm Hg systolic after surgery. Hypertension can potentially start bleeding at the operative sites or suture lines. This has to be avoided by sedation and using vasodilators as needed including using Nitroprusside drip which maybe started in the OR and during transport to the ICU. Chest tube drainage should be watched carefully. It is usually less than 100 ml/ hour. Any drainage of more than 100 ml in the next 2 to 3 hours after surgery is a concern. Early exploration for bleeding is entertained to control bleeding. No patient in this series required exploration for bleeding.

There is wisdom in the practice of sedating the patient and waiting for about four hours prior to considering endotracheal extubation. By this time, the patient stabilizes hemodynamically and it can be ascertained that there is no bleeding. With satisfactory parameters of cardiac index, pulmonary diastolic pressure and good urinary output, sedation is discontinued, the team can proceed with ventilation weaning and endotracheal extubation according to protocol.

Discussion:

Since these operations were done in a span of several years, the surgical technique has undergone some adjustments to "fine-tune" things and adopt new things that work better. The sound medical and surgical principles however did not change much. To avoid blood loss, meticulous and precise surgical technique remains the most important. By carefully following this total management approach and carefully adhering to sound surgical principles and techniques as suggested here, redo-cardiac surgery can be performed safely and successfully without blood transfusion. Note that the one death in this report was in the early experience.

It may be difficult to duplicate this single-surgeon experience; however it is a testimony that it can be done successfully. A surgeon who wishes to attempt this undertaking should not be take it lightly. He has to believe that this can be done and then commit to do it by applying all his talents and skills. It is recommended to start with the primary operations, and try to do many of them well, which builds confidence for the next step to doing the redo-operations. The surgeon should assemble an A- team whose members are also committed to the goal. A positive attitude for success is a desirable virtue.

About the Author

Manuel R. Estioko, MD

is a Cardiac Surgeon from Los Angeles, California. He first developed an interest and involvement in Bloodless Surgery because of the very high incidence of Hepatitis C in open heart patients (18 % in New York City). At that time (late 1960's & 1970):

- Almost all patients received blood transfusion, the early heart/lung machines required high volume prime with use of blood.

- Blood was obtained from donors with questionable health through commercial blood banking, (the change to all volunteer donors came years later).
- There was no blood test for Hepatitis.

In 1996, Dr. Estioko coined and popularized the term "Transfusion Free Surgery" which is the other widely used designation for Bloodless Surgery.

CLINICAL PEARLS

MedStar Bloodless asked Dr. Estioko to elaborate on some key points in his report. Here are his replies:

Please explain why meticulous hemostasis is especially critical in cardiac surgery.

Blood flows unimpeded inside the arteries and veins which are lined by smooth surface that is biologically active and provides a friendly environment for the blood. This is disturbed when there is injury to the surface lining of the blood vessels which triggers the aggregation of platelets and formation of fibrin matrix which now traps red blood cells to form a clot that seals the bleeding site and stops bleeding. The same mechanism is involved in forming clots that can obstruct the blood flow. For example, if this occurs in the coronary artery, it can lead to heart attack.

Surgery can never be 100% bloodless; there is always some blood loss. However, the surgeon can minimize this by meticulous technique, which involves controlling bleeding sites at every step of the operation, mainly using the electrocautery. He therefore makes controlled cuts instead of making big incisions and trying to catch the bleeders later, in which case blood is lost in the process. With meticulous surgery, whatever blood is spilled in the surgical field is collected in the pericardial sac and can then be recovered by using the cardiotomy suction which returns it to the heart lung (HL) machine. The less spillage the better. If there is excessive blood loss, which is not desirable, the cell saver is needed. The cell saver suction collects the blood and processes it, which involves spinning it and concentrating it to remove the excess fluid. Too much use of the cell saver is not recommended. It gives a false since of security, instead of avoiding blood loss as a primary mission. The intervention of processing causes breakdown of the blood elements. The goal of the cell saver is to recover the red blood cells and discard the liquid portion, which contains the clotting factors.

The HL machine, although now much improved, is only a temporary way to support the patient's circulation during the operation. It is not as good as the body's normal circulation. Many heart operations require the use of the HL machine for one to two hours, which is well tolerated with few ill effects. However, if the operation last longer than four hours, and the cell saver is used because of significant blood loss, there is an increased risk and occurrence of coagulation problems and poorer outcomes.

What role does Heparin play, and how is the effect of Heparin reversed?

The use of Heparin is mandatory with the HL machine, to ensure that the blood does not clot as it is circulated in the bypass system. A calculated full Heparin dose is given through a central venous line (CVP), not a peripheral IV line, which maybe unreliable. This procedure is critical. If through medical error the Heparin is not delivered centrally, it is almost sure to lead to clotting of the whole blood in the system in minutes, with immediate fatal outcome.

After the conclusion of the operation, heart perfusion is restarted by removing the aortic cross clamp. The heart now is being nourished with blood and oxygen, and is also rewarmed to get rid of the effect of the cold K cardioplegia that was used to protect the heart. The vast majority of hearts start beating right away; a few require electric shock or pacing. It takes about 10 to 20 minutes for the heart to recover, which is evaluated by direct vision and the use of the transesophageal echocardiogram (TEE), plus pressure measurements. If the surgical team determines that the heart is contracting well, the flow of the HL machine can now be gradually decreased, allowing the heart to gradually take over the work of circulation. This procedure is what we call the weaning process. During full bypass, the machine is pumping about four to five liters every minute. The bypass can now be gradually dialed down to 3 liters, 2 liters, and down to zero. The machine is discontinued when the patient is tolerating things well with good cardiac contractility and good blood pressure.

Once bypass has been completely discontinued, the surgeon rechecks the suture lines and surgical sites and controls any bleeding. Careful hemostasis is particularly important in redo-surgery, because there are more dissections due to the presence of scar tissue. At this time, the fluid and blood in the bypass circuit is gradually returned to the patient via the cannula tubings, which are still in place, so actually no blood is lost. Since there is not a lot of fluid, volume overload and accompanying stress on the heart are avoided. The drug Protamine is next given to reverse the effect of Heparin and to allow the clotting function to return to normal. We suture, legate, and cauterize bleeders, but we cannot do these with the tiny capillary oozing. Repair at the capillary level must rely on normal clotting. A good illustration of this is when one falls and has a deep abrasion of the knee. This cannot be treated by suturing; compression must be used as we wait for normal clotting to do its work.

The reversal of heparinization is not like an electrical off-switch. It takes some time, depending how the blood clotting properties have been adversely affected during surgery. The less trauma to the blood, the sooner normal clotting returns. So if there is no bleeding and the clotting function is restored, the chest can now be closed after placing a couple of drainage tubes. Postoperatively, some small amount of oozing occurs inside the chest. The resulting fluid is drained by the tubes, which allows monitoring to be sure there is no bleeding (the tubes are removed in two days). The patient now is transferred to the intensive care unit (ICU) for recovery.

How have technological improvements improved patient safety in bloodless cardiac surgery?

Historically, the early HL machines were large, requiring large priming volumes of 3 to 5 liters, and blood was used from the outset of the surgery, as part of the priming volume. With technical improvement through the years, more efficient machines were developed so that less than a liter (800 ml) of total prime is needed, without using blood; saline and other solutions are used.

Another development in the early years of heart surgery arose because the first HL machines did not reliably maintain good perfusion. This created the need for surgeons to work fast. Thus the era of the "virtuoso surgeons" was born. These were surgeons who pioneered heart surgery, such as my friend and colleague Dr. Denton Cooley, who developed and excelled in Bloodless Surgery and began performing successful bloodless heart surgery for Jehovah's Witnesses during the 1960's.

In Acute Normovolemic Hemodilution, is the blood in continuous circulation, and how is the ANH circuitry synced with that of the Heart/Lung Machine?

The human body is wonderfully made and the circulatory system is a marvel of creation. The heart pumps about five liters (depending on the patient's size) to perfuse the tissues of the whole body. Aside from the arteries and veins there is an enormous capillary network with intricate movements of blood and other fluids. With the use of high-powered microscopes, capillary circulation has been observed to flow and ebb in constant flux, with some channels open and others closed at any given time. The organs and tissues that are working harder at a given time (the digestive tract after eating, the muscles during exercise) require and receive more blood circulation. This shows that there is not always continuous flow even in nature. When we stop the heart lung machine, the blood in the bypass system is not actually circulating but the system is still in continuity with the circulatory system, and hence may be considered to be an extension of the patient's circulation. The blood removed in the process of ANH before the use of the HL machine and returned to the patient at the end of the procedure may be viewed in the same way. This blood is kept in continuity with the bypass-patient circuit but is not in continuous flow. The Heparin must be reversed prior to returning the blood conserved in the ANH process. The Heparin has predominant effect of not allowing clotting, so it will be of no value to return this blood prematurely. If ANH is properly utilized, it provides two benefits: it improves coagulation and increases the patient's hemoglobin and hematocrit to levels favorable for good recovery.