UCSD Pulmonary Thromboendartecectomy (PTE) Program
A Quarter Century of Success

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"I used to bike to work every day, but now I can't any more…"

"I am a young mom to a healthy, energetic toddler. I would love to play and run around with him, but I just can't, it exhausts me completely…"

"It's hard to leave the house for even a short outing, I'm utterly drained…"

These are a few of the stories that 3 of our over 2,500 patients have told over the past twenty-five years that the UC San Diego PTE Program has been in existence.

Since 1970, the year of the first PTE surgery at UCSD (Moser, 1973), we have been perfecting the diagnosing, surgical treatment, and postoperative care of pulmonary hypertension resulting from chronic thromboembolism of the pulmonary artery vasculature. Our patients continue to come from near and far, seeking to improve their condition with this life saving and permanently curative surgical procedure (Jamieson, 2003). As a result, of the approximately 3,500 cases of PTE's done worldwide, most were done at UCSD; to date numbering 2,526. UCSD is the largest referral center for thromboembolic pulmonary hypertension in the world (Thistlethwaite, 2008).

Pathophysiology of PH:

Living with Pulmonary Hypertension (PH) can be very difficult. This disease ranges along a wide continuum from mild shortness of breath on exertion, to severe dyspnea and oxygen dependency with complete debilitation. Previously active individuals are severely hampered in their abilities to go on with life as they were used to living it, and therefore they seek surgical intervention as a cure.

Pulmonary hypertension is a rare condition of high blood pressure in the blood vessels of the lungs. Over time, the progression of the disease causes large clots that block the pulmonary artery system. This leads to decreased blood flow in the pulmonary vasculature causing alterations in lung function. Additionally, the back pressure caused by these clots places increased pressure on the right side of the heart leading to increase in size and decrease in functional ability. The right side of the heart can become so enlarged and weakened that it eventually fails, leading to poor quality of life and eventually death (Gaine, 1998). Figure 1.

Preoperative workup:

At the point when medical management has been unable to adequately manage symptoms, our patients begin their journey to UC San Diego for medical workup to assess if they meet the criteria for surgical therapy. The following are criteria for surgery (Thistlethwaite, 2006).

- A calculated pulmonary vascular resistance above 300 dynes/sec/cm-5 (normal value is 100 to 250 dynes/sec/cm-5).
- Pulmonary Hypertension with evidence of surgically accessible pulmonary thrombus on pulmonary angiography
- an absence of significant coexisting non-cardiac disease

Diagnostic testing often begins several months before surgery. Patients undergo a multitude of routine diagnostic tests (physical, CBC, urinalysis, ECG, etc), in addition to pulmonary-specific testing, including:

- Impedance plethysmography (measures small changes in electrical resistance of the chest, calf or other regions of the body. These measurements reflect blood volume changes, and can indirectly indicate the presence or absence of venous thrombosis)
- Venous duplex evaluation (a test using ultrasound that evaluates the flow of blood through the veins in the arms or legs)
- Ventilation/perfusion scan (looks at the ability of air to reach all parts of the lungs, while the perfusion part evaluates

Figure 1: Depicting the progression from healthy pulmonary artery on the left to advanced formation of pulmonary thrombus on the right.

Healthy pulmonary artery-open and elastic; blood flows through easily

Artery with signs of PAH-resistance to blood flow

Artery with advanced PAH-vessel narrows and stiffens from blood vessel wall thickening, scar tissue, and clotting

how well blood circulates within the lungs)

• Pulmonary angiography (Pulmonary blood vessels are x-rayed to detect pulmonary thromboembolic disease)

• Coronary angiography (for patients >45years of age)

As the pulmonologists are determining whether a patient is a surgical candidate, it is important for them to differentiate between chronic and acute pulmonary thrombus. The respective pulmonary angiographic findings are different (Fedullo, 2001) and therefore it is critical to determine that a true endarterectomy is what the patient needs and not just an embolectomy (Jamieson, 2003).

Surgical Treatment:

On the day of surgery the patient is brought to the operating room. A median sternotomy is performed. Full cardiopulmonary bypass is instituted with a high aortic and two vena cava cannulae. A temporary pulmonary artery (PA) vent is placed and patient cooling is begun. One of the most important aspects of this surgery is cooling the patient to 20°C. Doing this lowers the basal metabolic rate (BMR- the minimum caloric requirement needed to sustain life in a resting individual) thus providing protection to the vital organs and brain. Cooling is achieved with a head and heart cooling jacket and a full body cooling blanket placed under the patient. These jackets continuously circulate very cold saline to keep the surrounding tissues at the required temperature. Cooling a patient takes approximately 45 minutes, depending on their size (Thistlethwaite, 2008).

When the patient has reached the desired degree of hypothermia, the heart goes into ventricular fibrillation. An additional vent (a small tube which allows the escape of excess blood) is placed in the left atrium to prevent heart distention from the large amount of bronchial blood flow which is often seen in these patients. Circulatory arrest is initiated along with exsanguination of blood from the heart via the cardiopulmonary bypass machine, creating a bloodless field required for the surgery (Long, et al, 1994).

A self retaining retractor (Blunt Cerebellar) is placed in the region of the right pulmonary artery and an incision is made into the vessel. Any loose thrombus is removed at this time. Using long forceps and a hollow ball-tip dissection instrument specifically designed for this surgery, the endarterectomy is begun. This special instrument eliminates the need to stop dissection to suction blood from the operative field thus reducing circulatory arrest time which results in improved patient outcomes (Long, et al, 1994).

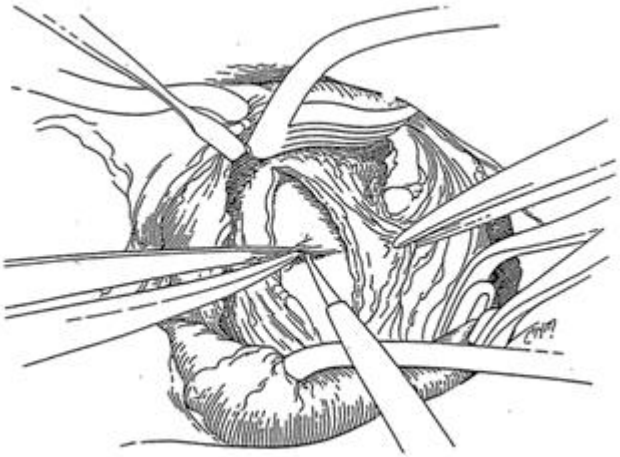

Figure 2: Endarterectomy plane is raised off normal vessel wall using forceps and hollow ball-tip dissector. Self-retaining retractor is in place holding tissues out of the way of the dissection.

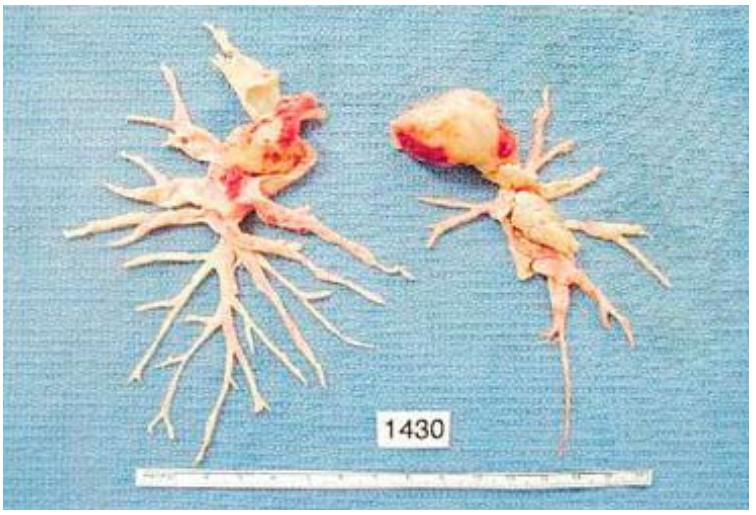

Figure 3: An endarterectomy specimen, right and left Pulmonary Arteries, as it appears in situ.

Gentle sweeping motion and traction/counter-traction is used to separate the endarterectomy specimen from the vessel wall. (Figure 2)

The surgeon extracts the left and right endarterectomy specimens separately. Each lobar branch of the PA appears in the specimen (Figure 3). It is important that the specimen from each branch of the PA is freed until it ends in order to be certain that there is no further obstruction (Thistlethwaite, 2008).

After both sides of the PA have been endarterectomized, the cooling jacket is removed from the heart and the head, cardiopulmonary bypass resumes and the rewarming of the patient begins. The blanket beneath the patient now begins to circulate warm fluid. It takes approximately 90 minutes to rewarm patients to the desired rectal temp of 36°C. If any other cardiac procedures are necessary (i.e. CABG, MVR, etc.) they are done during the rewarming period. At the completion of rewarming, cardiopulmonary bypass is terminated and chest closure follows usual routine.

The surgeon now lays out the specimen as it appeared in situ (Figure 3). The specimen is analyzed and photographed for research purposes and is then sent to pathology (Long, 1994).

Some Statistics:

The average length of the operation is 6.5 hours. The median stay in the SICU is 4 days. The median hospital stay is 10 days. The surgical mortality rate 4.7% (Thistlethwaite, 2008).

The Nursing Perspective:

This surgery poses challenges for the operating room nurse on many levels. First, the nurse realizes that this subset of patients are often critically ill and have little pulmonary reserve. The surgery has to be expedited in a very methodical and organized manner to minimize the patient's anesthesia time.

The morning of surgery, the patient and family are met in the preoperative holding area. The chart is checked, verified and rechecked for all the vital components required to insure that the correct surgery is performed on the correct patient. Consent, informed consent, blood consent, updated history and physical and current lab values are all verified with the patient. Any questions that may linger for the patient and family are answered at this point.

When all these components are in place and the surgeon has arrived in the operating suite, the patient is then taken to the operating room accompanied by the circulating RN and the anesthesia care provider.

Patients are entering an environment that is cold and foreign to them. Their anxiety increases when the doors of the operating room are opened and they enter the room. At this point, it becomes important for the nurse to provide a warm blanket and stay close by, often times holding the patient's hand as they drift under anesthesia.

The operating room team consists of the anesthesia attending and resident, the anesthesia monitoring technician, the perfusionist, the scrub person (technician or RN), the circulating RN, the surgeon and surgical assistant. They now begin a well choreographed and rhythmic "dance" that is performed efficiently, quickly and quietly. The team has worked together for many years and each member is well versed in his or her role during this "dance". Visitors often comment on how so much can be accomplished with so few words being uttered.

All the intravenous lines and catheters are now inserted. The patient is placed in the surgical position which includes a shoulder roll placed (to extend the chest) and arms carefully

padded and tucked at the sides.

On one side of the room the perfusionist readies the cardiopulmonary bypass machine by connecting the many tubes, connectors, filters and valves together. This network of what appears to be tubing "spaghetti" will keep the patient at the desired temperature and will drain blood from the body via the vena cava and, after oxygenation, return it to the patient via the aorta.

On the opposite side of the room the scrub person is organizing vast numbers of instruments required to perform this complicated surgical procedure. There is a sternal saw used to split the sternum in half lengthwise, making it possible to access the heart. There are several retractors used to make it possible to visualize inside the deep cavity of the chest. There are clamps that are used to hold bleeding vessels closed until they can be sewn shut or electrocauterized (closed shut using electrical energy). There are specialized and extremely delicate needle holders used for the fine, 13mm, needles used to sew the pulmonary artery closed. There is a sterile slush machine which will keep ice and cold saline on hand to be used to cool the heart. These are a few examples of the necessary instruments found on the eight foot sterile covered table used during this surgery.

The circulating RN takes a leading role in the choreographed "dance". His or her finger is on the pulse of all the activities occurring during the surgery. It is the role of the circulator RN to ensure that events of surgery happen smoothly and to anticipate the needs of the entire team. Patient advocacy and safety are foremost on the mind of the circulator. Their duties range from assuring sterility in the operating room, to checking blood with the anesthesia provider, to counting instruments, needles and sponges with the scrub person, to sending labs and blood gases for the perfusionist, to coordinating with the SICU for postop care. These are a few of the many tasks which the RN performs during the surgery.

After the procedure, the RN circulator ensures safe transfer of the patient from the operating table to the ICU bed and escorts the patient to the next phase of their recovery in the SICU. A verbal handoff is conducted with the receiving ICU RN and the critical details of the surgery are reviewed together.

As the nurse leaves the patient in the ICU there is the great hope that this patient will do well in their post-operative course. We anticipate that with this curative surgical procedure we will be able to help this individual regain their health, feel better, and recover some of the previous vitality in their life.

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