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Endoscopic Repeat Sternotomy

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ABSTRACT

Background: Repeat cardiac surgery represents eight to twenty five percent of cardiac surgical procedures. Catastrophic hemorrhage is a known complication of repeat sternotomy. A number of techniques have been described to reduce the incidence of injury to the heart and mediastinal structures during reoperation. This paper reports a new endoscopic technique to visualize and lyse the adhesions between the sternum and heart prior to repeat median sternotomy.

Methods: A unique substernal retractor and endoscopic visualization system was developed specifically to facilitate safe and rapid sternotomy in reoperative cardiac cases. Twenty-four patients underwent elective reoperation using the Endoscopic Redo Sternotomy Retractor® and instrumentation. There were 5 patients with prior valve surgery and 19 with coronary bypass grafts in place. Retrosternal adhesions were divided with special endoscopic cautery or scissors after which a standard reciprocating saw was used to open the sternum without damage to underlying structures.

Results: The time required for endoscopic dissection of retrosternal adhesions ranged from 6 to 22 minutes. No injury to any cardiac structure or conduit occurred.

Conclusions: The Endoscopic Redo Sternotomy Retractor® provides excellent visualization of all retrosternal structures and adhesions allowing safe and meticulous dissection prior to sternal opening.

INTRODUCTION

Repeat cardiac surgery represents eight to twenty five per cent of adult cardiac surgery, depending upon whether the procedure is a coronary or valve operation [STS Database 1998]. In the United States, that number accounts for 35,000 to 50,000 cases per year. The mortality of repeat cardiac surgery is higher than that of first time cardiac surgery [STS Database 1998] One factor influencing the result of repeat cardiac surgery is the technique of repeat sternotomy. There are no prospective studies on the incidence of cardiac injury or death associated with repeat sternotomy. However, massive hemorrhage is a well-recognized complication of repeat sternotomy, and is associated with a high mortality [Dobell 1984] At the time of repeat sternotomy, there is risk of injury to the right ventricle, right atrium, vein grafts, internal mammary artery conduits, aorta, innominate vein, valve conduits and lungs [Machiraju 1997] Injury to mediastinal structures results in increased operating time, bleeding, transfusion, the use of emergency femoral-femoral bypass, and death.

Several factors may adversely influence the risk of reoperation [Loop 1984]:

- More than one reoperation
- Ascending aortic aneurysm
- Multiple valvular disease, or conditions enlarging the right atrium or ventricle
- Patients with right ventricular outflow patch or conduit
- Previous mediastinitis with sternal osteomyelitis

A number of operations and maneuvers have been described to reduce the risk of injury to the heart at repeat sternotomy:

- Oscillating saw on the anterior sternal table, wires left in place, oscillating saw or scissors on the posterior table [Garrett 1989]
- Anterior sternal retraction with takedown of adhesions under direct vision: ART procedure [Eddy 1991]
- Left thoracotomy for reoperative coronary artery bypass [Ungerleider 1985]
- Right or left thoracotomy for avoidance of patent anterior grafts [Walker 1986]
- Use of an osteotome and Lebsche-knife to open the sternum, with use of the osteotome to resect the posterior sternum in continuity with severely adherent structures [Robicsek 1993]
- Blind takedown of adhesions with a long scissors, and open the sternum with the scissors in place [Tyers 1998]
- Angulation of the oscillating saw in a plane parallel to

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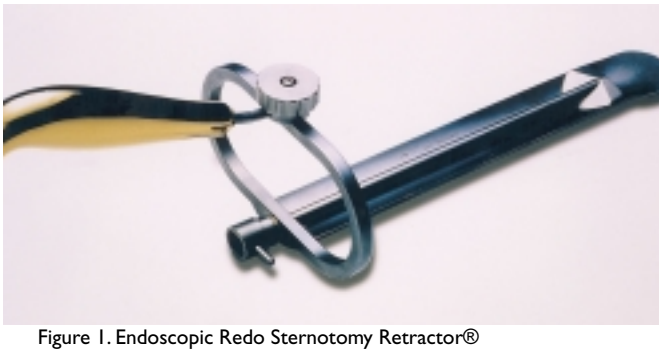

Figure 1. Endoscopic Redo Sternotomy Retractor®

the sternum, rather than perpendicular to the sternum [Machiraju 1997]

- Cannulation of the femoral vessels with or without institution of cardiopulmonary bypass for decompression of the heart [Boncheck 1997]
- Hyperinflation of the lungs to move the heart away from the sternum [Ancalmo 1993]
- No preparation at all, with reopening the sternum using a reciprocating saw [Irarrazaval 1977]

The sheer volume of different approaches is testimony to the desire of surgeons to avoid catastrophe at the time of reopening the sternum.

The ultimate means by which to prevent the injury to the heart at repeat sternotomy is to visualize the structures behind the sternum prior to sternotomy, and to mobilize them from the sternum. If an adherent structure cannot be mobilized, then continuous visualization of the structure during the sternal split will allow the surgeon to avoid the structure.

An instrument set has been developed that allows endoscopic visualization and endoscopic lysis of the adhesions between the heart and sternum prior to repeat sternotomy (Redo Sternotomy Retractor®, Genzyme Surgical Products, Cambridge, MA, USA). In essence, it allows the surgeon to see behind the sternum and to mobilize the heart away from the sternum to allow a safer repeat sternotomy.

MATERIALS AND METHODS

Instrumentation

The device has several parts. The retractor portion is designed to act as a large tongue-blade, used to gently depress the heart away from the sternum, putting the adhesions under tension (see Figure 1, ◉).

Mounted onto the retractor is a custom-built 5 millimeter endoscope (0 degree or 30 degree, Genzyme Surgical Products, Cambridge, MA) and a three chip camera (Genzyme Surgical Products, Cambridge, MA). The retractor is attached to a handle that remains suspended over the sternum to allow manipulation of the tip of the retractor behind the sternum. The EndoCautery Probe® (Genzyme Surgical Products, Cambridge, MA) is an elongated cautery device that fits onto most standard cautery pencils, is three millimeters in diameter, and is long enough to reach the entire length of the sternum. The cautery device is equipped with suction to aspirate plume from the field, and to keep the endoscope lens from fogging (see Figure 2, ◉).

Technique

The endoscopic redo sternotomy procedure is begun by removing the xyphoid process, and by elevating the distal sternum ventrally with a Rultract® or similar retractor. Sternal wires are left intact during this portion of the procedure and will be used as a guide. The tip of the Endoscopic Redo Sternotomy Retractor® is placed between the heart and the sternum (see Figure 3, ◉).

As if using a large tongue blade, the heart is gently depressed, placing the retrosternal adhesions under tension. The retrosternal adhesions are viewed on the video screen, and are taken down endoscopically with electrocautery or endoscopic scissors (see Figure 4a, ◉). As adhesions are divided, the instrument blade is carefully advanced under endoscopic control. Care must be taken to follow the sternal wires cephalad (see Figure 4b, ◉), and not to deviate to the right or left If the dissection is directed away from the midline, injury to native mammary arteries, lung, or to bypass conduits can occur.

When the musculature on the posterior aspect of the manubrium is reached, or when the base of the manubrium is visualized, identified either by the Angle of Louis or by counting wires, then the dissection is complete. The sternal wires are then removed, and a routine sternotomy with the saw of choice can be performed (see Figure 5, ◉). After sternotomy is performed, it will be noted that there are no cardiac adhesions to the sternal edges. Therefore, no traction injury occurs to the anterior surface of the heart or epicardium when the sternal edges are elevated, or when a sternal retractor is placed.

Materials and Methods

Custom fields were created in the Summit® STS database at the Fuqua Heart Center of Piedmont Hospital, Atlanta. Data was prospectively acquired by the cardiovascular surgical data management team. Custom reports were generated out of the database and reviewed. Twenty

Figure 2. EndoCautery Probe®

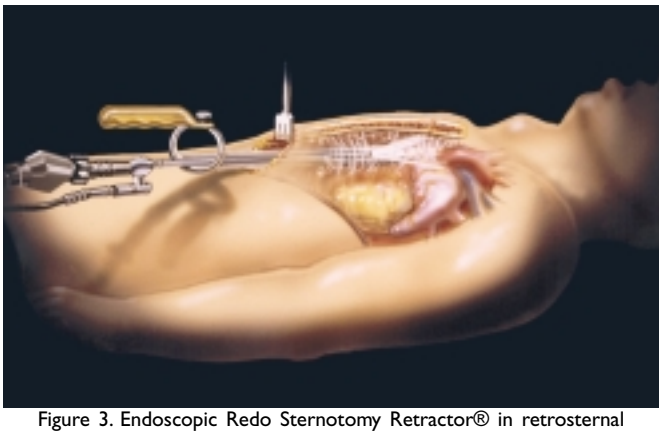

Figure 3. Endoscopic Redo Sternotomy Retractor® in retrosternal space

four consecutive patients undergoing second or more cardiac procedures underwent endoscopic repeat sternotomy using the Endoscopic Redo Sternotomy Retractor®.

Demographics

Twenty three patients underwent their first reoperation, and one underwent their second repoeration. Five patients had previous valve surgery, nineteen had undergone coronary bypass. All were elective or urgent operations, none was emergent. The average age was 65.2 years, range 46 to 80 years. Four were females. The average time from the last procedure to the present procedure was 11.5 years, the range was 0.5 years to 18 years.

RESULTS

The time required for the endoscopic dissection ranged from 6 to 22 minutes. The patient who required 22 minutes had a left internal mammary artery densely adherent to the posterior table, in the midline. Extra time was spent in attempts to mobilize the pedicle. The mobilization attempt was unsuccessful. Therefore, the sternotomy was performed while observing the LIMA endoscopically. In the area of the LIMA, the saw was turned briefly to the right, and the graft was avoided. In no patient was a conduit injured or interrupted.

DISCUSSION

Early in the development of the technique, we learned several important details. First, dissection must remain in the midline, and the wires used as a guide for the dissection. Early in our experience, before this series, the dissection was carried toward the left chest, away from the wires, and cautery was applied to the lung. The resulting air leak was later repaired with a tissue stapling device.

Another detail revolves around the angle of endoscope used. Although the device can be used with a zero or thirty degree endoscope, we strongly recommend the use of a zero degree endoscope for the first twenty five cases. In one patient, while a 30 degree endoscope was in use, when re-introducing the instrument back into the mediastinum while watching the video screen, the blade of the redo retractor was directed downward to the heart at a thirty degree angle, lacerating the epicardium and causing moderate bleeding. The epicardium was repaired with fine Deklene®, without an untoward result for the patient. However, the use of the 30 degree endoscope is not recommended for routine use early in one's experience. Also, the retractor should be re-introduced back into the chest using direct vision to orient the blade while a 30 degree endoscope is in use.

In all the patients, following the endoscopic lysis of adhesions, a routine reciprocating Hall sternal saw was subsequently used to open the sternum (see Figure 5) and no injury to the heart or other mediastinal structures occurred.

The Endoscopic Redo Sternotomy Retractor® represents an effective means to visualize and lyse retrosternal adhesions prior to repeat sternotomy. It requires very little endoscopic experience, is intuitive to use, and may prevent injury to the heart and mediastinal structures during reoperation.

Acknowledgments

The deepest gratitude is extended to Shirley Mayfield for giving me time to pursue these projects. Appreciation is given to Karen Vaughn, RN for following and caring for these patients, and to Alice Canty, RN, and Holly McKay RN, for assistance in preparation of the manuscript.

Disclosure

William Mayfield, MD is a consultant for Genzyme Surgical Products.

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REVIEW AND COMMENTARY

1. Editorial Board member AR11 writes:

I would ask the authors, however, the level of their previous endoscopic experience(s) prior to the development of this technique and whether they think surgeons with little or no endoscopic experience would be able to free the heart in 6-22 minutes as they did.

Author's Response by William R. Mayfield, MD:

The author has a ten year experience with thoracoscopy, and extensive experience with endoscopic procedures relating to cardiac surgery. However, the instrument is *intuitive* to use. The instrument requires essentially no endoscopic experience once it is assembled. It orients itself to the retrosternum, and the surgeon immediately knows what he is looking at. The use of cautery is not new to the surgeon. The main caveats are:

- follow the wires
- stay directly against the back of the sternum, do not dissect on the >heart.
- be patient, you are moving faster than you think.

The technique has been taught to over 250 surgeons, most of whom had no previous cardiac endoscopy experience. None registered serious objection, many demonstrated enthusiastic acceptance. One has appeared in a Florida newspaper claiming he will never do another redo without it.

2. Editorial Board member NL11 writes:

It is well written and describes a novel approach for resternotomy utilizing a special endoscope and retractor. The technique is well outlined and although the clinical experience is small, the results are good, avoiding injury to heart structures or vascular conduits. I would like to suggest to the authors to elucidate and expand more on the use of the different angles of the endoscope.

Author's Response by William R. Mayfield, MD:

The device can be used with either a zero degree endoscope, or a thirty degree endoscope. The zero degree endoscope might be compared to using a periscope, which looks directly ahead over the bow of the boat, and the bow of the boat (the tip of the retractor) is seen in the view. This is the *safest* way to use the redo sternotomy retractor. If the uplooking thirty degree scope is used, then the periscope is looking into the sky while the boat hits the dock....the scope is looking at the sternum while the retractor blade may be directed into the heart. Therefore, until substantial experience is gained with the instrument, one should use only the zero degree scope.

3. Editorial Board Member DK3X writes:

One important element here is the question about how often disastrous consequences from repeat sternotomy arise. This should be addressed in the paper with emphasis on how this technique reduces that risk in comparison to others.

Also, adhesions become much kinder (less vascular and "looser") with time. Mean interval between operations was 11.5 years. Was there a noticeable benefit of this technique on the "fresher" repeat sternotomies?

Author's Response by William R. Mayfield, MD:

The introduction clearly states that there are no prospective studies on the incidence of cardiac injury at redo sternotomy. However, the author has personally inquired of over 300 surgeons, and only one claims never to have had an incidence.

The very first operation that inspired the author was a third time redo only six months after a mitral valve replacement. The indication was wide open tricuspid regurgitation, right heart failure, in a patient with pulmonary hypertension and heart failure. The enlarged right heart and wet adhesions convinced the author to proceed with a device. The range of intervals in this study was as stated in the paper. The device has its greatest utility in the recent, *wet* adhesions, and third time redo's.