

EDITORIAL

Reoperative Cardiac Surgery: Part I – Preoperative Planning

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INTRODUCTION

While reoperative cardiac surgery has become safer in recent years, it is still more difficult and dangerous than a primary operation. In a recent review of the Cleveland Clinic's experience, 7% of the patients undergoing cardiac reoperations had major intraoperative adverse events (IAEs). In that report, if an IAE occurred, there was a 5% mortality and a 19% incidence of myocardial infarction (MI), stroke, or death [Roselli 2011]. Those are sobering statistics, particularly when reported by one of the busiest cardiac surgical services in the world. The take-home message is that reoperative cardiac surgery is riskier than primary cardiac operations and that there are strategies that should be employed at each juncture to lower the risks of a reoperation.

However, many of these strategies and recommendations have been more implicit than explicit. In fact, surprisingly little has been written about reoperative cardiac surgery. Thus, it seems appropriate to collect some of the lessons, adages, tricks, and tools that might make reoperations a click safer.

It has long been an axiom of mine that the little things are infinitely the most important. —Sherlock Holmes to Dr. Watson. Arthur Conan Doyle in *The Adventures of Sherlock Holmes: A Case of Identity*

This two part review will collate and outline some of the approaches that can be utilized to make a cardiac reoperation as safe as possible. Part I will cover preoperative considerations, and Part II will cover intraoperative and postoperative considerations. Here is an outline of the topics to be addressed in the two parts of this review:

Part I: Introduction

- First things first: performing the first operation to prepare for a second
- Initial planning for a reoperation
- Conduit appraisal
- Dealing with pacers and defibrillators prior to cardiac operations
- Checklists and time outs
- Prepping and draping
- Monitoring and vascular access

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Part II: The Incision for Reops

- Alternate approaches (various thoracotomy incisions)
- Dissection that can be done prior to the redo sternotomy
- Performing the redo sternotomy
- Use of cardiopulmonary bypass (CPB) to facilitate the redo sternotomy
- Initial mediastinal dissection after the sternotomy
- Freeing the superior vena cava (SVC) and the innominate vein
- Preparing the aorta for cannulation and clamping
- Dealing with “live” saphenous vein grafts
- Managing a patent internal mammary artery (IMA) graft
- Venting options for reops
- Conclusions

FIRST THINGS FIRST: PREPARING FOR A POSSIBLE REOPERATION DURING THE PRIMARY OPERATION

Since every patient being operated on should be considered to be potentially in need of a reoperation, sooner for some and later for others, a review of the principles of reoperative cardiac surgery should include a few notes about what to do in primary operations which may facilitate subsequent operations. The “sooner” category includes patients who do not heal properly or have mediastinal infections, while the “later” category could include patients who may undergo future valve operations, ventricular assist device implants, coronary artery bypass operations, or transplants.

A “first” operation should be undertaken following an old adage that should be part of every operation, which is to “open thinking about how you are going to close.” Covering the heart and great vessels at the end of a primary operation can sometimes be accomplished by closing the pericardium primarily, if it has been opened in the midline (though many do not find this approach appealing for a variety of reasons, including the occasional compression of the heart). One can reapproximate also some of the thymic and pleural fat so that the heart and great vessels are at least partially covered. Usually pulling these tissues together can be done with a few interrupted sutures. A small “relaxing incision” in the right pleura can facilitate the mobilization of such tissues, though there is some attraction to leaving the pleura intact if it has not been opened already. An additional trick to add to coverage of the right atrium and right ventricle is to tack the lower edge of the pericardium to the

diaphragm, as doing so will create some coverage of the right atrium and at least partial coverage of the lower portion of the right ventricle.

In the case of adult cardiac operations, consideration should be given to creating a “Flege flap” [Flege 1987], which takes but a few minutes and which facilitates coverage of the right ventricle (RV) at the end of the operation. Having the RV “kept away” from the sternum is one of the best things a surgeon can do to make a second operation, regardless of timing, safer. Here’s a diagram of that flap (Figure 1):

You can read the article itself to learn about this technique in more detail. Suffice it to say that opening and closing using this method requires only a minimal time investment, once

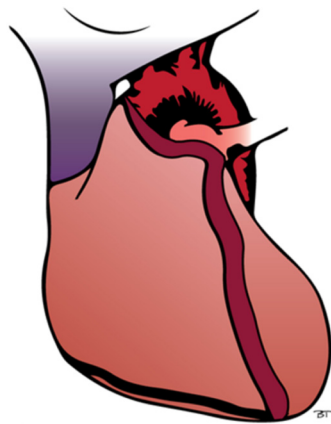


Figure 1. Diagram of the Flege Flap..

you get the hang of this approach.

Congenital cardiac surgeons, who are virtually always considering the issues of reoperations, have come up with some tricks and tips that may be worth considering. One idea some of these surgeons have suggested is to spray the heart with fibrin sealant. Carl Backer and his colleagues have suggested that a combination of an absorbable fabric next to the heart covered by a sheet of PTFE can make subsequent operations safer and easier [Kaushal 2011]. These suggestions may be particularly applicable to adult cardiac surgeons performing ventricular assist device implants.

The first operation should also limit the dissection to just what is necessary, if there is an opportunity to do so. For example, if the operation is a fairly straightforward coronary artery bypass grafting procedure (CABG), the pulmonary artery and the aorta do not need to be separated extensively. Leaving the pulmonary artery and aorta connected except for the area required for aortic cross-clamping can facilitate dissection in previously undissected territory at the time of a redo operation. Another example of leaving an area un-dissected would be the area around the superior vena cava (SVC), unless mobilization of the SVC is needed, for example, in a mitral valve operation, where such mobilization is advantageous. Likewise, the innominate vein should be left undissected to make a potential subsequent

operation easier and safer. Furthermore, if the ascending aorta is long, one can choose to leave the pericardial reflection near the origin of the innominate artery intact to allow the more distal aorta and the innominate vein to remain undisturbed and, thus, more easily approached in a subsequent operation.

It is also critical that the routing of an internal mammary artery graft be strategically performed to make redo operations easier. The internal mammary artery (IMA) should be kept away from the midline of the chest, and it should be covered if at all possible, so that it cannot become adherent to the sternum. One strategy for leading the left IMA to its target vessel on the heart is to make an incision in the left side of the pericardium that is parallel to the left phrenic nerve but below the anterior pericardial fat pad on the left side of the pericardium. This area is easy to see and feel when the fat pad is pulled up and medially to expose this “bare area” of the lateral pericardium. It is easy to see and avoid the phrenic nerve when the pericardium is pulled up in this way. Such an incision in the pericardium will allow the left IMA to travel in a fairly straight line from its origin to its insertion onto the LAD. And, the eventual position of the LIMA will be deep in the chest, away from the sternum, and it will not be affected by the left lung.

Some have advocated running an IMA that might be vulnerable later, like one crossing the midline anteriorly, through a Gortex graft, one of many creative tricks suggested by Dr. Noel Mills [Machiraju 1997]. The proximal anastomosis of a saphenous vein graft to the right coronary artery can be placed distal on the aorta, when possible, so that in case a subsequent aortic valve procedure should be needed, it will not be in the way of the subsequent aortotomy. Furthermore, an RCA graft can (and probably should) be led alongside the right atrium rather than over the right ventricle so that it won’t be as vulnerable if a reop is required (not to mention the advantage that locating the graft there will also prevent a distended RV from unduly stretching such a graft).

Many advise that the proximal sites of saphenous vein grafts be marked in some way. Some surgeons suggest adding radio-opaque markers near the proximal vein graft sites to make subsequent catheters easier, as well as to make these proximal sites visible during a reop. Others suggest marking both proximals and distals with a silk suture, with the hope that these sutures will make finding these sites easier if a reoperation should become necessary later.

Finally, one should dictate into the operative note, for such a primary operation, the location of the grafts, especially the IMA or IMAs, so that a subsequent surgeon will be able to have some idea where the IMA graft might lie during a reoperation. One should dictate the details of the distals as well, including the location of the anastomoses, the size of the vessels, the quality of the grafted arteries at these sites, and the quality of the runoff, as assessed by flushing saline through a vein graft (a technique known colloquially as “the poor man’s arteriogram”).

INITIAL PLANNING FOR A REOPERATION

Preoperative planning is obviously essential for any operation and is particularly critical for a reoperation. Old operative notes should be acquired and reviewed, if at all possible. One should look through these notes for any unusual findings or problems that were noted in the prior operation. The description of target vessels is important, as are the routes of the grafts, which should be dictated in all CABG op notes. Known abnormalities of valves or coronary arteries should be noted. Likewise, whether the left atrial appendage was oversewn or occluded should be noted. Knowledge of the use of pledgets and where they were used can be helpful. Whether a right superior pulmonary vein vent was used is helpful to know. The technique of sternal closure should be noted. The amount of fat on the heart, if commented upon, can be helpful in planning for a reop. Finally, one would want to know if the pericardium was closed at the earlier operation or if any attempt was made to cover the heart and great vessels with other tissue or prosthetic material.

It is worth noting that a history of prior radiation therapy to the chest, which can cause pericardial scarring, damage to valves and coronaries, and calcification of the ascending aorta, will make any cardiac operation more like a redo than a primary cardiac operation. Thus, a history of chest RT should alert all concerned that any subsequent operation will likely be a “slog”.

PREOPERATIVE IMAGING

A computed tomography angiogram (CTA) of the chest is very helpful for planning reoperative procedures and should be obtained in virtually every redo operation [LaPar 2013]. It is best if this CTA scan is cardiac gated. A 3D reconstruction can also be helpful, particularly in the setting of prior coronary bypass grafting, to examine the routing of the coronary artery bypass grafts. The amount of calcium in the aorta is important to note in all cases in which imaging is available and may aid in planning for sites of cannulation and clamping.

The relationship of the heart to the sternum is likewise crucial. The innominate vein can sometimes be near the sternum and, thus, it's important to note its location on a CT. Of course, the proximity of the aorta to the sternum is important to note as well. Obviously, any situation in which the aorta may be adjacent or adherent to the sternum requires that a CT scan be done to sort out the condition and location of the aorta. The most common situations in which this is the case are those with a pseudoaneurysm of the aorta, such as might be encountered after prior aortic surgery. The proximity of the right ventricle to the sternum and its location relative to the xiphoid should be noted, as knowing this information can guide the early portions of the reoperation. The routes and locations of coronary grafts are also important, and each should be traced on the CT if possible. The pathway and course of the left internal mammary should also be delineated.

The preop CT scan ordered to prepare for a reoperation should include not only the chest but also the abdomen and pelvis. One will want to review these portions of these CT scans to look for aneurysms or signs of obstructive disease of the aorta

and its branches that might affect planning, including visceral vessel obstruction (that might warrant preop treatment or at least awareness of the obstructions), aneurysms (which are said to have a higher incidence of rupture after other major operations), and obstructive disease in the iliacs and femorals (which might alter plans for peripheral arterial cannulation) [Blackbourne 1994]. Also, the discovery of diffuse vascular disease might change the preop conversations about plans and risks, since diffuse vascular disease is one of the most important harbingers of risk in any major cardiovascular surgery.

You must also have a preop echo for proper planning. Do NOT wait to use the intraop echo to sort out your plans. Pay particular attention while looking at the echo to aortic insufficiency, as the presence of AI will almost certainly change your cardiac protection strategies. If increased right-sided pressures are present, for example, in patients with pulmonary hypertension or in patients with a particularly full right heart with tricuspid regurgitation, planning for venous cannulation may be altered. For instance, some of these conditions may lead one to opt for percutaneous femoral venous cannulation to eliminate the inferior venous cannula in the operative field or to decompress the heart earlier in the operation than might otherwise be feasible. In summary, you need all the information you can get prior to getting to the operating room.

CONDUIT APPRAISAL & OTHER PREOPERATIVE CONSIDERATIONS

All possible conduit options must be considered in planning a reoperation if coronary bypass is planned or if coronary bypass is even a possibility. IMAs need to be evaluated with attention to the possibilities of injury to these vessels that might have occurred during the first operation (especially from closure of the sternum) or of proximal obstruction (especially left subclavian artery stenosis, which should be suspected when the left arm pressure is more than 10mm Hg less than the right arm pressure). Potential sources of vein for grafting must be evaluated (history of vein stripping, examination of the legs, possible vein mapping, etc.). An Allen test should be done to evaluate both radials as potential conduits. Attention should be given to whether a radial has been used for a cardiac catheterization, especially a cath done recently. Also, one should document lower extremity perfusion, not only for potential healing issues after vein harvest, but also for considering femoral cannulation, should that be needed.

Finally, one should consider cardioplegia options well before the day of the operation, since some cardioplegia formulations require preop preparation (such as del Nido cardioplegia).

DEALING WITH PACEMAKERS & DEFIBRILLATORS

Many patients who need reoperative cardiac surgery have some sort of electrophysiological device (such as a pacemaker or an AICD) in place, and these devices require considerable attention prior to, during, and after surgical procedures, especially cardiac surgical procedures.

If an implantable electronic device is present, the following information should be rounded up, well in advance of the operation:

- The type of device
- Records from the physician or clinic that monitors the device
- The device information card that the patient is supposed to carry
- The original indication for the device
- Information on whether or not the patient is pacer dependent
- The device settings and programming status

Preoperative interrogation or reprogramming of a device:

Someone from the electrophysiology (EP) team or a representative of the device company should usually be asked to turn off the defibrillator function, while leaving the pacing function on. It will also almost always be best to have the EP team interrogate whatever system the patient has preoperatively. There are a lot of reasons to do this interrogation, including the facts that these devices may be damaged during heart surgery and that they will almost certainly need to be adjusted after the planned procedure. The EP team might discover important device or lead dysfunction (such as lead fracture, which can be important in the setting of the use of electrocautery, as the current can enter the lead through such a defect and cause significant problems intraoperatively).

Electrocautery issues:

Electromagnetic interference (EMI) can cause malfunction of both pacemakers and internal cardiac defibrillators (ICDs). The most common cause of EMI is monopolar electrocautery, especially if it is used within 15 cm of the pulse generator. EMI can inhibit pacing, damage the pulse generator, or cause inappropriate tachycardia therapy. In the setting of surgery above the umbilicus, reprogramming may be necessary, both pre- and post-operatively. Using bi-polar cautery will lessen the risk of using cautery, though it is considerably more convenient to use the standard cautery device in most cardiac operations.

Pacemakers can interpret EMI as intrinsic cardiac activity and can, therefore, stop delivering a paced rhythm. This response is called “over-sensing.” Thus, it is important to determine preoperatively if the patient is pacemaker dependent, which means that the patient does not have an adequate rhythm without pacing. In these patients, an additional backup method of pacing needs to be considered, such as temporary pacing wires, and magnet application or reprogramming to convert the pacer to the asynchronous mode will likely also be needed. If the patient is not pacer dependent, and, therefore, does not require an additional temporary pacing strategy, one should still consider having the pacer reprogrammed if the EMI (cautery) source will be used within 15 cm of the pacer.

If an ICD is present (or is a component of a pacing device), the tachycardia response must be deactivated to avoid inappropriate pacing or shocks caused by EMI. If a biventricular pacing system (a cardiac resynchronization device) is in place, its function is to optimize cardiac output. In this scenario, allowing the device to pace will improve hemodynamic stability, while

turning off the device may impair the hemodynamics. All of these issues require close collaboration with the EP team.

The use of magnets when devices are present:

Magnets can be applied to convert most pacemakers into the asynchronous mode, which will protect them from EMI, but the responses to magnet application are quite variable. That is, different models react differently to magnet application. Thus, the availability of a sterile magnet should be assured prior to starting a cardiac operation when a pacer or defibrillator is present. The response to magnet application can be programmed in most devices, so that the pacemaker will have no response to EMI or will pace asynchronously when a magnet is placed over the device. The magnet effect on individual devices must be confirmed prior to any operative procedure, if the use of magnets is considered. Finally, battery life can affect a pacemaker’s response to magnet application. If the device’s battery is low, the pacemaker will pace at lower rates, and this situation may result in inadequate hemodynamics. Therefore, battery life must be documented prior to the planned operation.

After the operation is over, if a magnet has been used and is taken off the device, an ICD will usually become, once again, capable of shocking the patient, which may be a useful function in some situations. While the pacemaker should revert back to its former settings after removing the magnet, a post-operative interrogation of the device is crucial to ensure that programming is optimal and that the lead parameters remain unchanged.

Other pacing options to consider:

In addition to temporary pacing wires, pacing Swan Ganz catheters can be considered as part of the overall strategy for maintaining pacing during cardiac operations. The newer types of pacing Swans are much more reliable than the older versions, and placement of this type of Swan Ganz catheter should be considered in all pacer dependent patients undergoing a cardiac operation. Temporary transvenous pacing wires can also be placed, usually through the right internal jugular vein. If the possibility of using a transvenous temporary pacing wire exists, one should consider where the usual central venous access for the cardiac operation should be located, with alternative options being the left internal jugular vein and the right subclavian vein, though temporary pacing wires can also be inserted from a femoral vein. Finally, temporary epicardial ventricular pacing wires can be placed during the cardiac operation, once enough of the right ventricle has been exposed, though they can be in the way during the operation, and they are at constant risk of being displaced.

Consider the need for adding a permanent left ventricular lead intraoperatively:

Another possibility to consider preoperatively is whether a patient about to undergo heart surgery is a candidate for bi-ventricular pacing, as some thought may be given to placing a permanent epicardial LV lead during the operation. These leads can be led from the heart to a pacer pocket through one of the upper rib interspaces, usually the second. If the placement of such a lead is contemplated, the pacer pocket must be prepped into the field, so that it can be opened, under sterile conditions, to attach the new lead.

Other preop or early intraop strategies to consider:

There are a variety of other preop or intraoperative strategies to consider if a device is present. First of all, external defibrillator pads should be placed on every patient undergoing a reoperation, whether or not a device is present. These pads should be kept away from implanted devices, and they should be placed anteriorly and posteriorly (usually on the right side anteriorly and on the left side posteriorly, so that the defibrillating current will pass optimally through the heart). The grounding plate for the electrocautery should be placed far from the device (i.e., the pacer or an implanted defibrillator), usually on a thigh. Some say this grounding plate should be on the thigh opposite the pacer, though this likely doesn't matter. One should strive to avoid using electrocautery near the device (nor near the leads, especially if there is any suspicion of a lead fracture, which is not uncommon). If the cautery does seem to affect pacing, it should be used in short bursts. One can consider using a bipolar device, though, again, this type of electrocautery is not very practical for most cardiac surgical operations. As noted, one should also be prepared to pace the patient intraoperatively with standard temporary wires and external temporary pacers. These temporary wires can be used throughout the dissection if the Bovie is consistently affecting the pacer's function and the patient is pacer dependent.

Removing devices and wires after a heart transplant:

Finally, almost all patients receiving a heart transplant will have some sort of device in place (ICD's, biventricular pacers, etc.). Traditionally, these devices are removed after the transplant is completed. However, removing them is easier said than done, and parts of the intravascular portions of the leads often cannot be completely removed. Realization that remnants of the wires may remain and that these remnants have reportedly gotten infected later has led some to recommend that the device and its leads be removed at some later time, utilizing up-to-date lead extraction techniques and devices to remove these lead remnants. The optimal strategy for dealing with these leads is currently unsettled.

Summary of issues related to pacers and defibrillators in cardiac surgery:

Many patients undergoing cardiac surgery, especially reoperative cardiac surgery, will have electrophysiological devices present. Knowing about and dealing with the issues related to these devices is, at least partly, the responsibility of the surgical team, as the surgical team cannot assume that the patient's primary cardiologist will have sorted out all these issues preoperatively and, of course, will not usually be able to help with issues that may arise intraoperatively [Schulman 2017].

MONITORING AND VASCULAR ACCESS

A pulmonary artery (PA) catheter with its 8.5-9.5 Fr introducer should be inserted in most, if not all, reoperative cases. Venous access for rapid venous inflow should be assured, should rapid transfusion become necessary during entry into the chest prior to establishing cardiopulmonary bypass. Remember that once inside the chest, a line for rapid infusion

can be placed through a small pursestring in any vein or right sided structure (such as the right atrium), if other access sites are not working optimally for any reason. If this technique is utilized, the best line is simply a sterile piece of sterile IV tubing with the end cut off, as this type of line allows extremely rapid administration of fluid or blood products.

The setup for a reoperation should include reliable access for venous cannulation for cardiopulmonary bypass, with the right femoral vein generally being preferred for venous cannulation when femoral venous cannulation is contemplated (which many consider very useful for reoperative cardiac surgery). At the very least, a catheter should be placed in one of the femoral veins so that femoral venous cannulation can be accomplished expeditiously, using the Seldinger technique, though this access is generally obtained after draping to keep the catheters sterile.

A reliable radial arterial line is usually adequate for arterial monitoring in most cases. However, one should virtually always place a femoral arterial line in patients with questionable ventricular function, preoperative ischemia, or prior cardiac surgery, both for monitoring and to have rapid access for arterial cannulation for bypass. Again, this line usually should be placed by the surgeon after the patient is prepped and draped, in order to assess the quality of the artery, to optimize the sterility of the line should it be needed intraoperatively for an IABP or femoral arterial cannulation, and to assure that the trajectory and location of the line are optimal (i.e., the line should enter the common femoral artery at an angle that insures the catheter will be directed proximally, and so that the line does not enter the iliac artery beneath the inguinal ligament).

Many prefer to place a femoral arterial line, when used, in the left femoral artery, if that artery is suitable, given that the right groin will likely, under these circumstances, have a femoral venous line placed. It is usually easier to get a percutaneous femoral venous cannula in the RA from the right side, given that the left iliac vein may be compressed or somewhat distorted by the right iliac artery. If femoral venous cannulation is contemplated, one should have a good set of vascular dilators available. Cook makes a good set of vascular dilators (often called "the gray dilators"), which come in a set of 12, 14, 16, 18, and & 20 French sizes.

Options for femoral vascular access, if the need for cannulation arises early in the operation, include opening the femoral triangle to expose the femoral vessels with a cutdown or inserting wires in the chosen femoral artery and one of the femoral veins. The use of femoral or internal jugular venous cannulas generally requires the use of vacuum assisted venous drainage. These veins can be cannulated percutaneously and, when the cannula is removed, a skin stitch is all that will be needed to prevent bleeding in these low pressure situations. This strategy is actually superior to open cannulation and repair of the vein, as it has been shown to cause less narrowing of the vein and to be associated with a lower risk of clot formation at the site of cannulation.

Having a femoral arterial line can also be useful for monitoring. A long angiocath (18 gauge) is a good choice for such a line. It should be hooked up to a monitor. Some favor a longer 5 French catheter for this line, which will allow the catheter

to reach well into the external iliac and may be appropriate in a larger patient. Both of these types of catheters are large enough to allow for the passage of the wire needed for the insertion of an IABP or a femoral arterial cannula. If a femoral artery is cannulated for perfusion, a cutdown onto the femoral artery will be needed at some point. This cutdown can be done prior to cannulation or it can be done after cannulation. If done afterwards, a small incision can be started at the entry site in the skin, following the arterial perfusion cannula right down to the site of entry into the femoral artery. The site of entrance into the artery must be cleared of loose tissue so that a purse string of 5-0 Prolene can be placed in the adventitia of the artery around the site of entry of the cannula. After the cannula is withdrawn, the purse string is tied. A second figure-of-eight stitch should be placed over the purse string stitch to reinforce this site, after the cannula is removed, and this stitch should be placed deeper in the wall of the artery.

Consideration can be given to administering some heparin if wires are placed in the vessels early in the operation, but heparin must certainly be given if the cannulas are actually inserted. Of course, prior to starting CPB, an adequate activated clotting time (ACT) must be assured, which sometimes reveals that more heparin needs to be administered prior to going on bypass.

Additional options for cannulation include axillary cannulation (with a side arm graft) for arterial return and the use of internal jugular cannulation for additional venous drainage (which might be particularly useful if an IVC filter is in place). An excellent video with Joss Fernandez demonstrating axillary artery access for cardiopulmonary bypass (CPB) can be found on CTSNET [Calcaterra 2011]. This video demonstrates a more lateral approach to the axillary artery than is commonly done, which makes access to the artery easier and avoids denervation of the pectoralis major muscle, which can be quite debilitating to some patients.

There is increasing enthusiasm for using the innominate artery as an alternate site for arterial cannulation in reops. The innominate artery can be accessed even prior to sternotomy with a slight extension of the sternal skin incision towards the right in the neck, anterior to the sternocleidomastoid muscle. The

innominate artery will almost never have scar around it from the primary operation. The innominate artery can be cannulated directly or a side arm graft can be sewn to it [Lee 2014]. This technique is also described in the congenital cardiac literature. Here's a drawing of the cannulation of the innominate (Figure 2):

Finally, in the setting of reoperative cardiac surgery, the perfusion team should be in the room with the pump set up prior to starting the sternotomy.

CHECKLISTS & TIMEOUTS

Preop checklists and timeouts are probably as important, or more important, in reoperations as they are in any other type of case. Each team should consider having a checklist that is specific to reoperative cardiac surgery that can be reviewed with the OR team, the EP consultants, the perfusion team, and the postop team. These checklists should be used during the workup [LaPar 2013] and in the operating room just prior to starting the operation. Many find it useful to send out a checklist the day prior to an operation to those who will be involved in the operation, especially when the operation is an unusual or complex one.

Appropriate blood product availability should be assured, depending on the operative procedure being performed. The availability of these products should be reviewed and established prior to beginning the operation, on several occasions, including during the intraoperative timeout. In reoperations, complex aortic operations, or more complex multivalve operations, the availability of a rapid, trauma-style transfusion-warming device can be helpful to assure the ability to rapidly transfuse blood products.

PART II:

The second part of this review of reoperative cardiac surgery will address intraoperative technical considerations. The issues to be covered in Part II are outlined above in the introduction to Part I.

ACKNOWLEDGMENT

Ben Tribble created the figures in this review.

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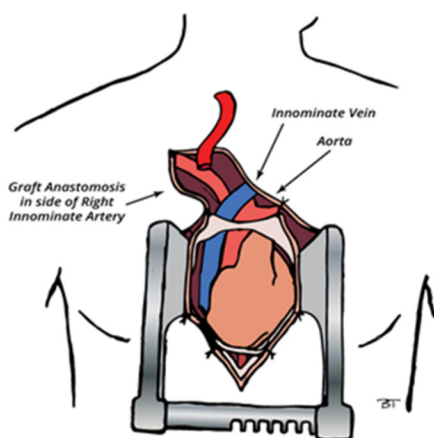


Figure 2. Cannulation of the innominate artery.

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