Cardiac Surgery Simulation Curriculum

Simulation-based training in surgical skills and decision making

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Preface

For most surgical training, including training in cardiothoracic surgery, technical skills are taught by the apprentice model, in which resident physicians learn in the operating room, doing parts or all of real operations on real patients. Thousands of excellent surgeons have been trained this way. But the apprentice teaching method today provides insufficient time in which to teach surgery, has zero tolerance for the inefficiency inherent in education, is limited in its scope of education by the conditions specific to the patient who is having the operation, eliminates the possibility of deliberate and distributive practice of skills, and cannot possibly provide for orchestrated training in how to deal with adverse events. Yet all of these are essential to producing a safe surgeon. Until recently, there have been few alternatives to using the operating room for teaching surgical skills.

This manual represents the combined work by the investigators and staff at the eight institutions in the Cardiac Surgery Simulation Consortium (University of North Carolina at Chapel Hill, Johns Hopkins University, Massachusetts General Hospital, Mayo Clinic, Vanderbilt University, University of Rochester, University of Washington and Stanford University) as part of a three-year study, "Improved Patient Safety by Simulator Based Training in Cardiac Surgery," funded by the Agency for Healthcare Research and Quality (AHRQ Grant # R18HS020451). Over a two-year period, 30 first-year cardiothoracic surgery residents in traditional three-year training programs, or third- or fourth-year cardiothoracic surgery residents in Integrated 6 programs (which combine general surgery and cardiothoracic surgery training in a six-year program) participated, resulting in more than 3,600 hours of simulation training. The curriculum, produced by the investigators, was revised twice based on practical experience, after the first year and again after completion of the study, to provide a comprehensive framework for imparting important cardiac surgery skills and decision-making to the resident.

We believe the simulation training experience gained during this study is perhaps the most extensive for any surgery specialty. To make the curriculum readily available to all trainees in cardiac surgery, the Consortium has given it to the Thoracic Surgery Directors Association. It is hoped that the curriculum will continue to be expanded and refined as simulation becomes an essential part of resident training.

The Consortium wishes to thank the Agency for Healthcare Research and Quality (AHRQ) for its grant support, Teleflex Inc. for providing the surgical instruments and suture material used, and the Cardiothoracic Surgery programs at the eight participating institutions for their dedication to improving cardiothoracic surgery resident education.

We believe from our experience that the curriculum that has been developed now gives us the ability to overcome, in part, the constraints on training that exist in the modern operating room. We have seen the beneficial effect of simulation-based training universally throughout our experience and are excited about the ability to make it available to all residents and trainees.

Richard H. Feins, M.D.
on behalf of the members of the Cardiac Surgery Simulation Consortium

About the Simulator

The University of the West Indies (UWI) Cardiac Surgery Simulator (UWICSS), also known as The Ramphal Simulator, is a device for training cardiac surgeons in various aspects of open-heart surgery. The simulator consists of a specially prepared pig's heart, a mock chest cavity, an actuator for animating the heart, a system of pumps and valves for replicating the flow of blood in and around the heart, a monitor to display vital sign traces, and a computer to coordinate them all. It was invented in Jamaica in 2001 by Paul Ramphal, Michael Craven and Daniel Coore, but it received limited exposure before 2008. In 2009, Ramphal and Coore began updating the simulator to increase its degree of automation so that suitable copies could be produced for the eight cardiac surgery training centers that were participating in this AHRQ-funded study.

When the simulator is fully set up, the user is presented with what looks like a draped patient, whose chest has already been opened, and whose beating heart has been exposed. The monitor shows traces for various vital signs such as an ECG, systemic and pulmonary pressures, and oxygen saturation levels, which all vary in sync with the movement of the heart. Blood circulates around the arterial/venous lines from a CPB machine, and a realistic pressure can be detected in the aorta by touching it.

The operator of the simulator stands behind the drapes, where the anesthesiologist would normally be, and conducts the progress of the simulated patient by using the computer software to select appropriate beating patterns and modes of operation. For example, the heart can be made to beat at any rate between arrested and 200 bpm, or to go into ventricular fibrillation. The selected mode controls how blood flows into and around the heart to achieve various objectives, such as maintaining an appropriate aortic pressure before and during cannulation, permitting the CPB lines to be divided, filling the heart before cannulation, and flowing realistically through the cannulae after the heart has been put on bypass. The operator responds to commands from the trainee surgeon that would normally be directed at the perfusionist or the anesthesiologist, directing the simulator to exhibit appropriate responses.

The simulator has come a long way from its very first incarnation. Ramphal built the very first prototype from an old roller-pump head and some PVC pipes. It could basically make the heart beat at a steady rhythm, which could be varied by manually adjusting the speed of the roller pump. He created it out of a need to provide his residents with a realistic simulation model to compensate for the low numbers of cases that they would see. UWI residents in cardiac surgery routinely did a rotation in a partner institution in the United Kingdom to receive sufficient exposure to cardiac cases. Ramphal wanted to improve his residents' exposure to cardiac training before they went to the UK. Once he had a proof of concept, he recruited Michael Craven along with a small team of engineers from the University of Technology (Jamaica), as well as Daniel Coore from the Department of Computing (UWI) to automate the beating of the heart and synchronize it with the display of vital signs. All other functionality was still to be manually controlled by the operator (Ramphal). By 2004, Ramphal was using the first working prototype of this automated model with his residents.

In late 2007, the simulator came to the attention of Richard Feins, MD, of the University of North Carolina at Chapel Hill, who was then chairman of the American Board of Thoracic

Surgery. Feins contacted Ramphal to ask for a live demonstration. But by this time, Ramphal was no longer in Jamaica, Craven had returned to England, and the simulator had been reduced to scrap. Feins was persistent, and with the blessing of the UWI, he invited Ramphal, Craven and Coore to meet at UNC in January 2008 to reconstruct the simulator. It was a bit of a gamble. Some very specialized parts had been acquired to build the first automated model, and those that had been salvaged had gone through a lot of abuse. So, it was not clear whether they would still work. The software, though mostly intact, existed in several versions, and it was not clear which were compatible with the hardware at hand, and what aspects of the others needed to be incorporated into the main version. Moreover, the computer to run the software was brand new, and there was no way to know ahead of time what additional software would be required in order to get the old software running on it.

After about 10 days of coding, soldering, drilling, splicing and reconfiguring, with only brief interruptions for sleep and quick excursions to the hardware store, the simulator had been restored to its former level of functionality. Feins then filmed UNC faculty performing two full procedures on the simulator in front of a small group of amazed onlookers. Feins and Ramphal showed those videos at STS 2008, and the simulator got invited to the Cardiothoracic Technology Symposium (CTS), which was held in Cincinnati at the time. Later that year the simulator was featured at the inaugural Thoracic Surgery Directors' Association Boot Camp, held in Chapel Hill, NC, to give incoming cardiothoracic surgery residents from across the country some initial exposure to surgical procedures and techniques.

The responses from onlookers and users was overwhelmingly positive. The simulator was repeatedly lauded for its realism, for its ability to achieve suspension of disbelief, and for its ability to focus a trainee's attention on the management of the team in the operating room. It was invited back to successive meetings of the CTS and the Boot Camp, and residents who had heard about it would look forward to having an opportunity to practice on it. By early 2009, Feins, Ramphal and Coore began to think about how best to allow the simulator to be used by more residents, and in a more sustainable and regular way in their training. The plans that would culminate in the AHRQ-funded study were set in motion.

They agreed on a model that had eight institutions agreeing to beta test the simulator, in exchange for the opportunity to incorporate deliberate practice through simulation into their curricula in a structured way. It became clear at this point that they needed a new version of the simulator. Up until this point, every time the simulator was transported, it required both Coore and Ramphal to set it up and tear it down, such was the complexity of the connection between the parts. Moreover, every time it was demonstrated, Ramphal would have to operate it because only he knew how to regulate all the requisite blood flows and how to interact with the software to select hemodynamics and beating patterns. The new version needed to be portable and to be able to automate all of the activities that Ramphal would manually perform during demonstrations.

Armed with Ramphal's specification documents, Coore set about designing and building the next version in Jamaica in mid-2009. The Principal's Office at UWI, Mona (in Jamaica), funded the costs of building the prototype of the new design. From the point of view of logistics, there was very little room for error. Purchasing components from a centrally managed university fund is a slow bureaucratic business, and shipping to Jamaica usually

means long delivery times and higher costs, and that there is little chance of returning an item. So, Coore and his team of one graduate student (Matthew Budram) and one intern (Marcel Blair) had one chance at getting each component right with the funds and the time available. They had no capacity to prepare a pig's heart in Jamaica, so to test the final machine, they had to use a simple artificial model that had the same qualitative behavior as the real pig's heart would have had.

In spite of these challenges, by June 2010, the first fully automated prototype was usable, and Coore's team began delivering units on a phased basis, starting from January 2011. It was not perfect: it has taken over 20 software updates to evolve to its current state of capabilities, and it is difficult to service. But it remained functional, and the UNC unit was even used alongside the new commercial model at Boot Camp 2015.

Since 2011, the simulator has been an integral part of the eight-center AHRQ grant project that studied the contribution of simulation based training to produce a safer cardiac surgeon and produced this curriculum.

We (the developers of the simulator) recognize the hard work that has been put into this project at the beta sites, and it is with a great sense of pride and honor that we have participated in this landmark study. We hope that it will prove to be useful in improving patient safety.

Daniel Coore

Paul Ramphal

Acknowledgments

Richard H. Feins:
Performing more than 400 hours of simulation-based training over three years could never have been accomplished without the tremendous amount of help from many people at the University of North Carolina at Chapel Hill.

We are indebted to Jose Piscoya, Rebekah Macfie, Brian Charnock, Sam Heathcote, Hadley Wilson, Ruben Bocanegra and Andrew Shirlen for setting up, running, and cleaning up after the many simulation sessions in the study.

Dr. John Alexander and Dr. Walter Wolfe, both retired cardiothoracic surgeons who are members of the TSDA Senior Tour, dedicated countless hours training our residents on the Ramphal Simulator.

Dr. Bruce Baron was an invaluable adviser in helping us write the grant application to the Agency for Healthcare Research and Quality that made this work possible.

Margaret Alford Cloud coordinated and edited this curriculum, and she compiled and edited the AHRQ grant application that led to funding for the study.

And finally, thank you to the Department of Surgery at UNC, the surgeons and staff of the Division of Cardiothoracic Surgery, and UNC Hospitals for providing the space and support necessary for such a large undertaking.

Harold M. Burkhart:
For my lovely wife, Jennifer, and children Michael, Holly and Allison, without whose endless support, this project would not be possible. A very special thank you to Carla MacLean, whose commitment and dedication ensured that this was a success.

John V. Conte:
I would like to acknowledge our dedicated lab technicians, Melissa Jones and Jeff Brawn, without whom this project could never have been successful.

Daniel N. Coore:
The following people were instrumental in developing and producing the cardiac simulator that served as one of the cornerstones of this study:

Graduate student Matthew Budram laid out all the circuit boards, wrote significant portions of the firmware and application level software, and was an integral part of the development effort to produce the simulator.

Undergraduates Marcel Blair wrote some components of the application software. Raymond Dixon and Atara O'Sullivan contributed to assembly process, the soldering, wiring and testing of the units.

Fitzhugh Forrest provided me with various surgical scraps, such as pressure transducers, pieces of tubing, connectors and syringes which were invaluable for exploring possibilities.

A few departments at the University of the West Indies provided support above and beyond their normal operations. The Mechanical Engineering Workshop provided useful advice on the design of the case, in addition to making the final versions for all eight units. The Department of Computing provided much administrative support as well as some dedicated space for the development of the simulator and its components. The Office of the Principal funded the design process, and the cost of building a prototype. The Office of Sponsored Research provided logistic support in importing parts and exporting the final units. The Bursary provided special services to permit on-line transactions and expedited payments when necessary.

I am also grateful to my UWI colleagues, especially those in my department and in the Faculty of Science and Technology, for their continued interest in the project and regular words of encouragement.

Finally, I recognize the grace with which my wife and children accommodated my long hours away from home while I worked on the project. They provided much emotional support, sometimes even in ways unknown to them.

Nahush A. Mokadam:
The conceptualization, development, and execution of a comprehensive Cardiac Surgery Simulation curriculum spanned more than three years. Many individuals and groups have my gratitude.

First, I would like to acknowledge the dedication and effort of the University of Washington Institute for Simulation and Interprofessional Studies. The faculty, staff and technicians embraced this process wholeheartedly, and continually strived to maximize and improve this experience for all.

I must thank the Cardiothoracic Faculty at the University of Washington. Not only do my colleagues support my interests, they also covered my clinical absences so that we could carry out this project, and they accepted that our residents would not be available for clinical care in favor of simulation training. This culture-shift was instrumental in our success.

The residents at the University of Washington who tolerated this development process deserve much credit: they endured the growing pains, practiced at home, and I believe walked away as better surgeons. They also made me a better educator, and for this I am grateful.

Introduction

This curriculum is composed of training in six cardiac surgery modules: three basic cardiac surgery procedures and three important intraoperative adverse events:

Cardiopulmonary bypass (CPB)
Coronary artery bypass surgery (CABG)
Aortic valve replacement (AVR)

Massive intraoperative air embolism (MAE)
Acute intraoperative aortic dissection (AIAD)
Sudden perioperative deterioration of cardiac function (SDCF)

Training for each of the modules is broken down into its important component tasks; detailed simulation exercises on component task simulators are outlined in the curriculum. In the last few sessions of each module, the learned component tasks are combined into full cardiac surgery procedures using the Ramphal Cardiac Surgery Simulator. The principles of task and procedure mastery by repetitions, coaching, and debriefing are emphasized throughout the 29 sessions of the curriculum.

For each simulation session of each module, the curriculum provides the following:

Session overview
Prerequisites
Objectives
Equipment and materials required
Simulation set-up
Conduct of the simulation
Assessment tools

The investigators have found it very helpful to video-record the simulation sessions to allow for more detailed review and analysis. Although mandated for the AHRQ grant project, video recording and review will be left to the discretion of each instructor. However, we strongly advise using video recording and review during training with this curriculum.

Each session is designed to take between two and four hours and each module is composed of four to seven sessions. The actual time needed will depend on the individual resident's ability to meet the goals and objectives for each session. Trainees should attain defined benchmarks and prerequisites before advancing through the curriculum.

An important concept to remember is that mastery of a skill comes from multiple supervised repetitions of a task, along with self-practice. The ultimate goal of the CABG module, for example, is not to complete a coronary bypass procedure but rather to **repeat the components involved as many times as possible** with the goal of mastery. In addition, the mentor must balance in-depth supervision and coaching with allowing the trainee to make his or her own mistakes.

The curriculum does not prescribe a particular method for a given task - the individual institution can train its residents in its preferred way of doing a given task or procedure. This also applies to the Emergency Action Plans used in the adverse events modules.

1. Cardiopulmonary Bypass (CPB) Module

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Overview - CPB Module

The CPB Module is a four-session simulation-based training program leading to familiarity and competence with the surgical techniques of cardiopulmonary bypass. It has these objectives:

1. The resident will be able to master and recite the 7 steps of CPB from memory without hesitation.
2. The resident will be able to perform a full cardiopulmonary bypass run, including aortic cannulation, venous cannulation, cross-clamping, administration of cardioplegia, weaning from CPB, and decannulation on the Cardiac Surgery Simulator (Ramphal) with a Likert score of 5 for each step.

Residents are to repeat all steps until the session objectives are met.

Assessment using video is helpful but is at the discretion of the instructor.

It is recommended that the resident gown, glove and wear a mask to better simulate the OR setting.

The four-session CPB training program will consist of one half-day per session (approximately 3- 4 hours) for each resident. The component task and full procedure schedule is:

Session 1: Fundamentals of CPB
Aortic cannulation
Session 2: Venous cannulation
Administration of cardioplegia
Session 3: Full CPB run
Cardiac surgery simulator (Ramphal)
Session 4: Full CPB run
Cardiac surgery simulator (Ramphal)

Residents should have ample opportunity to practice between weekly sessions.

Each weekly session will begin with an evaluation of the component tasks covered in previous weeks.

CPB Session 1: Fundamentals of CPB and Aortic Cannulation

Overview

Session 1 of the Cardiopulmonary Bypass (CPB) Module consists of two parts: an introduction to cardiopulmonary bypass and training in the component task of aortic cannulation. Through an introductory didactic session and subsequent practice, the resident will train in the components of conducting cardiopulmonary bypass. The resident will then use the aortic cannulation component task simulator (CTS) to perform multiple aortic cannulations and de-cannulations. The skills learned will be:

1. Pre-bypass team briefing.
2. CPB communication of steps and commands.
3. Debriefing.
4. Aortic cannulation and decannulation. Deairing and testing of line.

Prerequisites

The residents should review:

TSDA Boot Camp lecture *Intro to CPB*: http://www.tsda.org/wp-content/uploads/2013/07/CPB-Skills.Print-Version.13.pdf

Anatomy of the Heart by Dr. Eugene A. Grossi: http://conference-cast.com/tsda/tsdaplayer/player1.php?fileid=grossi

The residents should also review the book *Cardiopulmonary Bypass: A Primer*, which is available for free download at: https://itunes.apple.com/us/book/cardiopulmonary-bypass-primer/id1024775439?mt=13

A. Fundamentals of Cardiopulmonary Bypass Training

Objectives

By the end of the first part of CPB Session 1:

1. The resident will be able to write down and recite the seven steps for CPB in order.
2. The resident will be able to identify the component parts of the cardiopulmonary bypass circuit.
   a. Review the lecture on CPB and pass the CPB Steps exam (90%) (Appendix A)
3. The resident will be able to conduct a complete pre-bypass briefing.
4. The resident will be able to conduct a simulated cardiopulmonary bypass run using all commands and checkpoints of the Seven Steps of CPB.

Equipment and Materials Required

1. Seven steps of cardiopulmonary bypass (Listed in Teaching Plan, #5, and Appendix B).
2. CPB Test (Appendix A).

Teaching Plan

All parts of the teaching plan should be repeated as many times as necessary for the resident to be able to perform them perfectly (deliberate practice).

1. Administer the CPB test - Appendix A.

2. Review *Intro to CPB* (see link above, under Prerequisites), which the resident should have reviewed prior to session.

3. Have a CPB circuit set up and review component parts with resident. The resident should be able to identify and state the function of all of the parts:
   a. Pumps

b. Oxygenator
c. Venous reservoir
d. Tubing
e. Cardioplegia
f. Heat exchanger
g. Safety devices

4. The resident will conduct a cardiac surgery preoperative briefing covering:
   a. Diagnosis
   b. Procedure
   c. Incision
   d. Significant surgical history (redo, patent grafts…)
   e. Cannulation
   f. Cardioplegia
   g. Temperature
   h. Questions

5. 7 STEPS OF CPB:
   The resident will go through a mock CPB run covering all of the following 7 steps of CPB, including appropriate communication to the team.
   a. Heparin
   b. Expose the heart
      Check BP/aorta
   c. ACT
      Cannulation of aorta
      Check aortic cannula
   d. Atrial cannulation
      Venous clamp off
      On bypass
      Lungs off
   e. Inspect the heart
      Place aortic and/or retrograde cardioplegia
      Reduce pump flow/Cross-clamp aorta/Return to normal flow/Check line pressure
      Begin cardioplegia

Set patient temp

f. Release aortic cross-clamp after warm cardioplegia
   Lungs working
   No bleeding in accessible areas
   Good contractility
   Stable rhythm
   Temperature at desired level
g. Wean off bypass
   Venous line clamped/remove when stable
   Remove aortic vent
   Protamine
   Follow RAP, PAP and BP
   Be alert for hemodynamic reaction
   Remove arterial cannula

6. The resident will practice a simulated debriefing of the procedure
   a. What went well?
   b. What went wrong?
   c. Questions

See **Appendix B: 50 Steps of Cardiopulmonary Bypass** for a more detailed summary of the steps of CPB.

Assessment Tools

In Appendix A:

CPBAT Cardiopulmonary Bypass Test

BAT Briefing Assessment Tool
SAT Steps Assessment Tool

The resident will complete enough repetitions until a score of "Yes" has been achieved on the BAT and SAT Assessment Tools.

B. Aortic Cannulation Component Task Simulation

Objectives

1. The resident will be able to place and secure the aortic cannula into the aorta.
2. The resident will be able to connect the arterial line and de-air it.
3. The resident will be able to de-cannulate the aorta and secure the purse strings.
4. The resident will perform complete aortic cannulation and de-cannulation a minimum of 10 times.

Resident should be given the opportunity to practice during the week after the session using the HeartCase or some equivalent simulation model or by having access to the simulation center.

The residents should be gowned, gloved and wear a mask to improve the real-world environment for the session.

Equipment Required

For each resident (may vary depending on cannulation technique being taught):

Aortic Cannulation Component Task Simulator (Appendix B)
Aortic cannulation simulation model
Length of aorta
2 bags of artificial blood
1 IV pole
Purse- string suture (2) (2-0 double-armed non-pledgeted suture)
Silk ties
2 tourniquet sliders
Needle driver
2 pairs of DeBakey forceps
2 small clamps
#11 blade on knife handle
Suture scissors
Metzenbaum scissors

2 tubing clamps
2 lap sponges
Aortic cannula with connector
Video camera and storage media (optional)

Simulation Set-up

Aortic Cannulation Component Task Simulation model (See Appendix B)

1. Aortic length is placed in the silicone well.
2. Bag of artificial blood is hung.
3. One arm of Y is connected to the quick connect of the aortic length, the other arm is clamped with a tubing clamp.
4. Blood is infused into the aorta.
5. The arterial line is advanced by removing the tubing clamp from the Y.

Conduct of the Simulation

1. During the simulation, the resident will be expected to perform the parts of the **7 Steps of CPB** (Appendix B) appropriate to aortic cannulation.

2. Starting at proximal end of the aorta and using the agreed upon method of the institution, the resident will:
   a. Give heparin, check aortic pressure, palpate aorta.
   b. Place the purse string(s), the slider(s), and clamp the slider(s).
   c. ACT check.
   d. Clean off aorta at cannulation site. Be sure cannula is ready and clamped with tubing clamp if necessary.
   e. Re-check aortic root pressure.
   f. Open aorta with #11 blade.
   g. Place aortic cannula.
   h. Tighten and secure purse string(s).

i. Fill aortic cannula into sponge by releasing clamp on cannula.
j. Advance arterial line by giving command. Arterial line is unclamped to allow it to fill.
k. Connect aortic cannula while line is being forwarded to remove air.
l. Check line for air.
m. Ask perfusionist to confirm proper pressure and flow.
n. Ensure that the patient is ready to come off bypass.
o. Come off bypass and decannulate aorta with purse strings being tied (aortic line may be clamped or not depending on centers procedure).

Repeat procedure until no errors using more distal parts of aorta. Aorta can also be turned to expose clean aorta. A minimum of 10 repetitions is recommended.

Assessment Tools

In Appendix A:

ACAT Aortic Cannulation Assessment Tool

The simulation session may be videotaped with proper identification of the resident and the number of the cannulation.

Resident should be given the opportunity to practice during the week after the session using the HeartCase or some equivalent simulation model or by having access to the Aortic Cannulation Simulation model in the simulation center.

Aortic Cannulation Assessment Form (ACAT) (see Appendix A) should be filled out for each resident on the first and last cannulation for each resident.

CPB Session 2: Venous Cannulation, Cardioplegia and Aortic Cross-Clamping

Overview

Session 2 of the Cardiopulmonary Bypass Module consists of simulation-based training on single atrial venous cannulation. Although not an inherent part of this session, bicaval cannulation can be discussed and demonstrated. The resident will also be trained in administering antegrade and retrograde cardioplegia.

The simulation uses a beating heart model (Ramphal Cardiac Surgery Simulator) for placement of the venous cannula, ascending aorta antegrade cardioplegia cannula, aortic cross clamping, and right atrial coronary sinus retrograde cardioplegia cannula placement (minimum of 7 repetitions for each)

The first 3 repetitions should be done on each of the 2 tasks separately (venous cannulation and antegrade catheter placement with aortic cross clamping, while the last 4 repetitions should be done with both in sequence.

Because of limited space on the right atrium, all purse strings will not be required to be in the optimal position.

Prerequisites

1. Able to write the 7 steps from memory (Appendix B).

2. Able to cannulate the aorta, showing mastery of pursestring placement, securing, and de-airing cannula.

Objectives

1. Able to cannulate the atrium showing mastery of purse-string placement, securing and managing the venous cannula, with a score of 4 or greater on all parts of the Venous Cannulation Assessment Tool (VCAT).

2. Able to initiate CPB, and wean from CPB, including decannulation using all commands appropriately.
3. Able to place aortic pursestring and cannula appropriate for antegrade cardioplegia, cross-clamp the ascending aorta, order antegrade cardioplegia appropriately, remove cannula and secure pursestring with a score of 4 or greater on all parts of the Cardiac Cardioplegia Assessment Tool (CCAT)
4. Able to place right atrial pursestring and retrograde cardioplegia cannula into coronary sinus, order retrograde cardioplegia, and remove cannula and secure right atrial pursestring.
5. OPTIONAL: Instruction in bi-caval venous cannulation.

Each resident will perform venous cannulations, antegrade, and retrograde cardioplegia until error-free, using the pressurized pig heart. A minimum of 7 repetitions should be performed.

The cannulation and de-cannulation and cardioplegia technique practiced will be specific to the training center.

The simulation will provide better training if the resident is gowned, gloved, and masked during the session.

Equipment Required

For each resident:

Ramphal Cardiac Surgery Simulator or pressurized pig heart model
14 atrial purse strings
14 silk ties
2 tourniquet sliders
2 small clamps
3 tubing clamps
1 single or double stage venous cannula
Antegrade cardioplegia catheter
2 liter bags of artificial blood/ Antegrade cardioplegia delivery tubing

11 knife blade on handle
Aortic cross clamp

Retrograde cardioplegia cannula
10cc syringe
7 additional pursestring sutures
7 additional silk sutures
Multi-line cardioplegia delivery system
Sinus pressure monitoring tubing
Suture scissors

OPTIONAL for BICAVAL VENOUS CANNULATION
2 smaller right angle caval venous cannulas
2 right angle venous cannulas
14 purse string suture
2 Rummel tourniquets

Simulators and Set-up

The Ramphal Cardiac Surgery Simulator can be used for exercises in this session. Or, a pig heart with the atrium and ascending aorta pressurized can be used.

Conduct of the Simulation

Resident must write from memory the 7 steps of CPB. During the venous cannulation simulation, the resident will be expected to perform the parts of the 7 steps appropriate to venous cannulation.

Venous (Atrial) cannulation

1. The resident will place a purse-string suture into the right atrium wall and place it through a tourniquet slider and clamp it.
2. The resident will insure the correct cannula is available, incise the atrium through the purse string, and place the cannula into the atrium.
3. The cannula is secured with the slider.
4. The cannula is filled with blood and connected to the venous line.

5. Mock CPB is initiated with appropriate commands.
6. The resident confirms that circumstances are appropriate to wean off bypass.
7. Bypass is discontinued, heparin given, the venous line is clamped.
8. The cannula is removed and the purse string tied.

Cardioplegia

1. Resident will assess the heart for placement of the cardioplegia line in the aorta and place the appropriate purse string.
2. Resident will insure the correct aortic cardioplegia cannula is available and place the cannula into the aorta.
3. The cannula is secured and connected to the cardioplegia line. The sump side arm is connected if used in the institution.
4. The resident places the purse string in the atrium for the retrograde cardioplegia line.
5. The retrograde cannula is placed into the coronary sinus through the atrial purse string. If it is not possible t thread the catheter into the coronary sinus, the resident should position it as close as possible to the coronary sinus.
6. The resident assures the proper conditions for cross clamping the aorta and then cross clamps the aorta.
7. The resident instructs the perfusionist to give the appropriate amount of antegrade and retrograde cardioplegia. The different amount for different procedures should be gone over with the resident.
9. The resident assures proper conditions for cessation of cardioplegia (temperature) and releases the cross clamp.
10. The aortic cardioplegia and coronary sinus cannulas are removed and the purse strings secured.

This is repeated until error-free.

Assessment Tools

In Appendix A:

VCAT Venous Cannulation Assessment Tool

CCAT Cardioplegia Cannulation Assessment Tool

Residents should be given the opportunity to practice during the week after the session using the HeartCase or some equivalent simulation model or by having access to the pressurized pig heart simulation model in the simulation center.

CPB Sessions 3, 4: Full Cardiopulmonary Bypass Run

The Ramphal Cardiac Surgery Simulator will be used in Sessions 3 and 4 to allow the resident to put all of the component tasks practiced in Sessions 1-2 together in series for full cardiopulmonary bypass runs. The resident should perform as many CPB runs as possible given allotted time

Prerequisites

Completion of Sessions 1-2 of the Cardiopulmonary Bypass Module with composite score of ≥4

90% or better score on the CPB test (Appendix A) given just prior this session

The cardiopulmonary bypass technique practiced will be specific to the training center.

In these simulations, the residents should be gowned, gloved, and masked.

The full cardiopulmonary bypass run should be performed as many times needed to produce an error-free CPB run.

Objectives

The objectives for Sessions 3 and 4 are:

1. The resident will perform a pre-procedure briefing of the team covering all critical aspects of the CPB run
2. The resident will conduct an informed, efficient, and technically expert cardiopulmonary bypass run including all cannulation steps, appropriate commands, and understanding of critical elements within 30 minutes
3. The resident will conduct a comprehensive debriefing of the CPB run at the conclusion of the procedure.

Teaching Plan

Equipment Required

For each resident:

10-question CPB test (Appendix A)

All usual and customary instruments, supplies, and equipment for cardiopulmonary bypass specific to your institution

The Ramphal Cardiac Surgery Simulator (Video optional)

Standardized prepared pig hearts prepared for the Ramphal Cardiac Surgery Simulator

Conduct of the Simulation

1. Resident conducts briefing of the procedure (Cardiopulmonary bypass)

2. Resident performs complete cardiopulmonary bypass run

3. Extra practice on component parts in which the resident is found to be deficient should be performed to achieve proficiency

4. Residents should perform the complete procedure **as both surgeon and assistant until error-free. Minimum of 5 complete CPB runs should be performed**

Assessment Tools

In Appendix A:

CPBAT Complete Cardiopulmonary Bypass Assessment Tool

Individual component task assessment tools (ACAT, VCAT, CCAT, BAT, DAT) can also be used as desired to give greater granularity to any deficiencies of component tasks

Each simulation session may be videotaped with proper identification of the resident and the number of the cardiopulmonary bypass run

Resident should be given the opportunity to practice during the week on component parts using the HeartCase or some equivalent simulation model or by having access to the Ramphal Cardiac Surgery Simulator in the simulation center

The CPBAT, Cardiopulmonary Bypass Assessment Tool (APPENDIX A), should be filled out for each resident on last cannulation for each session (3 and 4)

2. Coronary Artery Bypass Grafting (CABG) Module

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John V. Conte, M.D.
Jennifer D. Walker, M.D.
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Paul S. Ramphal, M.D.
Daniel N. Coore, Ph.D.

Overview – CABG Module

The CABG Module is a five-session module which focuses on technical components in the management of patients with severe coronary artery disease. Emphasis is placed on techniques of coronary artery anastomosis including instrument use and tissue handling.

Teaching and practice are based on orientation and feedback using component task simulators and the high-fidelity Ramphal Cardiac Surgery Simulator. The component task approach to cardiac surgery training in the dry-lab and wet-lab settings provides initial training and a basis for ongoing deliberate practice. The Ramphal Cardiac Surgery Simulator provides a realistic platform for practicing the overall approach to CABG. Competence in performing anastomosis on small vessels requires extensive and deliberate practice.

The goal of the session is to understand and demonstrate proficiency in basic skills, such as the ability to perform distal and proximal coronary artery anastomosis. Integral to the procedure is understanding instrument use, suture management, and tissue handling. Also, residents have to be comfortable with loupe magnification. Synthetic graft material will be used from the Chamberlain Group or from LifeLike.

A much greater emphasis will be placed on practice between sessions in this module than in the CPB module.

Objectives

The CABG module is a five-session simulation-based training program with the following objectives:

1. Perform distal and proximal end-to-side anastomosis using the HeartCase or equivalent simulators and porcine heart model.
2. Perform distal end-to-side anastomosis (left anterior descending artery, obtuse marginal artery and posterior descending artery) and proximal aorto-coronary anastomosis using the Ramphal Cardiac Surgery Simulator.

3. Learn how to find, select and open the artery for the distal anastomosis and perform a small aortotomy for the proximal anastomosis.
4. Determine the approximate length of the graft and orient the graft for the proximal anastomosis using the porcine model and the Ramphal simulator.
5. Provide antegrade cardioplegia via the graft.
6. Practice at home using the HeartCase or equivalent simulator and log the practice time.
7. Demonstrate proficiency in vessel anastomosis based on the assessment tool.

The CABG training program consists of one half-day per session (approx. 4 hours). If desired, tissue models (porcine heart, CryoVein) can be used for the simulation and homework sessions instead of synthetic models and conduits. The schedule of the components of training is as follows:

Session 1: **Fundamentals of CABG and end-to-side anastomosis (Chamberlain or Lifelike aorta and vessels and HeartCase or equivalent model)**
Briefing/debriefing (feedback)
Homework (HW): End-to-side anastomosis
(HeartCase/equivalent)

Session 2: Distal (e.g., LAD, OM, PDA) and proximal anastomosis with CryoVein/ porcine heart
Arteriotomy and end-to-side anastomosis
Aortotomy and end-to-side anastomosis
Measure length of graft
Briefing/debriefing (feedback)
HW: proximal and distal anastomosis
(HeartCase/equivalent); sim lab with porcine heart

Session 3: Ramphal model practice/feedback— LAD bypass grafting with CryoVein
Arteriotomy and aortotomy
Measure length of graft
Cardioplegia via the graft

Briefing/debriefing (feedback)
HW: proximal and distal anastomosis
(HeartCase/equivalent); sim lab with porcine heart

Session 4: Ramphal model practice/feedback— Complete 3 vessel bypass grafting of LAD, OM, PDA with CryoVein; emphasis on OM and PDA
Arteriotomy and aortotomy
Measure length of graft
Cardioplegia via the graft
Briefing/debriefing (feedback)
HW: proximal and distal anastomosis
(HeartCase/equivalent);
optional sim lab with porcine heart

Session 5: Ramphal model practice/feedback— Complete 3 vessel bypass grafting of LAD, OM, PDA with CryoVein
Arteriotomy and aortotomy
Measure length of graft
Cardioplegia via the graft
Assessment
Briefing/debriefing (feedback)

Feedback and Debriefing

The resident will receive guidance and formative feedback from the faculty during the exercises and guidance for practice. Likewise, the resident is encouraged to provide feedback regarding the perceived relevance of the assignments and the validity of the tasks. For instance, feedback may include perceived value of the tasks, difficulty of the tasks, perceived improvement and progress, and level of comfort performing the procedures. (Fanning R and Gaba D. *The role of debriefing in simulation-based learning*. Sim Healthcare 2007; 2: 115-125.)

Definitions

BAT	Briefing Assessment Tool (from Week 1 CPB Module)
CryoVein	Cryo preserved saphenous vein (CryoLife)

DAT	Debriefing Assessment Tool
HeartCase	Synthetic simulation platform (Chamberlain Group)
LAD	Left descending artery
OM	Obtuse marginal branch of circumflex coronary artery
PDA	Posterior descending branch of right coronary artery
VAAT	Vessel Anastomosis Assessment Tool (distal, proximal)

CABG Session 1: Fundamentals of CABG/End-to-side Anastomosis

Overview

The initial session includes orientation, introduction to the simulators, performing end-to-side anastomosis, baseline assessment and defining homework assignments. Coronary artery anatomy and angiography are illustrated in APPENDIX B

Prerequisites

Review of coronary anatomy prior to session.
Review coronary angiography.

Goals

To understand the goal and rationale for various anastomosis techniques.
To perform the sequence of events in coronary artery anastomosis.

Objectives

1. Describe indications for CABG.
2. Interpret coronary arteriography
3. Identify 3 coronary lesions seen on angiogram and describe the appropriate bypass strategy
4. Develop baseline resident performance profile of vessel anastomosis
5. Perform end-to-side anastomosis using the HeartCase/equivalent with all scores of 3 or greater on the Vessel Anastomosis Assessment Tool (VAAT)
6. Conduct debriefing of the procedure

Teaching Plan

Equipment Required

For each resident:
Model for reviewing coronary anatomy

Representative coronary angiograms
HeartCase or equivalent (APPENDIX B)
5-0 and 6-0 polypropylene sutures
Castroviejo needle driver
Gerald forceps
Potts scissors (forward and reverse)
Metzenbaum scissors
Hemostats (rubber shod)
#11 blade
Suture scissors
3-4 mm aortic punch
Graft material (3-4mm graft and target vessels from Chamberlain, LifeLike)
Video camera and storage media

Simulation Set-Up

Review of coronary anatomy and angiography:
Important aspects of coronary artery anatomy should be reviewed using pictures, diagrams, or plastic or tissue models

Coronary angiography should be reviewed using selected videos which demonstrate all important views and lesion and target identification.

Baseline assessment of anastomosis technique on the Vessel Anastomosis Assessment Tool (VAAT). This should also be video-recorded.
* In order to get a true baseline, each resident should perform an end-to-side anastomosis without any instruction or input

Training using HeartCase/equivalent to perform end-to-side anastomosis with 3-4 mm synthetic grafts with 5 repetitions minimum. The first supervised anastomosis (which would be the second one done) can also be video recorded for documentation.

End-to-side anastomosis overview: Simulation of the end-to-side anastomosis is performed using a synthetic conduit, such as Chamberlain or Lifelike graft and target vessels, and synthetic or

porcine aorta to simulate proximal anastomosis. Either the HeartCase or equivalent holder for the aorta should be used.

Conduct of the Simulation

For the proximal anastomosis:

Steps:
Make aortotomy.

1. Using synthetic or porcine aorta, make a small aortotomy with a knife (#11 blade) and enlarge with an aortic punch (3-4mm).

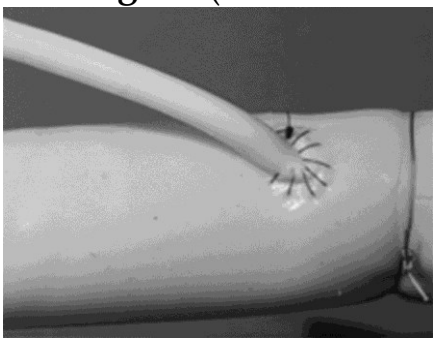
Perform anastomosis.

1. Perform using the synthetic graft vessel (3mm) with 5-0 polypropylene sutures (or institutional preference).
2. Cut graft just distal to the anastomosis and evaluate the anastomosis.
3. Technique varies among institutions and surgeons.
4. Recognize important components of anastomosis (see assessment).
5. Adjust the attachment to provide for anastomosis at different angles.

Understand instrumentation and sutures.

1. Varies among institutions and surgeons (e.g., locking vs. non-locking Castroviejo needle holders).
2. Direction of suturing (clockwise vs. counterclockwise).

Aortic graft (Chamberlain Group)



For the distal anastomosis:

Steps:
Make arteriotomy.

1. Using synthetic target vessel (3-4mm), make a small arteriotomy and extend with scissors.

Perform anastomosis.

1. Perform using the synthetic vessel (3mm) with 6-0 polypropylene sutures (or institutional preference).
2. Cut just distal to the anastomosis and evaluate inside of the anastomosis.
3. Technique varies among institutions and surgeons.
4. Recognize important components of anastomosis (see assessment).
5. Adjust the attachment to provide for anastomosis at different angles.

Understand instrumentation and sutures.

1. Varies among institutions and surgeons (e.g., locking vs. non-locking Castroviejo needle holders).
2. Direction of suturing (clockwise vs. counterclockwise).
3. Continuous vs. interrupted sutures.

Residents should perform the proximal anastomosis and the distal anastomosis <u>at least</u> 5 times at this session. Extra practice is on component parts in which the resident is deficient should be carried out to achieve proficiency.

Feedback and Debriefing
The resident will receive guidance and formative feedback from the faculty during the exercises and guidance for practice. Likewise, the resident is encouraged to provide feedback regarding the perceived relevance of the assignments and the validity of the tasks. The resident will practice debriefing of the procedure. Please refer to Debriefing Assessment Tool (DAT) at the end of Week 5.

a. What went well?
b. What went wrong?
c. Are there any technical issues?
c. Questions

Assessment Tools for Session 1

In Appendix A:

VAAT Distal and proximal (Baseline)

VAAT Last distal and proximal

DAT Debriefing Assessment Tool

Homework assignment (HW): proximal anastomosis (HeartCase/equivalent): 10 anastomoses/week

CABG Session 2: Distal (e.g., LAD, OM, PDA) and Proximal Anastomosis with CryoVein/Porcine heart

Overview

The focus of this session is vessel anastomosis using the porcine heart model (wet-lab environment). Porcine hearts placed in the wet-lab container are used for training in distal end-to-side anastomosis (e.g., LAD, PDA, and OM) and proximal anastomosis using cryo preserved saphenous vein (CryoVein). Important components include arteriotomy and aortotomy, measuring length of graft, technical challenges with anastomosis, and briefing/debriefing (feedback). Homework assigned will be proximal and distal anastomosis (HeartCase/equivalent) and optional sim lab with porcine heart model.

Prerequisites

Each resident will have performed at least 10 vessel anastomosis using the HeartCase/equivalent since the last session as homework. The actual requirements should be tailored to the technical skill needs of the individual resident

Objectives

1. Perform at least 5 distal and 3 proximal anastomoses on the porcine heart.
2. Achieve minimal scores of 3 on all parts of the Vessel Anastomosis Assessment Tool (VAAT) for proximal and distal anastomoses.
3. Understand different needle angles and approaches to various anastomoses.

Teaching Plan

Equipment required

For each resident:
Porcine heart with wet-lab container

CryoVein
5-0 and 6-0 or smaller polypropylene sutures
Castroviejo needle driver
Gerald forceps
Metzenbaum scissors
Potts scissors (forward and reverse)
Hemostats (rubber shod)
Beaver or #15 blades
Arteriotomy scissors
Suture scissors
4 mm aortic punch
Graft = CryoVein(CryoLife, Kennesaw, GA)
Video camera and storage media
Resident loops
Infusion needle and syringe with saline

Conduct of the Simulation Session

1. **Review of homework from previous week**. Review the quality of practice anastomoses done as "homework". The instructor may want to open the anastomoses and evaluate their quality with the resident.

2. **Perform at least 5 distal anastomoses** using CryoVein to LAD, OM and PDA of porcine heart.

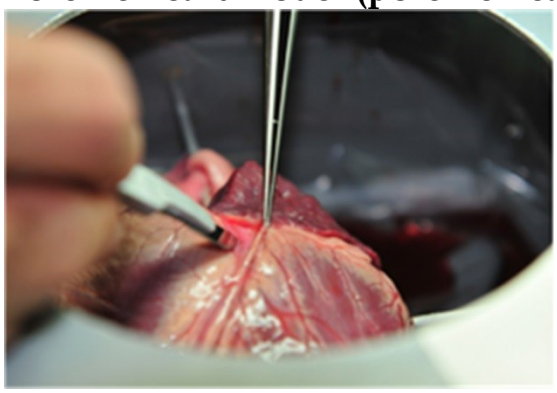
3. **Complete Vessel Anastomosis Assessment Tool (VAAT);** the resident should be able to perform a distal anastomoses with a level of proficiency with scores $\geq$3 using the VAAT. Video record first and last distal anastomosis for documentation.

4. **Perform 3 or more proximal anastomoses** using CryoVein to porcine ascending aorta. The resident should be able to perform a proximal anastomoses with this level of proficiency with scores $\geq$3 using the VAAT. If this is not the case, either more homework or more time in this session should be encouraged.

5. **Debriefing**

6. **Homework assignment (HW): end-to-side anastomosis**
   HeartCase/equivalent using synthetic vessels (Chamberlain and/or Lifelike): 10 anastomoses/week.

Porcine heart model (porcine heart in wet-lab container)



Achieve adequate exposure

1. With tissue-based model, the epicardium is incised exposing the target vessel.
2. Be facile at placing small epicardial retractor, if needed.
3. For LAD target, make a small arteriotomy and extend with scissors

Perform distal anastomosis

1. LAD targets (multiple LAD anastomoses).
2. Technique varies among institutions and surgeons
3. Recognize important components of anastomosis

Perform proximal anastomosis

1. Measure length of graft to aortic root.
2. Incise ascending aorta with #11 blade
3. Insert 4 mm punch
4. Perform proximal anastomosis

Understand instrumentation and sutures

1. Varies among institutions and surgeons (e.g., locking vs. non-locking Castroviejo needle holders).
2. Clockwise vs. counterclockwise direction
3. Continuous sutures (vs. interrupted sutures).

Residents should perform distal LAD anastomoses at least 5 times and the proximal aorto-coronary anastomoses **at least** 3 times at this session. Extra practice on component parts in which the resident is found to be deficient should be carried out to achieve proficiency.

Assessment Tools for Session 2

In Appendix A:

VAAT	Proximal anastomosis (CryoVein to Porcine Aorta)
VAAT	Distal anastomosis (CryoVein to Porcine LAD)
DAT	Debriefing

Resident's homework/operative experience log should also be submitted.

CABG Session 3: Full CABG using Ramphal Cardiac Surgery Simulator

Overview

The Ramphal Cardiac Surgery Simulator is used in sessions 3, 4, and 5 to allow the resident to synthesize all component parts practiced in sessions 1-2 for CABG. In session 3, the resident will perform CABG including conducting a briefing, properly cannulating the heart for CPB and cardioplegia, instituting cardiopulmonary bypass, arresting the heart using antegrade cardioplegia, performing distal and proximal anastomoses using CryoVein, weaning from bypass and de-cannulating, and conducting a debriefing. All technical skills learned during the CPB Module and thus far in the CABG Module will be employed. Session 3 will consist of a minimum of **3 LAD bypasses** per resident. Non-operating resident may serve as first assistant.

Prerequisites

Each resident will have performed at least 10 vessel anastomosis using the HeartCase or equivalent in the past week as homework.

Objectives

1. Perform briefing and de-briefing of the procedure with all Y's on the Briefing Assessment Tool (BAT, APPENDIX A).
2. Conduct informed, efficient cardiopulmonary bypass run including all cannulation steps, appropriate commands, and understanding of critical elements with all scores on the CPBAT of 3 or greater.
3. Perform vein graft to LAD anastomosis as baseline and at least 2 additional anastomoses.
4. Measure correct length of vein graft and perform a proximal anastomosis as baseline and at least 2 additional proximal anastomoses.

Teaching Plan

Equipment Required

For each resident:
All usual and customary instruments and supplies for cardiopulmonary bypass specific to your institution
Ramphal Cardiac Surgery Simulator
5-0 and 6-0 polypropylene sutures
Castroviejo needle driver
Gerald forceps
Metzenbaum scissors
Potts scissors (forward and reverse)
Hemostats (rubber shod)
Beaver or #15 blades
Arteriotomy scissors
Suture scissors
4 mm aortic punch
CryoVein
Video camera and storage media

Simulators and Set-up

The Ramphal Simulator is used for the remainder of the training. The heart is cannulated for CABG. The procedure should mimic as closely as possible CABG at your institution; note the conduit will be supplied.

Conduct of the Simulation

Steps:

1. The residents' homework and operative log should be reviewed.

2. The resident should conduct a briefing of the proposed procedure.

3. The resident will cannulate the heart and initiate CPB.

4. The resident will note target temperature and institute antegrade cardioplegia (retrograde may be optional, due to time constraints).
5. Identify appropriate LAD target and a distal anastomosis performed. The vein graft will be perfused with syringe and the appropriate length to the aorta determined. It is best to start with a somewhat distal target in order to preserve vein length for subsequent anastomoses. The vein graft can be clipped or tied adjacent to each anastomosis after each repetition.
6. At least 3 LAD grafts should be performed.
7. Measure the appropriate length of vein for each graft and anastomose to the aorta.
8. After the last bypass has been completed (distal and proximal), the resident will wean from cardiopulmonary bypass and de-cannulate.
9. The resident will conduct a de-briefing of the procedure.

Assessment Tools for Session 3

It is recommended that the entire procedure including briefing and de-briefing should be video recorded for review and feedback.

In Appendix A:

BAT	Briefing Assessment Tool
CPBAT	Complete Cardiopulmonary Bypass Assessment Tool
VAAT	Distal
VAAT	Proximal
DAT	Debriefing Assessment Tool

Homework should be assigned based upon areas that most need improvement.

CABG Session 4: Full CABG using Ramphal Cardiac Surgery Simulator

Overview

The Ramphal Cardiac Surgery Simulator is used in sessions 3, 4 and 5 to allow the resident to synthesize all component parts practiced in weeks 1-2 for CABG. In session 4, the resident will perform CABG including conducting a briefing, properly cannulating the heart for CPB and cardioplegia, instituting cardiopulmonary bypass, arresting the heart using antegrade cardioplegia, performing distal and proximal anastomoses using CryoVein, weaning from bypass and de-cannulating, and conducting a debriefing. All technical skills learned during the CPB Module and thus far in the CABG Module will be employed. Session 4 will consist of a minimum of one graft to the LAD and **at least 2 grafts** to the OM and/or PDA. The non-operating resident may serve as first assistant.

Prerequisites

Each resident will have successfully completed the homework assigned in Session 3.

Objectives

1. Perform briefing and de-briefing of the procedure with all Y's on the Briefing Assessment Tool (BAT)
2. Conduct informed, efficient cardiopulmonary bypass run including all cannulation steps, appropriate commands, and understanding of critical elements with all scores on the CPBAT of 3 or greater
3. Perform vein graft to LAD anastomosis with all scores being 4 or greater on the VAAT
4. Measure correct length of vein graft and perform a proximal anastomosis with all scores being 4 or greater on the VAAT
5. Identify suitable target and perform <u>at least 2</u> distal anastomoses on OM or PDA

6. Select correct graft length and perform at least 2 proximal anastomoses.
7. Conduct debriefing of the procedure

Teaching Plan

Equipment Required

For each resident:

All usual and customary instruments and supplies for cardiopulmonary bypass specific to your institution
Ramphal Cardiac Surgery Simulator
5-0 and 6-0 polypropylene sutures
Castroviejo needle driver
Gerald forceps
Metzenbaum scissors
Hemostats (rubber shod)
Beaver or #15 blades
Arteriotomy scissors
Suture scissors
4 mm aortic punch
CryoVein
Video camera and storage media

Simulators and Set-up

The Ramphal Simulator and the heart are situated for CABG. The procedure should mimic as closely as possible to CABG at your institution; note the conduit will be supplied.

Conduct of the Simulation

Steps:

1. The residents' homework and operative log should be reviewed

2. The resident should conduct a briefing of the proposed procedure

3. The resident will cannulate the heart and initiate CPB

4. The resident will note target temperature and institute antegrade cardioplegia (retrograde will not be used due to time constraints)

5. Identify appropriate LAD target and a distal anastomosis performed. The vein graft will be perfused with syringe and the appropriate length to the aorta determined. It is best to start with a somewhat distal target in order to preserve vein length for subsequent anastomoses

6. At least 2 similar grafts will be placed to either the OM or the PDA or both.

7. Measure the appropriate length of vein for each graft and anastomose to the aorta.

8. After the last bypass has been completed (distal and proximal), the resident will wean from cardiopulmonary bypass and de-cannulate.

9. The resident will conduct a de-briefing of the procedure.

Assessment Tools for Session 4

The entire procedure including briefing and de-briefing should be videotaped and submitted.

In Appendix A:

VAAT Proximal

VAAT Distal

Homework should be assigned based upon areas identified as needing the most improvement.

CABG Session 5: Full CABG using Ramphal Cardiac Surgery Simulator

Overview

The Ramphal Cardiac Surgery Simulator is used in sessions 3, 4, and 5 to allow the resident to synthesize all component parts practiced in sessions 1-2 for CABG. In session 5, the resident will perform CABG including conducting a briefing, properly cannulating the heart for CPB and cardioplegia, instituting cardiopulmonary bypass, arresting the heart using antegrade cardioplegia, performing distal and proximal anastomoses using CryoVein, weaning from bypass and de-cannulating, and conducting a debriefing. All technical skills learned during the CPB Module and thus far in the CABG Module will be employed. Session 5 will consist of **at least 1** vein graft to the LAD, OM, and PDA. The non-operating resident may serve as first assistant.

Prerequisites

Each resident will have successfully completed the homework assigned in Session 4.

Objectives

1. Perform briefing and de-briefing of the procedure with all Y's on the Briefing Assessment Tool (BAT)
2. Conduct informed, efficient cardiopulmonary bypass run including all cannulation steps, appropriate commands, and understanding of critical elements with all scores on the CPBAT of 4 or greater
3. Perform vein graft anastomosis to LAD, OM, and PDA with all scores being 4 or greater on the VAAT
4. Measure correct length of vein graft and perform a proximal anastomosis with all scores being 4 or greater on the VAAT
5. Conduct debriefing of the procedure

Teaching Plan

Equipment Required

For each student:
As per Sessions 3 and 4

Simulators and Set-up

The Ramphal Simulator and heart are situated for CABG. The procedure should closely mimic CABG at your institution; the conduit will be supplied.

Conduct of the Simulation

Steps:

1. The residents' homework and operative log should be reviewed.
2. The resident should conduct a briefing of the proposed procedure.
3. The resident will cannulate the heart and initiate CPB.
4. The resident will note target temperature and institute antegrade cardioplegia (retrograde will not be used due to time constraints).
5. Identify appropriate LAD, OM and PDA targets and distal anastomoses performed.
6. Measure the appropriate length of vein for each graft and anastomose to the aorta.
7. After the last bypass has been completed (distal and proximal), discontinue cardioplegia, de-air the grafts, wean from cardiopulmonary bypass, and de-cannulate.
8. The resident will conduct a de-briefing of the procedure.

Assessment Tools for Week 5

Optional: The entire procedure, including briefing and de-briefing, may be videotaped for further analysis.

In Appendix A:

BAT Briefing Assessment Tool

CPBAT CPB Assessment Tool

VAAT Last Distal

VAAT Last Proximal

DAT Debriefing Assessment Tool

3. Aortic Valve Replacement (AVR) Module

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Overview - AVR Module

The AVR Module is a five-session simulation based training program that will teach the resident to safely and efficiently replace the aortic valve with both a mechanical and tissue valve. The technical aspects of aortic valve replacement are broken down into their component parts which are learned and practiced at each weekly session and between sessions. The goal of this module is not only to have performed aortic valve replacement but also to have practiced the component steps enough to demonstrate basic proficiency in them.

Objectives

The AVR Module has the following objectives:

1. The resident will be able to describe the anatomy of the aortic root and the important relationships that exist (i.e. anterior leaflet of mitral valve, conduction system, RV etc.).
2. The resident will be able to perform and close an aortotomy (transverse/hockey stick)
3. The resident will be able to excise the aortic valve, size the annulus, place annular and valvular sutures, seat and tie down the sutures and assess appropriate positioning (with a score of 5 for all steps).
4. The resident will be able to perform all required cannulation and surgical steps for the institution of bypass, performance of an AVR and separation from bypass with a score of 5 for all steps.

The four-session AVR curriculum will consist of one half-day per session (approximately 4 hours) for each resident.

The schedule of the components of training is as follows:

Session 1: Anatomy, Aortotomy and Closure of the Aorta
Videos/presentations – Grossi/Northrup/Hicks (see p. 49)
Prosection of pig heart

Multiple aortotomies and aortic closures of both transverse and "hockey stick" on the pig aorta
Cannulation model used in CPB Module Session 2

Session 2: Valve Excision, Annular Suture Placement, Seating and Tying

Pig heart
Aorta opened: hockey stick or transverse
Valve excised
Annular sutures placed and organized multiple times
On final set of sutures: place through valve and tie down
Close aorta
Excise prosthetic valve as it can be used again.

Session 3: Deairing of the heart

Introduction of standardized method of de-airing the heart after cardiotomy.

Multiple repetitions of deairing procedure using the Ramphal Cardiac Surgery Simulator.

Session 4 & 5: Full Aortic Valve Replacement with Ramphal simulator

Full CPB with cardioplegia and cross clamp
1 aortotomy
Valve excision
Suture placement in annulus and sewing ring
2 valve replacements (1 mechanical, 1 tissue) each week for each resident

Aortic closure
Deairing maneuvers prior to cross clamp removal and separation from bypass for each replacement.
Separation from bypass for each replacement.
Decannulation at end of last procedure

Residents should have ample opportunity to practice between weekly sessions. Each session will begin with an evaluation of the component tasks covered in previous sessions.

Feedback and Debriefing

The resident will receive guidance and formative feedback from the faculty during the exercises and guidance for practice. Likewise, the resident is encouraged to provide feedback regarding the perceived relevance of the assignments and the validity of the tasks. For instance, feedback may include perceived value of the tasks, difficulty of the tasks, perceived improvement and progress, and the level of comfort performing the procedures. (Fanning R and Gaba D. *The role of debriefing in simulation-based learning.* Sim Healthcare 2007;2:115-125.)

AVR Session 1: Anatomy, Aortotomy and Closure of the Aorta

Overview

Session 1 of the AVR module consists of a video and instructor-guided dissection of the porcine heart. This session will teach the fundamentals of the aortotomy and closure of the aorta. Multiple aortotomies and closures will be performed.

Prerequisites

View *Anatomy of the Heart* by Dr. Eugene A. Grossi:
http://conference-cast.com/tsda/tsdaplayer/player1.php?fileid=grossi

View *Aortic Valve Replacement: Operative Technique* by Dr. Arie Blitz:
http://www.youtube.com/watch?v=C-sIdppyaPQ

View *Aortic Valve and Root Anatomy* by Dr. William Northrup III:
http://www.tsda.org/wp-content/uploads/2015/09/tsda-boot-camp-anatomy-2015.pdf

View *Introduction to Aortic Valve Surgery* by Dr. George L. Hicks, Jr.:
http://www.tsda.org/wp-content/uploads/2015/09/Aortic-Valve-Pathology-and-Treatment.15.pdf

Goals

To learn the anatomy of the aortic root and surrounding structures with particular attention to anatomic considerations of aortic valve replacement.

Objectives

1. The resident will be able to dissect the heart in such a way as to point out the anatomic features critical to safe aortic valve replacement.

2. The resident will make a transverse aortotomy at the correct location and of the correct length for an AVR
3. The resident will make a "hockey stick" aortotomy at the correct location and of the correct length for an AVR
4. The resident will be able to close the aortotomy with a score of 4 or better on all areas of the Aortotomy Closure Assessment Tool (ACAT)

Teaching Plan

Equipment Required

Computer with internet connection and DVD player
Access to prerequisite videos
1 pig heart from previous modules for each resident.
DeBakey forceps (2)
Metzenbaum or heavy curved scissors
Pig aorta/aortic cannulation simulation model used in CPB Week 2
Suture scissors
2 Forceps – fine DeBakey
Needle driver
Aortic cross clamp
Appropriate polypropylene sutures for aortotomy closure (6-12)
Teflon strips or pledgets(optional)
Hemostats
15 blade
Marking pen for designating annulus line
Video camera and storage media

Simulator and Set-up

Each student will be seated at a table with a pig heart previously used for other purposes in prior simulation sessions.

The Grossi and Northrup presentations should be played and visible to the resident. There should be capacity to readily start and stop the videos so that resident will have the time to study the anatomy. Alternatively, the instructor can take the resident through the anatomy.

The simulator should be set up in the same manner as in CPB Week 2. A line should be made on the aorta designating the level of an annulus.

Conduct of Simulation Training

Review the 2 videos (Grossi, Northrup) with resident supplementing content as needed.

Heart dissection:
A prosection of the pig heart will be done by the resident showing the aortic valve anatomy, LV outflow tract, right ventricle, ventricular septum, location of conduction system, left and right coronary arteries, aorto-mitral curtain, proper aortotomy location (transverse and "hockey stick")

Resident prosection:
The resident will demonstrate to the faculty the anatomy and its relevance.

Aortotomy and Aortotomy Closure:

1. The aorta is perfused and the cross clamp applied.
2. Aortotomy is made – transverse.
3. Aortotomy is closed.
4. Cross clamp is released and suture line checked for leaks.
5. Leaks, if any, are closed.
6. Repeated for "hockey stick".
7. Repeated for total of **at least** 3 times for each type of aortotomy .

Debriefing

A debriefing of the session will be conducted covering

1. Any persistent deficiencies in understanding the relevant anatomy
2. Any deficiencies in the videos or the dissection models

Residents will receive guidance and formative feedback from the faculty during the exercises. Residents will provide feedback regarding perceived relevance of assignments and validity of tasks.

Assessment Tools for AVR Session 1

In Appendix A:

PAT Prosection Assessment Tool

ARAT Aortotomy Repair Assessment Tool

AVR Session 2: Valve Excision and Annular Suture Placement

Overview

The focus of this session is to use the porcine heart model to learn the techniques of valve excision and annulus suture placement and organization. In addition, the resident will learn to place stitches through the valve and properly orient and seat the valve. Both mechanical and tissue valves should be available. The resident will learn to tie the stitches on both mechanical and bioprosthetic valves

Prerequisites

Session 1 objectives performed satisfactorily.

Objectives

1. The resident will perform an aortotomy based on institutional preference.
2. The resident will excise the valve (Score 4 or better on AVR Assessment tool).
3. The resident will size the annulus for both mechanical and pericardial valves (Score 4 or better on AVR Assessment tool – AVRAT).
4. The resident will place annular sutures and organize them on Deknatel or other organizing system (Score 4 or better on AVR Assessment tool). This will be repeated at least 4 times.
5. The resident will then place the sutures in the sewing ring of a mechanical valve with proper spacing and tie it down with a score of 4 or better on AVRAT Component Task.
6. The resident will repeat this on a bioprosthetic valve.
7. The resident will close the aortotomy(Score 4 or better on ACAT Assessment tool).

Teaching Plan

Equipment Required

For each resident:
1 porcine hearts with wet lab container
Valve sizers for mechanical and pericardial valves
6 sets of valve sutures
Set of suture holders
Needle driver
Metzenbaum scissors
#15 blade
Hemostats
Video camera and storage media
4-0 or 5-0 polypropylene
Mechanical aortic valve
Bioprosthetic aortic valve
Video camera and storage media

Simulator and Set-up

Pig heart set in pericardial well or in cardboard holder. Non-perfused.

Conduct of Simulation

1. Orient pig heart in cardiac well or positioning box.
2. Brief and describe anatomy.
3. Perform aortotomy (either variety).
4. Place traction sutures for visualization.
5. Excise aortic valve.
6. Size annulus of heart with mechanical and tissue sizers.
7. Place annular sutures and organize them.
8. Cut out annular sutures.
9. Re-place annular sutures and organize.
10. Repeat steps 6-8 a minimum of 4 times.
11. Place 4th set of sutures through the sewing ring of a mechanical valve with proper spacing and tie it down.

12. Place 5th set of sutures through the sewing ring of a bioprosthetic valve with proper spacing and tie it down.
13. Close aortotomy.

Feedback and Debriefing

The resident will receive guidance and formative feedback from the faculty during the exercises and guidance for practice. Likewise, the resident is encouraged to provide feedback regarding the perceived relevance of the assignments and the validity of the tasks. The resident will practice debriefing of the procedure.

Assessment Tools for AVR Session 2

In Appendix A:

AVRAT Aortic Valve Replacement Assessment Tool (1-5)

ARAT Aortic Repair Assessment Tool

AVR Session 3: De-airing the Heart

Overview

During the cardiopulmonary bypass module, we reviewed the cardiopulmonary bypass circuit, identified sources of air in the circuit and the heart, and made practical application to the pressurized pig heart. This session will utilize the pressurized pig heart to teach the resident the steps of air evacuation after cardiotomy. The resident will:

1. Review the 7 steps of CPB
2. Place the patient on cardiopulmonary bypass with antegrade and retrograde cardioplegia and LV decompression using LV sump
3. Understand and carry out the steps for de-airing the heart
4. Debrief

The objectives for this week are that by the end of the session

1. The resident will be able to initiate cardiopulmonary bypass and cardiac arrest (without air in the circuit or heart)
2. The resident will be able to adequately remove air from the heart after aortotomy

Prerequisites

Read Chapter 12, Extracoporeal Circulation, by Drs. Hammon and Hines, in Cohn's *Cardiac Surgery in the Adult.*

Able to write the 7 steps from memory of CPB (APPENDIX B).

Able to cannulate the aorta, atrium, and place antegrade and retrograde cardioplegia cannulas and decannulate.

Goals

1. Understand the sources of air within the CPB circuit and the heart.

2. Know the sequence of steps that maintains the integrity of the CPB circuit.
3. Understand the potential use of CO2.

4. Know the steps to de-air the heart.

Objectives

1. The resident will list the sources of air during CPB and aortotomy (cardiotomy).

2. The resident will perform the steps necessary to maintain the integrity of the CPB circuit with a score of 4 or better on the first 4 items of the AVR De-airing Assessment Tool (DAAT) on the last simulation.

3. The resident will perform the steps for de-airing of the heart with a score of 4 or better on points 5-7 of the AVR De-airing Assessment Tool (DAAT).

Each resident will perform at least 6 de-airing maneuvers using the pressurized pig heart.

Teaching Plan

All parts of the teaching plan should be repeated as many times as necessary for the resident to be able to perform them perfectly (deliberate practice).

Equipment Required

Ramphal Cardiac Surgery Simulator (or a pressurized pig heart model)
1 IV pole
2 aortic purse-string sutures
3 atrial purse-string sutures
2 cardioplegia purse-string sutures
I LV Vent purse-string suture
7 2-0 Silk ties
7 tourniquet sliders
11 knife blade on handle
Needle driver

2 pairs of DeBakey forceps
7 small clamps
7 tubing clamps
1 single or double stage venous cannula
2 smaller right angle caval venous cannulas
Aortic cross clamp
Aortic cannula with connector
1 aortic cardioplegia cannula with side vent
1 retrograde cardioplegia cannula
1 LV Decompress (Vent) cannula
2 liter bags of artificial blood connected to cardioplegia lines
Suture scissors
Metzembaum scissors
4 lap sponges
Cardiopulmonary bypass machine
Video camera and storage media (optional)
(CO2 line for the pericardial well)

Simulation Set-Up

This session will use the Ramphal Cardiac Surgery Simulator. In addition, it will be helpful to have a perfusionist working with the team to assist during the de-airing of the heart.

Because the pig heart prep has very small and thin pulmonary veins, the LV vent stitch will likely have to be placed very near or in the left atrial wall to simulate placement in a patient. It may also be a little difficult to pass the vent into the left ventricle and to have a sizeable return of blood through the vent due to the balloon in the left ventricle.

Lung ventilation will be stated as occurring (will not be simulated).

Conduct of Simulation

1. Resident must write from memory the 7 steps of CPB listed in CPB Module, Session 1 (APPENDIX B). During the simulation, the resident will be expected to perform the parts of the 7 Steps appropriate to the initiation of cardiopulmonary bypass, administration of cardioplegia, and placement of the LV vent.
2. Appropriately cannulate the ascending aorta and connect to CPB circuit.
3. Appropriately cannulate the atrium and connect to CPB circuit
4. Appropriately initiate cardiopulmonary bypass.
5. Place antegrade and retrograde cardioplegia cannulas, remove air from cardioplegia lines, connect to CPB circuit.
6. Cross-clamp aorta (may differ from institution) and initiate cardiac arrest.
7. Place LV (Vent) and connect to CPB circuit.
    a. Identify area for cannulation at the right superior pulmonary vein (RSPV) LA junction.
    b. Place purse string suture .
    c. Use #11 blade to make venotomy inside purse-string in RSPV or adjacent left atrial wall.
    d. Confirm blood is continuously ejected and air is not entering the left atrium.
    e. Gently dilate the opening in the RSPV or adjacent left atrial wall with a fine tonsil clamp.
    f. Insert the LV (vent) directing it toward (and through the mitral valve).
        i. Blood will be ejected vigorously through the LV decompress when it enters the left ventricle in a patient but may not with this model.
        ii. A hand behind the left atrium can confirm that the LV vent did not enter the left pulmonary veins and leaves the left atrium into the left ventricle where it cannot be palpated.
    g. Secure the purse-string with a Rummel tourniquet.

h. Confirm the tubing for the LV vent will aspirate fluid from the pericardium (this prevents inadvertent positive pressure from the CPB machine and pumping air into the left atrium).
i. Connect the LV vent to the CPB circuit and initiate suction with instruction VENT ON.
j. Ask perfusion to drain the volume from the heart.
k. Secure the LV decompress to the Rummel tourniquet with a silk tie.

8. Reduce pump flow/ Cross-clamp aorta/ Give antegrade and retrograde cardioplegia/ Return to normal flow/ Check line pressure.

Deairing procedure after successful operation:

1. De-air the heart prior to releasing the cross clamp
2. Stop LV sump several minutes before starting to deair (this will allow the LA and LV to fill slowly and minimize air
3. Administer both antegrade and retrograde cardioplegia
4. Release aortic cross clamp after reducing flow
    a. Trendelenberg (and patient right side down)
        i. Positions the ventriclular apex as the highest point
    b. Aspirate the aorta through the antegrade cardioplegia needle or an open vent site on the aorta
    c. Restrict venous return to allow the left and right heart to fill more completely
    d. Gently massage the left ventricle, left atrium, pulmonary veins and invaginate the left atrial appendage to remove trapped air
    e. Multiple small (300cc) tidal volume lung ventilations with 100% FiO2
        i. Mobilize air from the pulmonary veins
        ii. Pay attention to ECHO to assess residual air
    f. Continue active aspiration/ventilation of the aorta
    g. De-air any vein grafts
    h. Use TEE to assist with additional air evacuation
        i. Return the bed to normal position when the TEE demonstrates successful air evacuation

5. Wean off bypass, checking again for any residual air and citing all conditions that must be present to wean CPB
6. If stable off CPB remove LV vent and aortic vent
7. Discontinue CO2 (if utilized)

Repeat procedure at least 6 times without removing the aortic, atrial, or cardioplegia cannulas.

8. The resident will participate in a debriefing of the procedure
    a. What went well?
    b. What went wrong?
    c. Questions

Assessment Tool for AVR Session 3

De-airing Assessment Tool (see next page) should be filled out for each resident on the 1st, 3rd, and last simulation for each resident.

In Appendix A: DAAT - De-airing Assessment Tool

AVR Session 4: AVR on Ramphal Simulator

Overview

The Ramphal Cardiac Surgery Simulator will be used in Sessions 4 and 5 to allow the resident to put all of the component parts practiced in AVR Sessions1-2 together for a complete AVR procedure. In Session 4, the resident will perform AVR including conducting a briefing, properly cannulating the heart for CPB and cardioplegia and vent, putting the heart on bypass, arresting the heart using antegrade cardioplegia, performing an aortotomy, excising the valve, size the valve, perform aortic valve replacement and closing aortotomy, de-airing the heart, successfully weaning the heart off bypass and decannulating the heart and conducting a debriefing.

All technical skills and procedures learned during CPB and CABG module will be used.

Non-operating resident will serve as first assistant. Residents will then change roles and repeat.

Prerequisites

Successful completion of Weeks 1-2 of AVR module

Read Chapter 12, Extracorporeal Circulation, by Drs. Hammon and Hines, in Cohn's *Cardiac Surgery in the Adult*.

Able to write the 7 steps from memory of CPB (APPENDIX B)

Objectives

The objectives for this week are:

1. The resident will perform a briefing
2. The resident will conduct an informed, efficient and technically expert CPB run including all cannulation steps, appropriate

commands, myocardial protection as in Session 4 of CPB Module with scores of 4 or better on the CPBAT.

3. The resident will incorporate elements of the operation appropriate for AVR into the operation including aortotomy, valve excision, sizing, suture placement thru annulus and valve, valve seating and tying, and aortotomy closure with a score of 4 or better on the AVRAT.

4. The resident will wean and separate from bypass and decannulate with attention to de-airing, TEE and elements specific to AVR with a score of 4 or better on the AVRAT.

Teaching Plan

Equipment Required

For each resident:

All usual instruments, supplies and equipment for CPB from CPB sessions

Ramphal simulator
Cannulation sutures
2 sets valve sutures
Suture guards
Valve sizers
Valves
4.0 polypropylene
Needle driver
Metzenbaum scissors
Fine DeBakey forceps
Hemostats
15 blade

Simulator and Set-up

Ramphal Simulator and prepared pig heart.

Conduct of Simulation

1. The resident performs a briefing.
2. The resident performs full cannulation as in Session 4 of the CPB Module with all of the appropriate commands and communication
3. The resident places the cross clamp, and arrests the heart.
4. The resident performs an aortotomy and exposes the valve.
5. The resident excises the valve and sizes the annulus.
6. The resident places sutures through the annulus and secures them in suture guards.
7. The resident places the sutures through the valve and ties down the valve.
8. The resident closes the aortotomy.
9. The resident de-airs, removes the cross clamp and separates from bypass and decannulates.
10. The resident performs a debriefing.
11. The residents change sides and the operating resident becomes the assisting resident. Steps 1-10 will be repeated.

Each resident should perform one full AVR in each session and first assist for a full AVR at each session.

Assessment Tools for AVR Session 4

In Appendix A:

CPBAT - Cardiopulmonary Bypass Assessment Tool

AVRAT - Aortic Valve Replacement Tool

AVR Session 5: AVR on Ramphal Simulator

Overview

The Ramphal Simulator will be used in Sessions 4 and 5 to allow the resident to put all the component parts practiced in Session 1-3 together for AVR. In Session 5, the resident will repeat full aortic valve replacements including conducting a briefing, properly cannulating the heart for CPB and cardioplegia and vent, putting the heart on bypass, arresting the heart using antegrade cardioplegia, performing an aortotomy, excising the valve, size the valve, perform aortic valve replacement and closing aortotomy, deairing, successfully weaning the heart off bypass and decannulating the heart and conducting a debriefing. The resident will also understand and incorporate the concepts necessary for aortic insufficiency and upper septal hypertrophy.

All technical skills and procedures learned during CPB and CABG module will be used.

Non-operating resident will serve as first assistant. Residents will then change roles and repeat.

Prerequisites

Successful completion Sessions 1-4 of AVR Module.

Objectives

The objectives for this week are:

1. The resident will perform a briefing

2. The resident will conduct an informed, efficient and technically expert CPB run including all cannulation steps, appropriate commands, myocardial protection as in Session 4 of CPB Module with scores of 4 or better on the CPBAT.

3. The resident will discuss implications of aortic insufficiency with respect to initiation of bypass, cardioplegia delivery, venting and aortic clamping.

4. The resident will incorporate elements of the operation appropriate for AVR into the operation including aortotomy, valve excision, sizing, suture placement thru annulus and valve, valve seating and tying, and aortotomy closure with a score of 4 or better on the AVRAT. In addition, the resident will learn the proper location and technique for upper septal myectomy.

5. The resident will wean and separate from bypass and decannulate with attention to de-airing, TEE and elements specific to AVR with a score of 4 or better on the AVRAT.

Teaching Plan

Equipment Required

For each resident:

All usual instruments, supplies and equipment for CPB from CPB sessions

Ramphal simulator
Cannulation sutures
2 sets valve sutures
Suture guards
Valve sizers
Valves
4.0 polypropylene
Needle driver
Metzenbaum scissors
Fine DeBakey forceps
Hemostats
15 blade

Simulator and Set-up

Ramphal Simulator and prepared pig heart.

Conduct of Simulation

1. The resident will perform a briefing.

2. The resident will perform full cannulation as in Week 4 of the CPB Module with all of the appropriate commands and communication

3. The resident will discuss alterations to arresting the heart and placement of a vent in relationship to placing the cross clamp, and arresting the heart.

4. The resident will perform an aortotomy and expose the valve.

5. The resident will excise the valve and perform an upper septal myectomy and size the annulus.

6. The resident will place sutures through the annulus and secure them in suture guards.

7. The resident will place the sutures through the valve and tie down the valve.

8. The resident will close the aortotomy.

9. The resident will de-air, remove the cross clamp and separate from bypass and decannulate.

10. The resident will perform a debriefing.

11. The residents will change sides and the operating resident will become the assisting resident to repeat steps 1-10.

Each resident should perform one full AVR in each session and first assist for a full AVR at each session.

Assessment Tools for AVR Session 5

In Appendix A:

CPBAT Cardiopulmonary Bypass Assessment Tool

AVRAT Aortic Valve Replacement Assessment Tool

DAAT De-Airing Assessment Tool

4. Massive Air Embolism (MAE) Module

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Overview – MAE Module

The Massive Air Embolism (MAE) Module is a 4-session program to focus on the prevention, recognition, and management of massive air embolism (MAE) during cardiopulmonary bypass. Although MAE is an infrequent complication (0.03-0.07/1000 cases), the possibility of death or serious outcome after massive air embolism is greater than 50%. (Mejak BL, Stammers A, Raush E, et al. *A retrospective study of perfusion incidents and safety devices.* Perfusion 2000; 15:510)

Since it is quite likely that the resident will never see MAE in the clinical situation during his or her training, it is therefore essential that a resident have sufficient training in a simulated environment to be able to handle MAE should it ever occur. This module is designed to prepare the resident to appropriately prevent air embolism and effectively manage massive air embolism. As with other potentially catastrophic events during cardiac surgery, the management of MAE requires a closely coordinated team approach with surgeon, perfusionist, anesthesiologist, and nurses. All members of the team should be encouraged to participate in this module. The learning objectives are:

1. The resident will lead a team to develop a protocol for handling air embolism in the most common circumstances utilizing a team approach
2. The resident will be able to appropriately recognize air embolism and direct the team in its management
3. The resident will be able to manage institution of retrograde perfusion within 3 minutes of the time air is recognized
4. The resident will complete the air embolism protocol through to re-institution of normal CPB

The four session Air Embolism training program will consist of one approximately one half-day per session for each resident. The schedule:

Session 1: Development of team protocol/timeline for dealing with massive air embolism during cardiac surgery

The team, composed of CT surgery, anesthesia, nursing, and perfusion will derive a time sensitive protocol for handling massive air embolism. It is anticipated that the resident will lead the team in the development of the MAE Emergency Action Plan (MAE-EAP).

Session 2: Walk through of protocol for air embolism on static Ramphall Cardiac Surgery Simulator emphasizing retrograde perfusion and de-airing

The team will conduct walk-throughs of the protocols derived in Session 1 at the Ramphal Cardiac Surgery Simulator for various scenarios and conduct deliberate practice in the technique of retrograde perfusion.

Sessions 3, 4: Massive Air Embolism Emergency Action Plan MAE-EAP) Protocol on Ramphal Simulator - CABG and/or AVR

Use of air embolism protocol developed in MAE: Session 1 during single vessels CABG and/or Aortic valve Replacement.

Residents should have ample opportunity to practice between weekly sessions with "dry" run-throughs and the static pig heart.

Each weekly session will begin with an evaluation of the component tasks covered in previous week.

Feedback and Debriefing

The resident will receive guidance and formative feedback from the faculty during the exercises and guidance for practice. Likewise, the resident is encouraged to provide feedback regarding the perceived relevance of the assignments and the validity of the tasks. For instance, feedback may include perceived value of the tasks, difficulty of the tasks, perceived improvement and progress, and the level of comfort performing the procedures. (Fanning R and Gaba D. *The role of debriefing in simulation-based learning.* Sim Healthcare 2007; 2:115-125.)

NOTE: The Ramphal Simulator must be modified to allow for retrograde cerebral perfusion and the selective introduction of air. See Retrograde Perfusion Ramphal Modifications, APPENDIX B

MAE Session 1: Massive Air Embolism Protocol Development

Overview

Session 1 of the MAE module consists of a work session with anesthesia, perfusion, and nursing to derive a comprehensive emergency action plan (EAP) for handling all aspects of intra-operative air embolism.

Prerequisites

Read Chapter 12, Extracorporeal Circulation, by Drs. Hammon and Hines, in Cohn's *Cardiac Surgery in the Adult*.

Able to write the 7 steps from memory of CPB (from Week 1 of CPB)

Recruitment of a team member representing anesthesia, perfusion, and nursing

Goals

To understand the sources of air within the CPB circuit and the heart and to know the sequence of steps to de-air the heart. To use a team approach to derive an agreed upon protocol for response to "We have air on the arterial side in the _____ line"

Objectives

1. The resident will lead a team approach composed of CT surgery, anesthesia, perfusion, and nursing to derive an agreed upon protocol for handling air embolism during CPB
2. Prior to developing the protocol, the team should discuss sources of air during CPB and methods for deairing the heart prior to releasing the cross clamp during a standard case.
3. The protocol will clearly define the roles and actions of each member of the team at each time point during the procedure
4. The protocol will have defined communication and a defined timeline

Teaching Plan

Equipment Required

Conference area

Conduct of the Simulation Session

Briefly discuss the circumstance in which air can inadvertently enter the cardiopulmonary bypass circuit on the arterial side.

Complete the Massive Air Embolism Emergency Action Plan (MAE-EAP for each of the air entry mechanisms.

Assessment Tool

In Appendix A:

MAE-EAP Massive Air Embolism Emergency Action Plan

MAE Session 2: Air Embolism Protocol Walk-Through Practice, Institution of Retrograde Perfusion and Aortic Root De-Airing

Overview

Session 2 of the Massive Air Embolism module consists of becoming familiar with the protocols developed in the AE Module – Session 1 and engaging in dry runs of these protocols. The session will involve repeated walk-throughs of the various protocols with the resident and other members of the team saying what he or she would do.

The Ramphal Heart will be used in conjunction with the Massive Air Embolism Emergency Action Plan (MAE-AEP) created in Session 1 of the MAE Module. Principles of deliberate practice will be used to train the resident in the conversion to retrograde SVC perfusion and aortic root de-airing.

Prerequisites

The instructor must certify as correct the Massive Air Embolism Protocol-Emergency Action Plan (MAE-EAP) derived in Session 1.

Goals

To commit the procedures outlined in the Massive Air Embolism-Emergency Action Plan (MAE-AEP) to memory for the various circumstances so that they are performed in a timely, efficient, and reliable manner.

Objectives

1. Be able to initiate and carry out the standardized Massive Air Embolism – Emergency Action Plan (MAE-AEP) developed in Session 1 and communicate the situation to the team effectively.
2. Recognize variations in the appropriate actions depending on circumstances in which air is introduced.
3. Be able to go through the surgical steps of the MAE-EAP from memory

4. Achieve a score of 4 or better on the Protocol Performance Assessment Tool (PPAT).
5. Be able to convert the bypass circuit to effective retrograde perfusion of the superior vena cava within 3 minutes after recognition of air.
6. Follow the steps of the MAE-EAP through institution of retrograde perfusion up to reinstitution of normal cardiopulmonary bypass.
7. Be able to re-institute normal cardiopulmonary bypass within 2 minutes of de-airing of aortic root.

Teaching Plan

Equipment/Personnel

All usual instruments, supplies and equipment for CPB from CPB sessions (not including cardioplegia and sump sutures).

Ideally, team members from Perfusion, Nursing, and Anesthesia.

Sutures and equipment for at least 4 cannulations of the SVC
Rummel tourniquet
SVC cannula of choice for retrograde perfusion
Umbilical tape

Simulation Set-Up

Ramphal CSS modified for retrograde cerebral perfusion (Appendix B)

Resident will recite from memory all steps of the MAE-EAP from the point of recognition of air during CPB until reinstitution of air-free CPB.

Ramphal CSS modified for retrograde cerebral perfusion and set up with heart in place and cannulated will be used to train the resident to convert from standard CPB to retrograde cerebral perfusion with aortic root de-airing and back to CPB after de-airing complete

Initial cannulation can be done by the resident or prior to the exercise.

The steps of the plan will be repeated a minimum of 4 times.

Conduct of Simulation

1. It is anticipated that the CPB-EAP for Massive Air Embolism (MAE-EAP) will involve several different scenarios depending on the site of air introduction and the stage of the operation at which the air embolism occurs. These should include air prior to CPB institution, air on CPB prior to or after x-clamping, and air during x-clamping
2. The resident and team should walk through the action plan for each of the scenarios identified until the actions become automatic while standing at the table with the cannulated Ramphal
3. Appropriate responses from each member of the team should be elicited for each resident action when appropriate.
4. Partial examples of the MAE-EAP can be found in APPENDIX B – MAE-EAP Protocol Examples
5. Resident will initiate the MAE-EAP, place the SVC pursestring, cannulate the SVC and institute retrograde cerebral perfusion, open and de-air the aorta, re-institute CPB, and deccannulate the SVC. This should be repeated a minimum of 4 times. Point 3-5 of the MAE-EAPAT should be used
6. The full protocol should be repeated at least 4 times to include every major scenario i.e. air in through the arterial line, air in through the cardioplegia line, air in through a retrograde sump.
7. A full debriefing should be done at the conclusion of the simulation.

Assessment Tools

In Appendix A:

PPAT	Protocol Performance Assessment Tool
DAT	Debriefing Assessement Tool
MAE-EAPAT (#3-5)	Massive Air Embolism Emergency Action Plan Assessment Tool

MAE Sessions 3, 4: Emergency Action Plan-Air Embolism Protocol-Full

Overview

Sessions 3 and 4 of the Massive Air Embolism Module will consist of full execution of the Massive Air Embolism Emergency Action derived in MAE Session 1 during various stages of a coronary bypass procedure.

AVR can be substituted for CABG if desired.

Prerequisites

Successful completion of Weeks 1-2 of the Air Embolism Module

Objectives

The resident will execute all phases of the Massive Air Embolism Emergency Action Plan (MAE-EAP) protocol with a score of 4 or greater on all grading points of the Emergency Action Plan -Air Embolism Assessment Tool (MAE-EAPAT).

Teaching Plan

Equipment and Personnel

Ramphal Simulator modified for retrograde SVC perfusion
Extra purse- string sutures and cannulas or tourniquets as per your EAP
All usual and customary instruments, supplies, and equipment for cardiopulmonary bypass specific to your institution
5-0 and 6-0 polypropylene sutures
Castroviejo needle driver
Gerald forceps
Metzenbaum scissors
Hemostats
Beaver or #15 blades
Arteriotomy scissors
Suture scissors
4 mm aortic punch
CryoVein

Video camera and storage media
Anesthesia, Perfusion, and Nursing team members if possible

Simulator and Set-up

Ramphal Simulator will be set up using the modification for the MAE Module. This will allow the simulation technologist to insert air into the arterial line, the cardioplegia line, and the LV sump when needed.

Conduct of the simulation

1. The simulation will proceed as for a coronary artery bypass graft operation to the LAD.

2. During the course of the procedure, air will be introduced into the system by the simulation technologist at the following points:

    a. Into the cardioplegia line during the insertion of the antegrade cardioplegia catheter

    b. Into the arterial line during performance of the distal anastomosis

3. **The resident will have to execute the MAE-EAP formulated in MAE Session 1 and continue on to completion of the operation. Therefore, for a given run of the CABG simulation, the resident will have to execute the MAE-EAP when air goes into the root via the antegrade cardioplegia catheter prior to X–clamping, returning the patient to CPB when the protocol is completed. The resident at this point will proceed with CABG as though the air had not occurred. Sometime during the course of the LAD distal anastomosis, air will be introduced into the aortic cannula by the technician. The resident will have to again execute the MAE-EAP and then complete the operation after the patient is returned to normal CPB.**

4. Depending on time, the CABG (or AVR) with air embolism will be repeated as many times as possible but a least one full procedure.

5. The resident will conduct a debriefing with the team after each procedure.

Assessment Tools

In Appendix A:

MAE-EAPAT Massive Air Embolism Emergency Action Plan Assessment Tool

DAT Debriefing Assessment Tool

5. Acute Intraoperative Aortic Dissection (AIAD) Module

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Harold M. Burkhart, M.D.
Robert Shen, M.D.
George L. Hicks, Jr., M.D.
James I. Fann, MD
Jonathan C. Nesbitt, M.D.
Nahush A. Mokadam, M.D.
Paul S. Ramphal, M.D.
Daniel N. Coore, Ph.D.

Overview – AIAD Module

The Acute Intraoperative Aortic Dissection (AIAD) Module is a 5-session program to focus on the prevention, recognition, and management of accidental acute dissection of the ascending aorta occurring during cardiopulmonary bypass with the heart arrested. It will deal with a dissection localized to the ascending aorta with no tear distal to the innominate artery.

AIAD is an infrequent complication but carries with it a significant risk of morbidity and mortality for the patent.

Since it is quite possible that a resident may never see AIAD in the clinical situation during his or her training, it is essential that he or she has sufficient training in a simulated environment to be able to handle AIAD should it ever occur. This simulation-based training program prepares the resident to appropriately recognize and effectively manage acute intraoperative aortic dissection, including repair of the dissection, occurring during the course a standard cardiac operation learned during earlier modules. As with other potentially catastrophic events during cardiac surgery, the management of AIAD requires a closely coordinated team approach with the perfusionist, anesthesiologist, and nurses. All members of the team should be encouraged to participate in this module.

The learning objectives are:

1. The resident will lead a team to develop an emergency action plan for handling Acute Intraoperative Aortic Dissection (AIAD-EAP) utilizing a team approach.
2. The resident will be able to appropriately recognize Acute Intraoperative Aortic Dissection (AIAD) and direct the team in its management.
3. The resident will be able to manage institution of femoral arterial cannulation within 3 minutes of the time air is recognized.
4. The resident will be able to repair the acute ascending aortic dissection to allow antegrade flow within 20 min.

5. The resident will complete the Acute Intraoperative Aortic Dissection Emergency Action Plan (AIAD-EAP) through to completion of the operation.

The five-session Acute Intraoperative Aortic Dissection (AIAD) training program will consist of one half-day per week (approximately 4 hours) for each resident. The schedule is:

Session 1: Development and walk through of team protocol/timeline for dealing with acute intraoperative aortic dissection

The team, composed of CT surgery, anesthesia, nursing and perfusion will derive a time sensitive emergency action plan for handling Acute Intraoperative Aortic Dissection (AIAD-EAP).

Session 2: Femoral arterial cannulation

The team will conduct walk-throughs of the AIAD-EAP derived in Session 1 at the Ramphal Simulator .
Deliberate practice of technique of femoral arterial cannulation. using the femoral artery cannulation component task simulator.

Session 3: Repair of acute aortic dissection

Deliberate practice of repair of the aortic dissection by the methodology establish in AIAD Module: Session 1.

Sessions 4, 5: Acute Intraoperative Aortic Dissection Emergency Action Plan (AIAD-EAP) Protocol on Ramphal Simulator
Use of acute intraoperative aortic dissection emergency action plan developed in Acute Intraoperative Aortic Dissection (AIAD): Session 1 during cardiopulmonary bypass.

Residents should have ample opportunity to practice between weekly sessions with "dry" run-throughs and the static pig heart.

Each weekly session will begin with an evaluation of the component tasks covered in previous week.

Feedback and Debriefing

The resident will receive guidance and formative feedback from the faculty during the exercises and guidance for practice. Likewise, the

resident is encouraged to provide feedback regarding the perceived relevance of the assignments and the validity of the tasks. For instance, feedback may include perceived value of the tasks, difficulty of the tasks, perceived improvement and progress, and the level of comfort performing the procedures. (Fanning R and Gaba D. *The role of debriefing in simulation-based learning.* Sim Healthcare 2007;2:115-125.)

NOTE: The Ramphal Simulator must be modified to allow for femoral cannulation and arterial perfusion - Appendix B.

AIAD Session 1: Acute Intraoperative Aortic Dissection (AIAD): Emergency Action Plan Development

Overview

Session 1 of the AIAD module consists of a work session with anesthesia, perfusion, and nursing to derive a comprehensive protocol for handling all aspects of intra-operative aortic dissection occurring from a clamp injury when coming off bypass near the end of a case.

Prerequisites

Read Chapter 50, Aortic Dissection, by Drs. Mery, Reese and Kron, in Cohn's *Cardiac Surgery in the Adult*.

Able to write the 7 steps from memory of CPB (from Session 1 of CPB)

Recruitment of a team member representing anesthesia, perfusion, and nursing

Goals

To use a team approach to derive an agreed-upon protocol for response to acute intraoperative aortic dissection

Objectives

1. The resident will lead a team approach composed of CT surgery, anesthesia, perfusion, and nursing to derive an agreed upon emergency action plan (EAP) for acute intraoperative aortic dissection (AIAD-EAP)
2. The AIAD-EAP will clearly define the roles and actions of each member of the team at each time point during the procedure
3. The AIAD-EAP will have defined communication for team members and a defined timeline

4. The AIAD-EAP will include the emergency procedures to reestablish CPB in the face of acute ascending aortic dissection occurring during CPB and the technique of repair of a tear just distal to the aortic cannulation site.

Teaching Plan

Equipment Required

Conference area.

Conduct of Session

Briefly discuss the circumstance in which the ascending aorta can dissect during CPB and ways to prevent it.

The resident will lead a discussion of the steps necessary to deal with an unexpected acute intraoperative aortic dissection and derive the emergency action plan for such an occurrence. (AIAD-EAP)

Assessment Tools

None.

NOTE: Sessions 2 and 3 can be done in any order. To make best use of time and equipment the institution may want to have one resident do one session and the other resident do the other session at the same time for each of the 2 sessions.

AIAD Session 2: Femoral Cannulation

Overview

The model used in the CPB module for aortic cannulation (APPENDIX B) will be used in this week to learn and practice femoral cannulation as practiced at the residents' institution. The technique taught will be that preferred by the individual institution.

Prerequisites

Resident scores of 4 or better on all aspects of the Protocol Performance Assessment Tool (PPAT) for the acute intraoperative aortic dissection emergency action plan. If the resident was unable to achieve these scores additional training should occur prior to this week's simulation exercise

Objectives

The objectives for this session are:

1. The resident will be able to successfully "walk-through" acute Intraoperative aortic dissection protocol (AIADP) developed in Week 1 from memory at least 4 times achieving a score of 4 or better on the **Protocol Performance Assessment Tool (PPAT) for the AIADP**
2. Will be able to convert the bypass circuit to effective retrograde perfusion of the arterial side via the femoral artery
3. Will be able to dissect out, control, cannulate, and de-air the femoral artery and test the line with a score of 4 or better on the Femoral Artery Cannulation Assessment Tool (FACAT)

Teaching Plan

Equipment Required

For each resident:

Arterial Cannulation model (APPENDIX B)
Segment of pig aorta

Aortic cannula connected to perfusion
Femoral cannula and appropriate connectors
Umbilical tape
Rumel tourniquet
Vascular clamps (2)
Metzenbaum scissors
DeBakey pick-ups (2)
#11 blade
Umbilical tape
Simulated blood
5-0 arteriotomy closure suture
Needle driver
Percutaneous femoral artery cannulation kit

Conduct of Simulation Session

Resident goes through the Emergency Action Plan for Acute Intraoperative Aortic Dissection (AIAD-EAP).

Resident states the parts of the protocol leading up to femoral cannulation and then dissects out and cannulates the femoral artery (min 4 repetitions).

Resident de-cannulates femoral artery and repairs it (min 4 repetitions).

Resident performs a debriefing of the femoral cannulation procedure.

Assessment Tools

In Appendix A:

PPAT Protocol Performance Assessment Tool

FCAT Femoral Cannulation

DAT Debriefing Assessment Tool

AIAD Session 3: Repair of Dissected Aorta

Overview

In this session, the resident will repair and close the dissected aorta multiple times using a specially prepared pig aorta.

Prerequisites

Successful completion of Sessions 1 and 2 of the AIAD Module.

Objectives

1. The resident will be able to demonstrate the ability to identify and resect the primary tear of the aorta.

2. The resident will be able to demonstrate the ability to prepare the proximal and distal aorta for grafting.

3. The resident will interpose a tube graft in the ascending aorta.

4. The resident will achieve a score of 4 or greater on the Aortic Repair Assessment Tool (ARAT).

Teaching Plan

Equipment and Personnel

Aortic cannulation/closure model (APPENDIX B)
3-0 and 4-0 polypropylene sutures
Castroviejo or Ryder needle driver
Gerald or DeBakey forceps (2)
Metzenbaum scissors
Hemostats
Arteriotomy scissors
Suture scissors
Aortic x-clamp
Teflon Felt strips

Dacron tube graft 26-30 mm size
Video camera
Glue (optional)

Simulator and Set-up

The specially prepared dissected pig aorta (Aortic Dissection Model - APPENDIX B) is suspended in the aortic cannulation/closure model
Perfusion is not required until testing after repair

It is best to start by transecting the aorta in the middle and then pulling each end out to allow for a short piece of graft to be placed. This allows for multiple proximal and distal anastomosis.

Conduct of the simulation

1. The artery is cross clamped, opened, and the dissection identified. (cross clamp not required if being done under circulatory arrest). A short interposition graft is sutured in place after proper preparation of the aortic ends.

2. The closure is tested by perfusing the model with simulated blood solution.

3. The resident will conduct a debriefing with the team after each closure.

4. The procedure should be repeated a minimum of 4 times.

Assessment Tools

In Appendix A:

ARAT Aortic Repair Assessment Tool

AIAD Sessions 4, 5: Emergency Action Plan – Acute Intra-operative Aortic Dissection-Full

Overview

Sessions 4 and 5 of the Acute Intra-operative Aortic Dissection Module will consist of full execution of the – Acute Intra-operative Aortic Dissection Emergency Action Plan (AIAD-EAP) derived in AIAD Session 1 occurring during various stages of a coronary bypass procedure or aortic valve replacement with the heart arrested. The dissection repair will be confined to the ascending aorta

Prerequisites

Successful completion of Sessions 1-3 of the Acute Intra-operative Aortic Dissection Module.

Objective

The resident will execute all phases of the Acute Intraoperative Aortic Dissection Emergency Action Plan (AIAD-EAP) with a score of **4 or greater** on all grading points of the Acute Intra-operative Aortic Dissection Tool Emergency Action Plan Assessment Tool (AIAD-EAPAT - APPENDIX A).

Teaching Plan

Equipment and Personnel

Ramphal Cardiac Surgery Simulator modified for femoral artery cannulation (APPENDIX B)

Extra purse-string sutures and cannulas or tourniquets for femoral cannulation as per your AIAD-EAP

All usual and customary instruments, supplies, and equipment for coronary bypass grafting or aortic valve replacement specific to your institution

3-0 and 4-0 polypropylene sutures
Castroviejo or Ryder needle driver
Gerald or DeBakey forceps (2)
Metzenbaum scissors
Hemostats
Arteriotomy scissors
Suture scissors
Aortic x-clamp
Teflon Felt strips
Dacron tube graft 26-30 mm size
Video camera
Glue (optional)

Video camera and storage media

Anesthesia, Perfusion and Nursing team members if possible

Simulator and Set-up

Ramphal Simulator will be set up using the modification for cannulation of the femoral artery (APPENDIX B).

Conduct of the Simulation

1. The simulation will proceed as for a coronary artery bypass graft operation to the LAD.

2. During the course of the procedure, after the distal and proximal anastomoses have been made and the cross clamp is released a dissection will occur.

3. The resident will have to execute the EAP-AIAD formulated in AE Week 1 and continue on to completion of the operation. Therefore, for a given run of a simulated cardiac procedure (CABG or AVR), the resident will have to recognize the occurrence of acute intraoperative aortic dissection, direct the team in the Acute

Intraoperative Aortic Dissection Emergency Action Protocol derived in Session 1 by transferring the arterial cannula to the femoral artery and reinstituting CPB.

4. The resident will then repair the aortic dissection using the institutional methodology, complete the procedure, repair the proximal anastomosis and come off of CPB.

5. The AIAD-EAP will be repeated a minimum of 2 times during each procedure by starting with a very proximal cannulation site and working distally for subsequent repetitions.

6. The resident will conduct a debriefing with the team after each procedure.

Assessment Tools

In Appendix A:

AIAD-EAPAT	Acute Intraoperative Aortic Dissection Emergency Action Plan Assessment Tool
DAT	Debriefing Assessment Tool

6. Sudden Deterioration in Cardiac Function (SDCF) and Final Exam

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Jennifer Dale Walker, MD
Harold M. Burkhart, M.D.
Robert Shen, M.D.
George L. Hicks, Jr., M.D.
James I. Fann, MD
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Daniel N. Coore, Ph.D.

Overview - SDCF Module

The Sudden Deterioration in Cardiac Function (SDCF) is a 6 session program to focus on the prevention, recognition, and management of unexpected events following cardiopulmonary bypass. The Emergency Action Plans (EAPs) used to deal with the adverse events presented will be derived from the practices at the individual institution. The module also serves as a final exam and review of the Cardiac Surgery Simulation Curriculum.

The causes of SDCF are multiple, and one of the main points of this exercise is to systematically evaluate and manage the gamut of etiologies. This module and associated simulation based training program prepare the resident to appropriately diagnose and manage the common causes of SDCF. As with other potentially catastrophic events during cardiac surgery, the management of SDCF requires a closely coordinated team approach with the perfusionist, anesthesiologist, and operating room nurses. All members of the team should be encouraged to participate in this module. The learning objectives are:

1. The resident will be able to emergently re-establish cardiopulmonary bypass.
2. The resident will lead a team to develop protocols for handling SDCF in the most common circumstances utilizing a team approach
3. The resident will be able to appropriately recognize and handle the causes of SDCF and direct the intraoperative team in their management
4. The resident will be able to manage institution of appropriately directed resuscitative measures to restoration of cardiac function
5. The resident will demonstrate flexibility in approaching complex problems during routine cardiac operations

The six-session SDCF training program will consist of one half-day per session (approximately 4 hours) for each resident. The component task schedule is:

Session 1: Emergency Re-institution of Cardiopulmonary Bypass
The resident will establish cardiopulmonary bypass on a failing heart within 4 minutes by deliberate practice.

Protocols to address:
Intracoronary air
Unstable atrial fibrillation
Ventricular tachycardia/ fibrillation

Session 2: Problems with Cardiopulmonary Bypass – Failure to Wean

Protocols to address:
Protamine reaction
Right ventricular failure
Left ventricular failure
Hypoxia/ lung injury
Unable to defibrillate

Session 3: Issues with CABG

Protocols to Address:
CABG graft too long (kinked)
CABG graft too short (stretched)
Twisted graft
RCA occluded by AVR
Kinked button
Circumflex injury following MVR
Distal coronary anastomotic bleeding

Homework: heart case model

Session 4: Issues with Prosthetic Valves

Protocols to Address:
Stuck mechanical leaflet
Looped strut causing central regurg
Paraprosthetic Leak (moderate +) after AVR
Broken pledgeted stitch
Air-knot in mechanical valve

Sessions 5-6: Final Exams - Conduct of routine cardiac operations interrupted by one of several scenarios

Each resident will perform either AVR or CABG during which time they will need to appropriately manage one disaster scenario (one operation per resident per day)

Residents should have ample opportunity to practice between weekly sessions with "dry" run-throughs.

Each session will begin with an evaluation of the component tasks covered in previous week.

Feedback and Debriefing

The resident will receive guidance and formative feedback from the faculty during the exercises and guidance for practice. Likewise, the resident is encouraged to provide feedback regarding the perceived relevance of the assignments and the validity of the tasks. For instance, feedback may include perceived value of the tasks, difficulty of the tasks, perceived improvement and progress, and the level of comfort performing the procedures. (Fanning R and Gaba D. *The role of debriefing in simulation-based learning.* Sim Healthcare 2007; 2: 115-125.

SDCF - Session 1: Emergency Reinstitution of Cardiopulmonary Bypass

Overview

Session 1 of the SDCF module consists of a simulation of steps necessary to emergently re-establish cardiopulmonary bypass after the chest has been closed.

Prerequisites

Successful completion of Modules 1 through 5.

Goals

The main purpose of this exercise is for the resident to rapidly re-establish cardiopulmonary bypass after the chest has been closed on a simulated model.

Objectives

1. The resident will be able to recite the appropriate steps to re-establish cardiopulmonary bypass
2. The resident will be able to establish cardiopulmonary bypass within 4 minutes

Teaching Plan

Equipment Required

For each resident:

Modified Ramphal Simulator

All usual instruments, supplies and equipment for CPB from CPB session.

Chest wall simulator complete with sternal wires, subcutaneous tissue and dressing. Will also need coagulated blood in the field to obscure the view.

Conduct of Simulation Session

Establish steps needed for emergency reinstitution of cardiopulmonary bypass after chest closure, along with timeline to completion (Sudden Deterioration Of Cardiac Function Emergency Action Plan – SDCF-EAP).

Ramphal Cardiac Surgery SimulatorSimulator set up with chest wall simulator with chest closed and dressing in place. Monitor should reveal normal hemodynamics and conduct of post-operative "time out" per institution protocol. During this time, the resident will encounter a malignant rhythm and/or ST changes associated with acute cardiopulmonary collapse. (Rapid atrial fibrillation, ventricular fibrillation, bradycardia/ST changes, asystole)

Resident will carry out all parts of the SDCF-EAP plan for SDCF from the point of recognition of SDCF until reinstitution of full CPB.

This exercise should be repeated at least 3 times per resident.

Example:

"The patient is in ventricular fibrillation!"

Attempt external defibrillation at 360J 1 time while moving patient back to OR table, prepping, and draping. (unsuccessful defibrillation)

Rapidly open sternotomy sharply (if stapled, off to side of previous incision, if sutured, through previous incision), cut and remove sternal wires, place retratactor.

Perform open cardiac massage to decompress ventricle and defibrillate using internal paddles at 10J. (unsuccessful defibrillation)

"We are going to go back on bypass"

"Give heparin!"

Cannulate ascending aorta with a single purse-string suture and connect to circuit.

Incise and cannulate right atrium without purse string and establish CPB, then place purse string.

Troubleshoot etiology.

End of simulation.

Assessment Tools

In Appendix A:

SDCF-EAPAT Sudden Deterioration of Cardiac Function Emergency Action Plan Assessment Tool

SDCF Session 2: Problems with Cardiopulmonary Bypass – Failure to Wean

Overview

Session 2 of the SDCF module consists of common scenarios encountered during an unsuccessful wean from cardiopulmonary bypass. The session will involve repeated walk-throughs of the various protocols with the resident in a strictly cognitive setting.

Prerequisites

Completion of Session 1 of SDCF Module.

Goals

To understand the etiology and management strategies for common causes of sudden deterioration in cardiac function, and to systematically support the patient while addressing most frequent etiologies. Protocols developed will be recapitulated in weeks 3-8 of the SDCF module.

Objectives

1. The resident will be able to initiate and carry out emergency reinstitution of cardiopulmonary bypass in Session 1 and communicate the situation to the team effectively (cognitive only).

2. The resident will recognize variations in the causes of SDCF appropriate actions depending on circumstances in which SDCF has occurred.

3. The resident will be able to develop new protocols for common adverse intraoperative events.

Teaching Plan

Equipment/Personnel

Representatives from Anesthesia, Perfusion, and Nursing or a substitute familiar with common scenarios are invited to discuss and develop strategies to be used in this and future simulation sessions. Carefully elucidate and rehearse clinical diagnostic criteria followed by comprehensive checklists and action plans for each scenario.

Mock cardiopulmonary by-pass circuit is not necessary for this week. Rather, conference room setting dry runs and refinement of previously established and newly developed protocols should predominate the session with multidisciplinary participation and input with resident leadership.

Conduct of the Training

The resident and team should walk through the action plan for each of the scenarios identified until the actions become automatic.

Appropriate responses from each member of the team should be elicited for each resident action when appropriate.

As examples:

Protamine Reaction
Diagnosis: Very high PAP, very low SBP, RV failure during protamine administration.

Checklist	**Action Plan**
Ventilating?	Start Ventilator
Rate of administration	Stop infusion
Primary RV problem?	Use RV failure protocol below
Reestablish CPB?	Give heparin/cannulate
Etc.	

Right Ventricular Failure
Diagnosis: Low PAP, high CVP, low SBP, RV distention.

Checklist	**Action Plan**
Ventilating?	Start Ventilator
RV volume overloaded?	Decrease transfusion/rev T'berg
Baseline RCA anatomy	Left or Right dominant?
RCA occlusion by AVR	RCA graft (Or OM for L dominant)
Cx injury during MVR	OM/RCA graft
Myocardial protection?	Time/graft/IABP/RVAD
RCA graft too long?	Shorten Graft
RCA graft too short?	Lengthen graft
RCA graft twisted?	Untwist graft
TEE Appearance	
New TR?	Consider TV repair
Dissection?	Dissection repair
LV appearance?	Treat LV failure
RV unloading	Milrinone or dobutamine
	Nitric Oxide or epoprostenol
Reestablish CPB?	Give heparin/cannulate
Etc.	

Left Ventricular Failure
Diagnosis: Low BP, High PAP, new MR, LV distention, regional WMA

Checklist	**Action Plan**
Myocardial protection?	Time/IABP/LVAD
TEE Appearance	
New WMA	Grafts long/short twisted
	Graft flows
Paravalvular AI 2+	Rearrest and redo AVR
Central AI 2+	Rearrest and redo AVR
AI after MVR	Rearrest and perform AVR
SAM	Volume/beta block/redo MV rep

MR	Unload LV/possible MV repair
Reestablish CPB?	Give heparin/cannulate
Etc.	

Hypoxia/ Lung Injury

Diagnosis: Normal BP, normal to high PAP, Unable to maintain oxygen saturation, pulmonary edema from ETT, subsequent RV and LV failure.

Checklist	**Action Plan**
Ventilating?	Start Ventilator
PEEP?	Add PEEP
New MR?	Unload LV/Poss MV repair
New R>L Shunt?	TEE for PFO or VSD, repair
Pulmonary edema?	Consider bronchoscopy
Unable to wean due to sats?	Reestablish CPB.
Unable to wean due to sats?	Consider ECMO
Etc.	

Unable to Defibrillate (note many of the same concepts exist in RV and LV failure, and should be recapitulated for this scenario)

Checklist	**Action Plan**
VF?	Reestablish CPB, rest, retry wean
Ventilating?	Start ventilator
RV volume overloaded?	Decrease transfusion/rev T'berg
Baseline RCA anatomy	Left or right dominant?
RCA occlusion by AVR	RCA graft (Or OM for L dominant)
Cx injury during MVR	OM/RCA graft
Myocardial protection?	Time/graft/IABP/RVAD
CABG graft too long?	Shorten graft
CABG graft too short?	Lengthen graft
CABG graft twisted?	Untwist graft
TEE Appearance	
New TR?	Consider TV repair

Dissection?	Dissection repair
LV appearance?	Treat LV failure
RV unloading	milrinone or dobutamine Nitric Oxide or epoprostenol
Myocardial protection?	Time/IABP/LVAD
TEE Appearance	
New WMA	Grafts long/short twisted Graft flows
Paravalvular AI 2+	Rearrest and redo AVR
Central AI 2+	Rearrest and redo AVR
AI after MVR	Rearrest and perform AVR
SAM	Volume/beta block/ redo MV rep
MR	Unload LV/possible MV repair
Air?	High perfusion pressure on CPB
Coronary sinus cath balloon?	Deflate
Distended ventricle?	Massage
AI?	May need to repair
Still VF?	Rearrest heart
Etc.	

Other scenarios should be developed at the discretion of the center.

Assessment Tools

No assessments for Week 2.

SDCF Session 3: Issues with CABG

Overview

Common scenarios following completion of CABG will be reviewed, and simulated in a high fidelity setting. The resident will have an opportunity to perform corrective measures on grafts related to graft length and orientation, as well as discuss strategies to address other common problems with coronary circulation in the operating room.

Prerequisites

Successful completion of Sessions 1 and 2 of SDCF curriculum.

Objectives

The objectives for this week are:

1. Will be able to recognize issues with graft length and orientation on a static model.
2. Will be able to successfully plan and correct grafts with these issues.
3. Will perform deliberate practice in these techniques.
4. Will discuss strategies to address other myocardial perfusion problems.

Teaching Plan

Equipment Required

For each resident:

CryoVein (CryoLife, Inc)
All usual and customary instruments, supplies, and equipment for cardiopulmonary bypass specific to your institution
Ramphal Cardiac Surgery Simulator
6-0 and 7-0 or smaller polypropylene sutures
Castroviejo needle driver
Gerald forceps

Metzenbaum scissors
Hemostats
Beaver or #15 blades
Arteriotomy scissors
Suture scissors
Graft = CryoVein
Video camera and storage media
Resident loops
Infusion needle and syringe with saline

Simulators and Set-up

The Ramphal Cardiac Surgery Simulator is preferably used for this session. Alternatively, a porcine static perfused heart may be used. The heart is situated for CABG. The procedure should mimic as closely as possible a Coronary Bypass operation at your institution except that conduit will be supplied rather than harvested. The instructor sets up 3 anastomoses per resident (twisted, too long, too short) for correction. This process is repeated at least 3 times, and preferably 5, for each resident. Evaluation is completed on the first and last repetition.

Conduct of Simulation Session

Perform 3 distal anastomoses on porcine heart using CryoVein. The first distal anastomosis should be evaluated using the Vessel Anastomosis Assessment Tool (VAAT, APPENDIX A)

The instructor will set up 3 perfused CryoVeins with one twisted, one too long, and one too short. The resident will then perform 3 proximal anastomoses using these grafts. The first anastomosis should be scored using the Vessel Anastomosis Assessment Tool (VAAT, APPENDIX A). If routine at your institution, CryoVeins may be marked with a "racing stripe" to aid in orientation.

The residents will correct the 3 lesions found on each CryoVein. The first set of corrections will be evaluated using the Conduit Revision Assessment Tool (CRAT) and videotaped.

Strategies to address common perfusion scenarios should be discussed in detail similar to the process used in Session 1 of SDCF. Suggested scenarios include:

RCA occluded by AVR
Kinked Button
Circumflex injury following MVR
Distal coronary anastomotic bleeding

Assessment Tools

In Appendix A:

CRAT Conduit Revision Assessment Tool

SDCF Session 4: Issues with AVR

Overview

Session 4 of SDCF module will cover common issues encountered during aortic valve replacement. Cognitive tasks will include review of abnormal physiology correlated with intra-operative echocardiograms. On a perfused porcine heart, the resident will perform a routine aortic valve replacement with both a mechanical and bioprosthetic valve, then be presented with various scenarios and correct them.

Prerequisites

Successful completion of Sessions 1-3 of SDCF Curriculum

Objectives

1. The resident will review physiology and echocardiographic clips for the following scenarios:

   Stuck mechanical leaflet
   Looped strut causing central regurg
   Paraprosthetic leak (moderate +) after AVR

   Broke a pledgeted stitch
   Air-knot in mechanical valve
   Management of paravalvular leak

2. The resident will perform a mechanical and bioprosthetic AVR, and simulate recovery from the suture related scenarios.

Teaching Plan

Equipment Required

For each resident:
1 porcine hearts with wet lab container
Valve sizers for mechanical and pericardial valves
4 sets of valve sutures

Set of suture holders
Needle driver
Metzenbaum scissors
2 DeBakey forceps
1 mechanical aortic valve
1 tissue aortic valve
#15 blade
8 Hemostats
Suture scissors
Video camera and storage media

Simulator and Set-up

Pig heart set in pericardial well or in cardboard holder. Non-perfused.

Conduct of Simulation

1. Physiology and echocardiography for each scenario are reviewed
2. Resident performs a mechanical AVR
3. Prior to aortic closure, the instructor breaks a pledgeted stitch and the resident must retrieve the pledget.
4. Prior to aortic closure, the instructor deliberately makes an air knot, and the resident must successfully repair it, either by placing a suture or re-doing AVR.
5. After aortic closure, the instructor informs the resident of a paravalvular leak. The resident must successfully repair it, either by placing a suture on the noncoronary cusp (if applicable), or re-doing AVR. Advanced Aortic Valve Assessment tool (AAVRAT) is completed.
6. If time permits, Steps 2-4are repeated with a bioprosthetic AVR and AAVRAT completed.

Assessment Tools

In Appendix A:

AAVRAT Advanced Aortic Valve Replacement Assessment Tool

SDCF Sessions 5 and 6: "Final Exams"

Overview

Sessions 5 and 6 of SDCF module will constitute "Final Exams" for the residents. In each session, the resident will conduct either a CABG or AVR during which time there will be one or more intraoperative events consisting of SDCF, MAE or AIAD.

Prerequisites

Successful completion of Sessions 1-4 of the SDCF Module

Objectives

The resident will successfully establish CPB, perform the intended operation (CABG or AVR) and successfully navigate one of the EAP scenarios with a score of 4 or greater on EACH assessment tool.

Teaching Plan

Equipment and Personnel

Ramphal Simulator modified for possible retrograde SVC perfusion and femoral artery cannulation (APPENDIX B)
Extra purse string sutures and cannulas or tourniquets as per your EAP
All usual and customary instruments, supplies, and equipment for cardiopulmonary bypass specific to your institution
5-0 and 6-0 polypropylene sutures
Castroviejo needle driver
Gerald forceps
Metzenbaum scissors
Hemostats
Beaver or #15 blades
Arteriotomy scissors
Suture scissors

4 mm aortic punch
CryoVein
Prosthetic aortic valve
Video camera and storage media
Anesthesia, perfusion and nursing team members if possible

Simulator and Set-up

Ramphal Simulator will be set up using the modification for the AE and AIAD Modules. This will allow the simulation technologist to insert air into the arterial line and into the aortic root line to simulate air coming back from the head during retrograde perfusion should this scenario be chosen.

Conduct of the simulation

1. The simulation will proceed as for a coronary artery bypass graft operation to the LAD or an AVR
2. Over the course 2 sessions with 2 residents each, a total of 4 scenarios will be conducted from the following list. The second scenario performed should be (g), no emergency encountered.
    a. Massive Air Embolism while on CPB and heart arrested
    b. Acute Intraoperative Aortic Dissection
    c. CABG Graft Revision (Graft Too Short)
    d. Unable to Defibrillate
    e. RV Failure
    f. Sudden deterioration of cardiac function immediately post - op
    g. No emergency encountered
3. The resident will get a summative assessment for the performance on this "final exam."
4. The resident will conduct a debriefing with the team after each procedure.

Appendix A – Assessment Tools

AAVRAT - Advanced Aortic Valve Replacement Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____**DATE**_____
EVALUATOR_____**REPETITION MECH BIO**

	Poor			Excellent
1. **Root set-up**	1 Inadequate exposure of valve	2	3 Valve is exposed but not optimally Annulus not completely exposed	4	5 Valve and annulus completely exposed Exposure optimal for valve excision and replacement

Additional Comments:
_____
_____

2. **Valve excision**	1 Leaves leaflet tissue in place Excises too deep damaging annulus	2	3 Partially excises leaflets	4	5 Completely excises valve preserving annulus and deeper structure

Additional Comments:
_____
_____

3. **Valve sizing**	1 Incorrectly sizes valve	2	3 Picks valve size but is unsure about it	4	5 Correctly sizes valve

Additional Comments:
_____
_____

4. **Suture placement**	1 Unacceptably deep or shallow Hesitant, multiple tries Incorrect spacing	2	3 Mostly regular entry/exit Mostly single tries at correct placement	4	5 Correct placement No hesitation

Additional Comments:
_____
_____

5. **Suture management**	1 Sutures unorganized and mixed up	2	3 Less than half of sutures correctly organized and secured	4	5 All sutures organized, secured

Additional Comments:
_____
_____

6. **Valve suturing**	1 Sutures placed at wrong depth in annulus Sutures very unevenly placed around annulus Annulus suturing completely disorganized	2	3 More than 50% of sutures placed incorrectly	4	5 Sutures placed correctly into annulus Annulus suturing organized and flows without hesitation Valve correctly oriented

Additional Comments:
_____
_____

7. **Valve seating and tying**

1	2	3	4	5
Valve incorrectly oriented Valve will not slide down sutures Valve does not seat Sutures not pulled up/ Pledgets loose Sutures not tied efficiently Valve movement not checked		Valve seats but with difficulty 90% of sutures pulled up and tied correctly		Valve correctly oriented Valve slides down sutures, seats easily Valve movement correctly checked

_____
_____

8. **Lost pledget management**

1	2	3	4	5
Unable to find Pledget Injured Valve Did not recognize need to remove valve Annular disruption		Found with moderate difficulty Heavy valve manipulation		Found easily No injury or valve manipulation Removed valve without hesitation

9. **Air-knot management**

1	2	3	4	5
Injured Valve Did not recognize need to remove valve Annular disruption		Heavy valve manipulation		No injury or valve manipulation Removed valve without hesitation

10. Paravalvular leak management

1	2	3	4	5
Did not address leak Injured Valve Did not recognize need to remove valve Annular disruption		Found with moderate difficulty Heavy valve manipulation		Found easily No injury or valve manipulation Removed valve without hesitation

Additional Comments:

_____
_____
_____

General Definitions:

5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

ACAT - Aortic Cannulation Assessment Tool

RESIDENT NAME_____YR OF TRAINING_____ DATE_____
EVALUATOR_____Repetition Number_____

	Poor			Excellent
1. **Aortic site**	1	2	3 4	5
	Does not palpate aorta Interferes with graft or aortotomy BP not mentioned		Minimal aortic evaluation Close to grafts or aortotomy BP noted	Palpates and evaluates aorta Adequate spacing for grafts or aortotomy BP noted, appropriate

Additional Comments:
_____
_____

2. **Needle angles**	1	2	3	4	5
	Not aware of angles Does not consider subsequent angles		Understand angles, not consistent Partial consideration of subsequent angles		Consistent correct angles Consistent adjustment for subsequent angles

Additional Comments:
_____
_____

3. **Bite**	1	2	3	4	5
	Irregular entry/exit Hesitant, multiple punctures		Mostly regular entry/exit Mostly single puncture		Consistent regular entry/exit Consistent single puncture

Additional Comments:
_____
_____

4. **Spacing**	1	2	3	4	5
	Uneven/irregular spacing Irregular distance from previous bite		Mostly even spacing Mostly consistent distance from previous bite		Consistent even spacing Consistent distance from previous bite

Additional Comments:
_____
_____

5. **Needle holder use**	1	2	3	4	5
	Awkward finger placement Unable to rotate instrument Awkward and not facile Inconsistent needle placement		Functional finger placement Hesitant when rotating Moderate facility Generally good placement		Comfortable, smooth finger placement Smooth rotation High facility Consistent proper placement

Additional Comments:
_____
_____

6. **Use of forceps** 1 2 3 4 5

Awkward or no traction Unable to expose Not use to stabilize needle	Moderate proper traction Able to assist in exposure Able to stabilize but rough	Consistent proper traction Consistent proper exposure Knows when to stabilize, gentle

Additional Comments:

_____
_____

7**. Needle transfer** 1 2 3 4 5

Marked hesitation in mounting needle	Able to mount needle with hand and partial manipulation	Able to mount needle and manipulate needle easily

Additional Comments:

_____
_____

8. **Scalpel control** 1 2 3 4 5

Not perpendicular Too big or too small aortotomy Significant leakage	Somewhat perpendicular Close to appropriate aortotomy Some leakage	Perpendicular Appropriate size aortotomy No leakage

Additional Comments:

_____
_____

9. **Cannula placement** 1 2 3 4 5

Improper orientation Too deep or shallow	Somewhat improper Readjusted, good position	Proper orientation Perfect position

Additional Comments:

_____
_____

10. **Securing cannula** 1 2 3 4 5

Too loose, too tight Awkward finger/hand motion	Somewhat loose, tight Hesitant finger/hand motion	Appropriately snug Smooth, comfortable motion

Additional Comments:

_____
_____

11. **Connecting cannula** 1 2 3 4 5

Air in line No testing line	Some bubbles in line Sometimes tests line	No air in line Tests line, BP and flow

Additional Comments:

_____
_____

12. **Decannulation** 1 2 3 4 5

Conditions for decannulation not met Significant bleeding with loss of control	Conditons for decannulation partially met Bleeding requiring stitch(es)	All conditions for decannulation met No bleeding

AIAD-EAPAT - Acute Intraoperative Aortic Dissection Emergency Action Plan Assessment Tool

FIRST REPETITION ASSESSMENT

RESIDENT NAME_____YR OF TRAINING_____ DATE_____
EVALUATOR_____REPITITION # _____

	Poor				Excellent
1 **Recognition of dissection**	1	2	3	4	5
	Did not recognize dissection		Recognized dissection but does not immediately institute emergency action plan.		Recognized dissection and started AEP promptly

Additional Comments:
_____
_____

2. **Femoral cannulation**	1	2	3	4	5
	Unable to cannulate		Cannulates femoral artery but with hesitation		Efficiently and timely cannulates femoral and reinstitutes CPB

Additional Comments:
_____
_____

3. **Aortic Repair**	1	2	3	4	5
	Does not know how to repair aorta		Repairs aorta but repair leaks moderate amount requiring further repair stitches		Repairs aorta in a timely manner No leak

Additional Comments:
_____
_____

4. **Emergency Action Plan Compliance**	1	2	3	4	5
	Very little compliance		Complied with 50% of plan		Complete compliance perfectly

Additional Comments:
_____
_____

Overall: Pass Fail

ARAT - Aortic Repair Assessment Tool

FIRST REPETITION ASSESSMENT

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**REPITITION #** _____

	Poor				**Excellent**
1. **Repair plan**	1	2	3	4	5
	Does not have a plan for repair		Only has partial plan lacks completeness	Has a comprehensive plan for repair	

Additional Comments:

---

2. Distal aortic prep	1	2	3	4	5
	Unable to exclude the false lumen		Excludes false lumen but with hesitation and uncertainty of motion		Creates a stable sewing cuff efficiently and in a timely fashion

Additional Comments:
_____
_____

3. **Proximal aortic prep**	1	2	3	4	5
	Unable to exclude the false		Excludes false lumen but with hesitation and uncertainty of motion		Creates a stable sewing cuff efficiently and in a timely fashion

Additional Comments:
_____
_____

4 **Graft interposition**	1	2	3	4	5
	Does not use interposition graft		Places interposition graft hesitantly. Incorrect length		Efficiently places interposition graft

Additional Comments:
_____
_____

Overall: Pass Fail

ASAT - Aortotomy Suture Assessment Tool

FIRST TRANSVERSE AORTOTOMY AND CLOSURE ASSESSMENT

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**TIME TO COMPLETION**_____

	Poor				**Excellent**
1. Aortotomy	1	2	3	4	5
	Wrong site Wrong length		Too short but corrected		Perfectly correct site Perfectly correct length

Additional Comments:
_____
_____

2. **Bite**	1	2	3	4	5
	Irregular entry/exit Hesitant, multiple punctures Inconsistent distance from edge		Mostly regular entry/exit Mostly single puncture Mostly consistent from edge		Consistent regular entry/exit Consistent single puncture Consistent from edge

Additional Comments:
_____
_____

3. **Spacing**	1	2	3	4	5
	Uneven/irregular spacing Irregular distance from previous bite		Mostly even spacing Mostly consistent distance from previous bite		Consistent even spacing Consistent distance from previous bite

Additional Comments:
_____
_____

4. **Needle holder use**	1	2	3	4	5
	Awkward finger placement Unable to rotate instrument Awkward and not facile Inconsistent needle placement		Functional finger placement Hesitant when rotating Moderate facility Generally good placement		Comfortable, smooth finger placement Smooth rotation High facility Consistent proper placement

Additional Comments:
_____
_____

5. **Use of forceps**	1	2	3	4	5
	Awkward or no traction Unable to expose Not use to stabilize needle		Moderate proper traction Able to assist in exposure Able to stabilize but rough		Consistent proper traction Consistent proper exposure Knows when to stabilize, gentle

Additional Comments:
_____
_____

6. **Needle angles**	1	2	3	4	5
	Not aware of angles Not compensate for depth Does not consider subsequent angles		Understand angles, not consistent Partial compensation for depth Partial consideration of subsequent angles		Consistent correct angles Compensate for depth Consistent adjustment for subsequent angles

Additional Comments:
_____
_____

7. **Needle angles**	1	2	3	4	5
	Not aware of angles Not compensate for depth Does not consider subsequent angles		Understand angles, not consistent Partial compensation for depth Partial consideration of subsequent angles		Consistent correct angles Compensate for depth Consistent adjustment for subsequent angles

Additional Comments:
_____
_____

8. **Needle transfer**	1	2	3	4	5
	Marked hesitation in mounting needle		Able to mount needle with hand and partial manipulation		Able to mount needle and manipulate needle easily

Additional Comments:
_____
_____

9. **Suture management**	1	2	3	4	5
	Not use tension Suture entangled		Tension use inconsistent Sutures occasionally get in way		Proper use of tension Suture consistently not in way

Additional Comments:
_____
_____

10. **Knot tying**	1	2	3	4	5
	Marked hesitancy, slow speed No follow through Not able to tie, breakage Loose or "air" knot		Moderate facility, moderate speed intermittent follow through Able to tie and tension, intermittently loose		Consistent facility, no hesitancy Consistent follow through Consistent tension and tight

Additional Comments:
_____
_____

11 .**Hand Mechanics**	1	2	3	4	5
	No pronation or supination Awkward finger/hand motion No wrist motion		Incomplete pronation or supination Hesitant finger/hand motion Incomplete wrist motion		Able to modulate pronation, supination Smooth, comfortable motion Smooth, appropriate wrist motion

Additional Comments:
_____
_____

12. **Use of both hands**	1	2	3	4	5
	Awkward /not coordinated use Non-dominant hand neglect		Moderately coordinated use Moderate use of non-dominant hand to assist/expose		Smooth, seamless coordination Full use of non- dominant hand to assist/expose

Additional Comments:
_____
_____

13. **Economy of time and motion**	1	2	3	4	5
	Marked hesitation Not aware of goal Unable to do task		Some hesitation Some awareness of goal Able to do task but discontinuous		No hesitation Fully aware of goal Able to do task smoothly

Additional Comments:_____
_____

14. **Alignment of aortic closure**	1	2	3	4	5
	Uneven edges		Slight mismatch in alignment		Perfect alignment Aortic sides line up evenly

Additional Comments:_____
_____

Overall: **Pass** **Fail**

AVRAT - Aortic Valve Replacement Assessment Tool

FIRST VALVE REPLACEMENT ASSESSMENT

RESIDENT NAME_____YR OF TRAINING_____ DATE_____
EVALUATOR_____TIME TO COMPLETION_____

	Poor				Excellent
1. **Root set-up**	1	2	3	4	5
	Inadequate exposure of valve		Valve is exposed but not optimally. Annulus not completely exposed		Valve and annulus completely exposed Exposure optimal for valve excision and replacement

Additional Comments:
_____
_____

2. **Valve excision**	1	2	3	4	5
	Leaves leaflet tissue in place Excises too deep damaging annulus		Partially excises leaflets		Completely excises valve preserving annulus and deeper structure

Additional Comments:
_____
_____

3. **Valve sizing**	1	2	3	4	5
	Incorrectly sizes valve		Picks valve size but is unsure about it		Correctly sizes valve

Additional Comments:
_____
_____

4. **Suture placement**	1	2	3	4	5
	Unacceptably deep or shallow Hesitant, multiple tries Incorrect spacing		Mostly regular entry/exit Mostly single tries at correct placement		Correct placement No hesitation

Additional Comments:
_____
_____

5. **Suture management**	1	2	3	4	5
	Sutures unorganized and mixed up		Less than half of sutures correctly organized and secured		All sutures organized and secured

Additional Comments:
_____
_____

6. **Valve suturing**	1	2	3	4	5
	Sutures placed at wrong depth in annulus Sutures very unevenly placed around annulus Annulus suturing completely disorganized Valve incorrectly oriented		More than 50% of sutures placed incorrectly		Sutures placed correctly into annulus Annulus suturing organized and flows without hesitation Valve correctly oriented

Additional Comments:
_____
_____

7. **Valve seating and tying**	1	2	3	4	5
	Valve incorrectly oriented Valve will not slide down sutures Valve does not seat Sutures not pulled up/ Pledgets loose Sutures not tied efficiently Valve movement not checked		Valve seats but with difficulty 90% of sutures pulled up and tied correctly		Valve correctly oriented Valve slides down sutures, seats easily Valve movement correctly checked

_____

_____

Additional Comments:

_____

_____

Overall: **Pass** **Fail**

General Definitions:
5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

BAT - Briefing Assessment Tool

RESIDENT NAME_____ YR OF TRAINING_____ DATE_____
EVALUATOR_____

Y= Yes I = Intermittent N= No
Briefing

Y I N Diagnosis
Y I N Procedure
Y I N Incision
Y I N Significant surgical history (redo, patent grafts…)
Y I N Cannulation
Y I N Cardioplegia
Y I N Temperature
Y I N Questions

Additional Comments:
_____
_____

CCAT - Cardioplegia Cannulation Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**REPETITION #**_____

	Poor			Excellent
1. **Aortic site**	1	2	3	4 5
	Does not palpate aorta Interferes with graft or aortotomy BP not mentioned	Minimal aortic evaluation Close to grafts or aortotomy BP noted	Palpates and evaluates aorta Adequate spacing for grafts or aortotomy BP noted, appropriate	

Additional Comments:
_____
_____

2. **Needle angles**	1	2	3	4 5
	Not aware of angles Does not consider subsequent angles	Understand angles, not consistent Partial consideration of subsequent angles	Consistent correct angles Consistent adjustment for subsequent angles	

Additional Comments:
_____
_____

3. **Bite**	1	2	3	4 5
	Irregular entry/exit Hesitant, multiple punctures	Mostly regular entry/exit Mostly single puncture	Consistent regular entry/exit Consistent single puncture	

Additional Comments:
_____
_____

4. **Spacing**	1	2	3	4 5
	Uneven/irregular spacing Irregular distance from previous bite	Mostly even spacing Mostly consistent distance from previous bite	Consistent even spacing Consistent distance from previous bite	

Additional Comments:
_____
_____

5. **Needle holder use**	1	2	3	4 5
	Awkward finger placement Unable to rotate instrument Awkward and not facile Inconsistent needle placement	Functional finger placement Hesitant when rotating Moderate facility Generally good placement	Comfortable, smooth finger placement Smooth rotation High facility Consistent proper placement	

Additional Comments:
_____
_____

6. **Use of forceps**	1	2	3	4 5
	Awkward or no traction Unable to expose Not use to stabilize needle	Moderate proper traction Able to assist in exposure Able to stabilize but rough	Consistent proper traction Consistent proper exposure Knows when to stabilize, gentle	

Additional Comments:
_____
_____

7. **Cannula placement**	1	2	3	4	5
	Improper orientation Too deep or shallow No blood return		Somewhat improper Readjusted, good position Sluggish blood return	Proper orientation Perfect position Good blood return	

Additional Comments:

_____
_____

8. **Securing cannula**	1	2	3	4	5
	Too loose, too tight Awkward finger/hand motion		Somewhat loose, tight Hesitant finger/hand motion		Appropriately snug Smooth, comfortable motion

Additional Comments:

_____
_____

9. **Connecting CPG line**	1	2	3	4	5
	Air in line		Some bubbles in line		No air in line

Additional Comments:

_____
_____
_____

Overall: **Pass** **Fail**

General Definitions:
5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

CPBAT - Cardiopulmonary Bypass Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____

	Poor				Excellent
1. **Briefing**	1	2	3	4	5
	No briefing		Incomplete briefing		Complete briefing

Additional Comments:
_____
_____

2. **Communication**	1	2	3	4	5
	No communication Timid, quiet		Sometimes communicates Some communication, incomplete		Good communication throughout Confident, appropriately audible

Additional Comments:
_____
_____

3. **Aortic cannulation**	1	2	3	4	5
	Awkward Hematoma, bleeding Air in line No testing of line No heparin		Moderate facility Reasonable, some ooze Bubbles stuck to tubing Partial testing, BP or flow		High facility, smooth No hematoma or leakage Line de-aired Line tested for BP and flow Heparin given

Additional Comments:
_____
_____

4. **Venous cannulation**	1	2	3	4	5
	Awkward RCA injured Leaking		Moderate facility Too close to RCA Reasonable, some ooze		High facility, smooth Appropriate position No leakage

Additional Comments:
_____
_____

5. **Initiating CPB**	1	2	3	4	5
	No ACT checked No communication No confirmation of circuit function		ACT checked, unsure Partial communication Some acknowledgement of circuit function		ACT checked, appropriate for CBP Communicates “on bypass” Confirms circuit is functioning properly

Additional Comments:
_____
_____

6. **Cross clamp, CPG**	1	2	3	4	5
	Clamp placed, no communication No CPG given LV not assessed		Clamp placed, no flow down CPG given, no dose Questions LV distention		Clamp placed, flow down CPG given, dose appropriate Questions LV distention, palpates LV

Additional Comments:
_____
_____

7. **Terminating CPB**	1	2	3	4	5
	No ventilation No de-airing Bleeding, temperature, rhythm, contractility not noted		Incomplete de-airing		Ventilates Complete de-airing Bleeding, temperature, rhythm, contractility noted

Additional Comments:

_____

_____

8. **Decannulation**	1	2	3	4	5
	No protamine Hemodynamics ignored Cannulation sites bleeding		Cannulation sites oozing/repaire		Protamine Hemodynamics observed Cannulation sites secure

Additional Comments:

_____

_____

Overall: Pass Fail

General Definitions:

5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

CRAT - Conduit Revision Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____ **REPETITION 1 LAST**

	Poor				Excellent
1. **Conduit Transection**	1	2	3	4	5
	Multiple Incisions No Bevel (0 deg) Bevel too acute (> 60 deg)		Inadequate Bevel (10-30 deg)		Clean incision Proper Bevel (45 deg)
	Marked irregular edge		Mild irregular edge		Smooth edge

Additional Comments:
_____
_____

2. **Graft Length Adjustment**	1	2	3	4	5
	Unable to determine length Unable to Re-orient		Determined length with some hesitation Re-orient with some hesitation		No hesitation in graft length adjustment Proper heel-toe re-orientation

Additional Comments:
_____
_____

3. **Graft Re-orientation**	1	2	3	4	5
	Unable to Re-orient Not know start point Not know end point Marked hesitation		Re-orient with some hesitation Start with some hesitation Knows end point with Some hesitation		Proper heel-toe re-orientation Consistent start Knows end point No hesitation

Additional Comments:
_____
_____

4. **Extra Conduit Preparation**	1	2	3	4	5
	Unable to determine length Unable to Re-orient		Determined length with some hesitation Re-orient with some hesitation		No hesitation in length selection Proper heel-toe re-orientation

Additional Comments:
_____
_____

5. **Spacing**	1	2	3	4	5
	Uneven/irregular spacing Irregular distance from previous bite Unmatched Bevels		Mostly even spacing Mostly consistent distance from previous bite		Consistent even spacing Consistent distance from previous bite Matched Bevels

Additional Comments:
_____
_____

6. **Suture management**	1	2	3	4	5
	Not use tension Suture entangled		Tension use inconsistent Sutures occasionally get in way		Proper use of tension Suture consistently not in way

Additional Comments:
_____
_____

7. **Knot tying**	1	2	3	4	5
	Marked hesitancy, slow speed No follow through Not able to tie, breakage Loose or "air" knot Anastomosis purse-stringed		Moderate facility, moderate speed intermittent follow through Able to tie and tension, intermittently loose Partial purse-string		Consistent facility, no hesitancy Consistent follow through Consistent tension and tight No purse-string

Additional Comments:

_____

_____

8. **Conduit Flow**	1	2	3	4	5
	Completely obstructed		Some resistance		No resistance

Additional Comments:

_____

_____

9, **Conduit Length**	1	2	3	4	5
	Kinked		Slightly long or short		Excellent length

Additional Comments:

_____

_____

General Definitions:
5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

DAT - Debriefing Assessment Tool - CABG Session 5

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**TIME TO COMPLETION**_____

	Poor				Excellent
1. **Done in a timely fashion**	1	2	3	4	5
	Not Done		Done more than 2 hrs after event		Done immediately after event

Additional Comments:
_____
_____

2. **Participation**	1	2	3	4	5
	Failed to engage anyone else		Engaged only part of team		Fully engaged all of team

Additional Comments:
_____
_____

3. **Comprehensiveness**	1	2	3	4	5
	Did not identify any areas for improvement		Identified fewer than 3 areas for improvement		Fully identified all areas of improvement

Additional Comments:
_____
_____

4. **Tenor**	1	2	3	4	5
	Adversarial Defensive Demeaning Accusatory Intimidating				Helpful Constructive Appreciated Open

Additional Comments:
_____
_____

5. **Efficiency**	1	2	3	4	5
	Inefficient				Efficient

Additional Comments:
_____
_____

FCAT - Femoral Cannulation Assessment Tool

FIRST FEMORAL CANNULATION

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**REPETITION #** _____

	Poor			Excellent
1 **Exposure of femoral artery**	1 Unable to find artery	2	3 Finds artery with some difficulty	4	5 Readily finds, exposes artery

Additional Comments:
_____
_____

2. **Control of artery**	1 Does not properly control artery	2	3 Partially controls artery with some bleeding	4	5 Artery readily controlled proximally and distally – no bleeding

Additional Comments:
_____
_____

3. **Cannulation**	1 Cannot cannulate femoral artery	2	3 Cannulates but with bleeding either proximally or distally	4	5 Readily cannulates and secures cannula No excessive bleeding

Additional Comments:
_____
_____

4. **De-airing of cannula**	1 Does not attempt to e-air	2	3 More than one attempt at de-airing	4	5 Cannula de-aired on first attempt

Additional Comments:
_____
_____

5. **De-cannulation**	1 Cannula removed with significant bleeding	2	3 Cannula removed with moderate bleeding	4	5 annula removed and vessel controlled Minimal to no bleeding

Additional Comments:
_____
_____

6. **Arterial closure**	1	2	3	4	5
	Closed with poor patency		Excessive time for closure		Readily closed with good patency

Additional Comments:
_____
_____

Overall: Pass Fail

MAE-EAPAT - Massive Air Embolism-Emergency Action Plan Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**NUMBER OF REPETITIONS** _____

Poor **Excellent**

1 **Initiation of CPB**

1	2	3	4	5
Poor communication No checking for circuit	Most communication OK Some but incomplete checking potential air sites		Clear, concise, relevant communication ircuit completely test to prevent air tested to prevent air	

Additional Comments:
_____
_____

2. **Recognition of air**

1	2	3	4	5
Did not recognize air	Recognized air but difficulty identifying source		Immediately identified air and source	

Additional Comments:
_____
_____

3. **Initial steps**

1	2	3	4	5
Did not communicate problem Did not stop Pump Did not X-clamp lines		Communicated and executed only part of the plan	Complete, thorough, and efficient execution of initial steps up to retrograde cerebral perfusion	

Additional Comments:
_____
_____

4. **Retrograde Cerebral**

1	2	3	4	5
Unable to perform retrograde perfusion		Able to perform RCP but ot timely or efficiently (> 3min)		Efficient, timely and effective performance of RCP (<3min)

Additional Comments:
_____
_____

5. **Reinstitution of CPB**

1	2	3	4	5
Unable to de-air pt Unable to reinstitute CPB		Pt only partially de-aired CPB accomplished but inefficiently		Fully successful de-airing Efficient and timely reinstitution of normal CPB

Additional Comments:
_____
_____

6. **Emergency Action**

1	2	3	4	5
Plan Compliance	Very little compliance	Complied with 50% of plan		Complete compliance

Additional Comments:
_____
_____

Overall: Pass Fail

PAT - Prosection Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____ **TIME TO COMPLETION**_____

Resident Reviewed Both Videos Prior to Session Y N

	Poor				**Excellent**
1. **AVR Anatomy**	1 Did not know anatomy Could not identify leaflets Could not trace annulus	2	3 Knew leaflets but not adjacent structures	4	5 Identified all leaflets Identified all coronary ostia Identified all commissures
2. **Conduction system**	1 Could not location site of conduction system	2	3 Knew only general area of conduction site Did not know relevance to AVR	4	5 Knew exact location of induction site Knew relevance to AVR
3. **Mitral valve**	1 Could not identify mitral valve from aortic root	2	3 Knew location of mitral valve but not what part of valve	4	5 Identified anterior leaflet from aortic root Knew relevance of mitral valve location Demonstrated Aorto-mitral curtain
4. **Intraventricular septum**	1 Could not identify the septum	2	3 Knew generally where septum was	4	5 Identified exact location of septum

Additional Comments:
_____
_____

Additional Comments:
_____
_____
_____

Additional Comments:
_____
_____

Additional Comments:
_____
_____

PPAT - Protocol Performance Assessment Tool

FINAL WALK-THROUGH

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**TIME TO COMPLETION**_____

	Poor				Excellent
1. **Leadership**	1	2	3	4	5
	No leadership displayed		Somewhat hesitant in command	Took full command of situation	

Additional Comments:
_____
_____

2. **Knowledge of protocol**	1	2	3	4	5
	Knew none of the steps		Knew about 50% of steps but hesitated on some	Knew all steps and stated them in timely fashion	

Additional Comments:
_____
_____

3. **Communication**	1	2	3	4	5
	No communication		Communicated with some but not all of team	Communicated fully and effectively with entire team	

Additional Comments:
_____
_____

Overall: Pass Fail

General Definitions:
5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

SAT - Steps Assessment Tool for CPB

RESIDENT NAME_____YR OF TRAINING_____ DATE_____
EVALUATOR_____

Y= Yes I = Intermittent N= No
Briefing

Y I N Diagnosis
Y I N Procedure
Y I N Incision
Y I N Significant surgical history (redo, patent grafts…)
Y I N Cannulation
Y I N Cardioplegia
Y I N Temperature
Y I N Questions
Additional Comments:
_____
_____

Steps for CPB

Y I N 1. Heparin
Y I N 2. Expose the heart
Check BP/aorta
Y I N 3. ACT
Cannulation of aorta
Check aortic cannula
Y I N 4. Atrial cannulation
Venous clamp off
On bypass
Lungs off
Y I N 5. Inspect the heart
Place aortic and/or retrograde cardioplegia
Reduce pump flow// Cross-clamp aorta/Return to normal flow/Check line pressure
Begin cardioplegia
Set patient temp
Y I N 6. Release aortic cross-clamp
Lungs working
No bleeding in accessible areas
Good contractility
Stable rhythm
Temperature at desired level
Y I N 7. Wean off bypass
Venous line clamped/remove when stable
Remove aortic vent
Protamine
Follow RAP, PAP and BP
Be alert for hemodynamic reaction
Remove arterial cannula

Overall: Pass Fail

Additional Comments:
_____
_____
_____

SDCF-EAPAT - Sudden Deterioration in Cardiac Function – Emergency Action Plan Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**REPETITION 1 LAST**
Timed Event: Stopwatch start at initiation of emergency and stopped when on CPB_____

	1	2	3	4	5
1. **Recognizes Emergency**	Does Not Recognize		With Some Prompting		Immediately

Additional Comments:
_____
_____

	1	2	3	4	5
2. **Communication**	None		Requires Prompting		Clearly Establishes Urgency

Additional Comments:
_____
_____

	1	2	3	4	5
3. **Heparin**	Did not give		Prompted		Given Immediately

Additional Comments:
_____
_____

	1	2	3	4	5
4. **Aortic cannulation**	Awkward Hematoma Air in line No testing of line		Moderate facility bleeding reasonable, some ooze Bubbles stuck to tubing Partial testing, Bp or flow		High facility, smooth No hematoma or leakage Line de-aired Line tested for Bp and flow

Additional Comments:
_____
_____

	1	2	3	4	5
5. **Venous cannulation**	Awkward RCA injured Leaking		Moderate facility Too close to RCA Reasonable, some ooze		High facility, smooth Appropriate position No leakage

Additional Comments:
_____
_____

	1	2	3	4	5
5. **Initiating CPB**	No ACT checked No communication No confirmation of circuit function		ACT checked, unsure Partial communication Some acknowledgement of circuit function		ACT checked, appropriate for CBP Communicates “on bypass” Confirms circuit is functioning properly

Additional Comments:
_____
_____

SEAT - Summative Exam Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**REPETITION 1 2**

Not Applicable – No Emergency Encountered

1. **Recognizes Emergency** 1 2 3 4 5
Does Not Recognize With Some Prompting Immediately

Additional Comments:
_____
_____

2. **Communication** 1 2 3 4 5
None Requires Prompting Clearly Establishes Urgency

Additional Comments:
_____
_____

3. **Stepwise Decision-making** 1 2 3 4 5
Disorganized/Haphazard Required Redirection Highly Efficient/Logical

Additional Comments:
_____
_____

4. **Leadership** 1 2 3 4 5
No leadership displayed Somewhat hesitant in command Took full command of situation
Additional Comments:
_____
_____

5. **Knowledge of protocol** 1 2 3 4 5
Knew none of the steps Knew about 50% of steps but hesitated on some Knew all steps and stated them in timely fashion

Additional Comments:
_____

Overall: **Pass** **Fail**

VAAT - Vessel Anastomosis Assessment Tool - CABG Session 1 - Developed by JCTSE

FIRST DISTAL ASSESSMENT (Baseline performance)

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**TIME TO COMPLETION**_____

	Poor				**Excellent**
1. **Arteriotomy/ Aortotomy**	1 Not identify artery Off-midline Multiple "tracks" Injury to back wall Marked irregular edge	2	3 Partial artery exposure Mainly midline Thick single "track" Close to back wall Mild irregular edge	4	5 Full artery exposure Consistent midline Thin single "track" No injury to back wall Smooth edge

Additional Comments:
_____
_____

2. **Graft orientation**	1 Unable to orient Not know start point Not know end point Marked hesitation	2	3 Orient with some hesitation Start with some hesitation Knows end point with Some hesitation	4	5 Proper heel-toe orientation Consistent start Knows end point No hesitation

Additional Comments:
_____
_____

3. **Bite**	1 Irregular entry/exit Hesitant, multiple punctures Inconsistent distance from edge	2	3 Mostly regular entry/exit Mostly single puncture Mostly consistent from edge	4	5 Consistent regular entry/exit Consistent single puncture Consistent from edge

Additional Comments:
_____
_____

4. **Spacing**	1 Uneven/irregular spacing Irregular distance from previous bite	2	3 Mostly even spacing Mostly consistent distance from previous bite	4	5 Consistent even spacing Consistent distance from previous bite

Additional Comments:
_____
_____

5. **Needle holder use**	1 Awkward finger placement Unable to rotate instrument Awkward and not facile Inconsistent needle placement	2	3 Functional finger placement Hesitant when rotating Moderate facility Generally good placement	4	5 Comfortable, smooth finger placement Smooth rotation High facility Consistent proper placement

Additional Comments:
_____
_____

6. **Use of forceps**	1	2	3	4	5
	Awkward or no traction Unable to expose Not used to stabilize needle		Moderate proper traction Able to assist in exposure Able to stabilize but rough		Consistent proper traction Consistent proper exposure Knows when to stabilize, gentle

Additional Comments:

_____

_____

7. **Needle angles**	1	2	3	4	5
	Not aware of angles Not compensate for depth Does not consider subsequent angles		Understand angles, not consistent Partial compensation for depth Partial consideration of subsequent angles		Consistent correct angles Compensate for depth Consistent adjustment for subsequent angles

Additional Comments:

_____

_____

8. **Needle transfer**	1	2	3	4	5
	Marked hesitation in mounting needle		Able to mount needle with hand and partial manipulation		Able to mount needle and manipulate needle easily

Additional Comments:

_____

_____

9. **Suture management**	1	2	3	4	5
	No use of tension Suture entangled		Tension use inconsistent Sutures occasionally get in way		Proper use of tension Suture consistently not in way

Additional Comments:

_____

_____

10. **Knot tying**	1	2	3	4	5
	Marked hesitancy, slow speed No follow through Not able to tie, breakage Loose or “air” knot		Moderate facility, moderate speed intermittent follow through Able to tie and tension, intermittently loose		Consistent facility, no hesitancy Consistent follow through Consistent tension and tight

Additional Comments:

_____

_____

11. **Hand mechanics**	1	2	3	4	5
	No pronation or supination Awkward finger/hand motion No wrist motion		Incomplete pronation or supination Hesitant finger/hand motion Incomplete wrist motion		Able to modulate pronation/supination Smooth, comfortable motion Smooth, appropriate wrist motion

Additional Comments:

_____

_____

12. **Use of both hands**	1	2	3	4	5
	Awkward /not coordinated use Non-dominant hand neglect		Moderately coordinated use Moderate use of non-dominant hand to assist/expose		Smooth, seamless coordination Full use of non- dominant hand to assist/expose

Additional Comments:

_____

_____

13. **Economy of time and motion**	1	2	3	4	5
	Marked hesitation Not aware of goal Unable to do task		Some hesitation Some awareness of goal Able to do task but discontinuous		No hesitation Fully aware of goal Able to do task smoothly

Additional Comments:_____
_____

Overall: **Pass** **Fail**

General Definitions:

5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

VCAT - Venous Cannulation Assessment Tool

RESIDENT NAME_____**YR OF TRAINING**_____ **DATE**_____
EVALUATOR_____**REPETITION NUMBER** _____

	Poor				Excellent
1. **Atrial site**	1	2	3	4	5
	Does not identify atrial appendage Injury to RCA		Notes general area of atrial appendage Close to RCA		Identifies atrial appendage site Appropriately away from RCA

Additional Comments:
_____
_____

2. **Needle angles**	1	2	3	4	5
	Not aware of angles Does not consider subsequent angles		Understand angles, not consistent Partial consideration of subsequent angles		Consistent correct angles Consistent adjustment for subsequent angles

Additional Comments:
_____
_____

3. **Bite**	1	2	3	4	5
	Irregular entry/exit Hesitant, multiple punctures		Mostly regular entry/exit Mostly single puncture		Consistent regular entry/exit Consistent single puncture

Additional Comments:
_____
_____

4. **Spacing**	1	2	3	4	5
	Uneven/irregular spacing Irregular distance from previous bite		Mostly even spacing Mostly consistent distance from previous bite		Consistent even spacing Consistent distance from previous bite

Additional Comments:
_____
_____

5. **Needle holder use**	1	2	3	4	5
	Awkward finger placement Unable to rotate instrument Awkward and not facile Inconsistent needle placement		Functional finger placement Hesitant when rotating Moderate facility Generally good placement		Comfortable, smooth finger placement Smooth rotation High facility Consistent proper placement

Additional Comments:
_____
_____

6. **Use of forceps**	1	2	3	4	5
	Awkward or no traction Unable to expose Not use to stabilize needle		Moderate proper traction Able to assist in exposure Able to stabilize but rough		Consistent proper traction Consistent proper exposure Knows when to stabilize, gentle

Additional Comments:
_____
_____

7. **Scissors control**	1	2	3	4	5
	Cuts purse string Too big or too small atriotomy Significant leakage		Too close to suture Close to appropriate atriotomy Some leakage		Appropriate atrial cuff left Appropriate size atriotomy No leakage

Additional Comments:
_____
_____

8. **Cannula placement**	1	2	3	4	5
	Improper orientation Too deep or shallow		Somewhat improper Readjusted, good position		Proper orientation Perfect position

Additional Comments:
_____
_____

9. **Securing cannula**	1	2	3	4	5
	Too loose, too tight Awkward finger/hand motion		Somewhat loose, tight Hesitant finger/hand motion		Appropriately snug Smooth, comfortable motion

Additional Comments:
_____
_____

12. **Decannulation**	1	2	3	4	5
	Conditions for decannulation not met Significant bleeding with loss of control		Conditions for decannulation partially met Bleeding requiring stitch(es)		All conditions for decannulation met No bleeding

Additional Comments:_____

Overall: **Pass** **Fail**

General Definitions:
5. Excellent, able to accomplish goal without hesitation, showing excellent progress and flow
4. Good, able to accomplish goal deliberately, with minimal hesitation, showing good progress and flow
3. Average, able to accomplish goal with hesitation, discontinuous progress and flow
2. Below average, able to partially accomplish goal with hesitation
1. Poor, unable to accomplish goal; marked hesitation

Appendix B

Seven Steps of CPB

1. Heparin
2. Expose the heart
   Check BP/aorta
3. ACT
   Cannulation of aorta
   Check aortic cannula
4. Atrial cannulation
   Venous clamp off
   On bypass
   Lungs off
5. Inspect the heart
   Place aortic and/or retrograde cardioplegia
   Reduce pump flow/ Cross-clamp aorta/ Return to normal flow/ Check line pressure
   Begin cardioplegia
   Set patient temp
6. Release aortic cross-clamp after warm cardioplegia
   Lungs working
   No bleeding in accessible areas
   Good contractility
   Stable rhythm
   Temperature at desired level
7. Wean off bypass
   Venous line clamped/remove when stable
   Remove aortic vent
   Protamine
   Follow RAP, PAP and BP
   Be alert for hemodynamic reaction
   Remove arterial cannula

50 Steps of Cardiopulmonary Bypass

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1. **Briefing:**
    - **a.** Diagnosis
    - **b.** Operation
    - **c.** Incision
    - **d.** Past surgical history
    - **e.** Temperature strategy
    - **f.** Cannulation strategy
    - **g.** Cardioplegia strategy
    - **h.** Team feedback/questions
2. **Incision and Exposure**
3. **Pericardiotomy**
4. **Heparin administration-** 3mg/kg IV
    - **a.** If no CABG: following pericardiotomy
    - **b.** If vein: after vein harvest
    - **c.** If LIMA: before dividing
    - **d.** If both vein and LIMA: after harvest and before dividing LIMA
5. **Pericardial stays to create well**
6. **Inspect the heart - gross evaluation of function, anomalies, etc**
7. **Inspect the aorta:**
    - **a.** Palpate the aorta for calcium
    - **b.** TEE to look for atheromatous areas at which to avoid cannulation
    - **c.** Consider epiarotic scan
    - **d.** Plan aortic layout
8. **Check ACT** (>480s for non-heparin bonded, >350s for heparin bonded)
9. **Divide the CPB lines into arterial and venous limbs** (may be done by scrub)
10. **CANNULATE ASCENDING AORTA**
    - **a.** Place 2 concentric purse-string sutures (2-0 Ti-Cron)- outer with pledget
    - **b.** Cut needles and attach rummel
    - **c.** Re-check SBP (goal <90 mmHg)
    - **d.** Create epiaortic soft tissue flap within purse-string
    - **e.** Stab-incise the aorta transversely (#15 blade)
    - **f.** Cannulate the aorta
    - **g.** Cinch down the rummels
    - h. Secure rummels to cannula with 2 ties (pull rummels up while pushing cannula into aorta)

11. **Attach aortic cannula to CPB circuit**
    - **a.** Tap cannula to loosen adherent air bubbles
    - **b.** Clamp the cannula- don't clamp wire reinforcement
    - **c.** Tighten luer lock
    - **d.** Remove plastic seal cap
    - **e.** Gently unclamp to purge all air
    - **f.** Coordinate with perfusion- roll pump for wet connections
    - **g.** Check for air bubbles
    - **h.** Unclamp cannula and check for bubbles again
    - **i.** Ask perfusionist to give 100 mL through arterial line (check pressure, goal is <100 greater than SBP)
    - **j.** Examine the aorta for hematoma/sign of dissection
    - **k.** Secure aortic cannula to drape with towel clamp
12. **CANNULATE THE RIGHT ATRIUM**
    - **a.** Place purse-string suture around right atrial appendage (4-0 Prolene pledgeted)
    - **b.** Cut needles and place rummel
    - **c.** Incise the right atrial appendage inside the purse-string
    - **d.** Dilate the incision
    - **e.** Plaw two-stage venous cannula, direct it into IVC
    - **f.** Check that the cannula is in the IVC by direct palpation
    - **g.** Cinch down the rummel
    - **h.** Secure the rummel to the cannula with a tie
    - **i.** Connect the venous cannula to venous CPB line
    - **j.** Remove venous line clamp
13. **Reconfirm ACT** (>480s, >350s) **with perfusionist**
14. **Place retrograde catheter**
    - **a.** Purse-string on the right atrial free wall (4-0 Prolene)
    - **b.** Cut needles and place rummel
    - **c.** Incise the right atrium inside the purse-string
    - **d.** Dilate the incision
    - **e.** Place retrograde cannula into the coronary sinus
    - **f.** Confirm placement by direct palpation and/or TEE
    - **g.** Cinch down the rummel
    - **h.** Connect and de-air retrograde catheter by backbleeding into cardioplegia lines
    - **i.** Leave retrograde cannula clamped
    - **j.** Ask anesthesia to flush forward the retrograde pressure monitoring line
15. **Place antegrade cannula:**
    - **a.** Place antegrade/root vent purse-string suture (4-0 Prolene- 1 ½ times around- 6 stitches)
    - **b.** Cut needles and place rummel

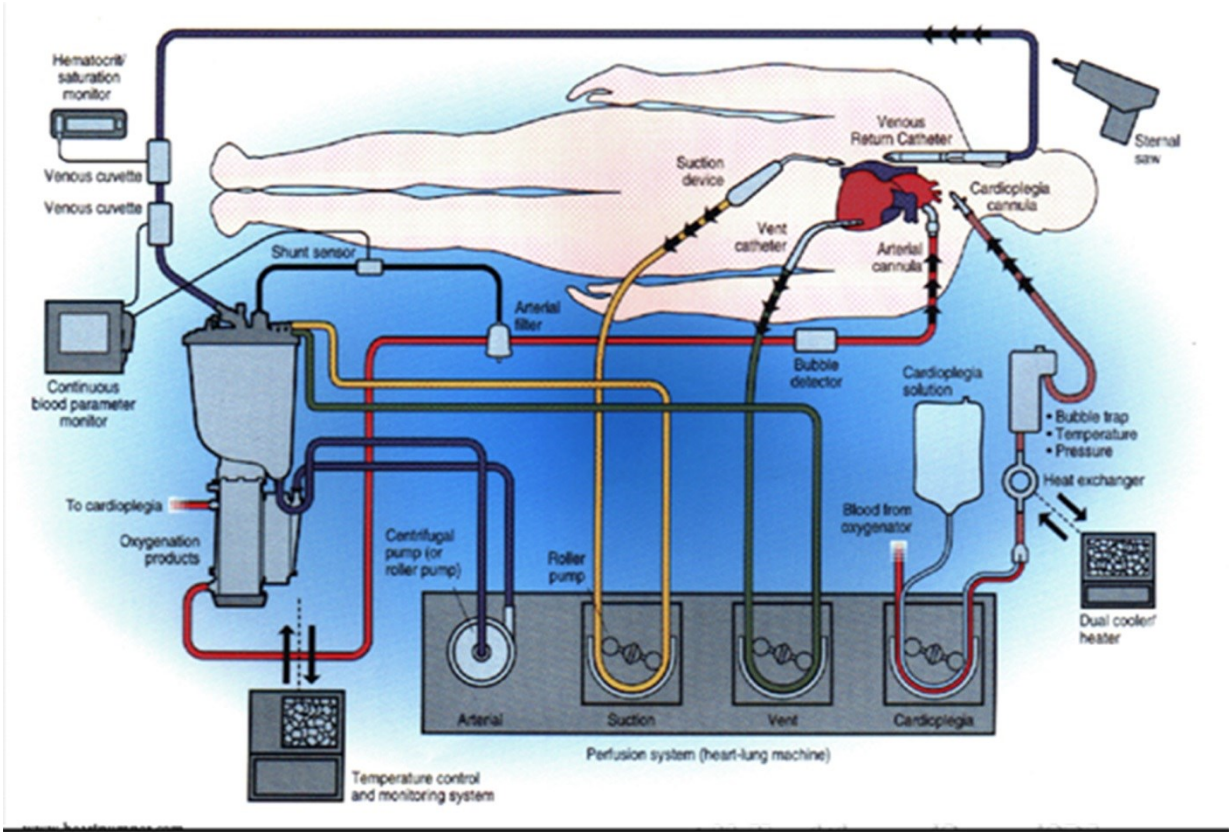
c. Place antegrade cannula inside the suture into the aorta
d. Cinch down the rummel
e. Connect and de-air catheter by backbleed and clamp

16. **GO ON BYPASS**
    a. Observe circuit for flow direction/color changes
    b. Assess cardiac decompression
    c. Assess air entry into venous line
    d. Discuss flows and pressures with perfusionist
17. **Cease ventilation when at full CPB support**
18. **Discuss temperature strategy with perfusion and begin to cool if needed**
19. **Ask perfusion to run up cardioplegia** (must be on CPB for this - 4:1 blood to cardioplegia mixture, metabolically enhanced)
20. **Dissect plane between aorta and pulmonary artery -** does not need to be circumferential unless planning aortic transaction
21. **CROSS CLAMP THE AORTA**
    a. Decrease flow to 0.51 pm ("Pump Down!")
    b. Cross clamp the aorta with the left hand
        i. Ensure the clamp is across the entire aorta
        ii. Ensure the clamp does not include the PA
        iii. Ensure the clamp does not include the aortic cannula or the root cannula
    c. Return to full flow ("Resume full!")
    d. Palpate distal to clamp to assess for turbulent flow
    e. Secure the aortic cross clamp to a towel/drape
22. **Start Cardioplegia** (20cc/kg total induction)
    a. Unclamp antegrade cardioplegia catheter
    b. Ask the perfusionist to give warm glutamate/aspartate enriched antegrade cardioplegia
    c. Palpate aortic root to assess pressurization, observe left heart for (absence of) dilatation
    d. At 750cc delivered, unclamp retrograde catheter, inflate balloon and begin to give cold retrograde
    e. Stop antegrade flow and aspirate on root vent
    f. When giving cardioplegia retrograde make sure that balloon is inflated, confirm coronary sinus pressure, examine coronary veins - should be bright red rather than dark
23. **PERFORM and COMPLETE THE PLANNED OPERATION**
24. **Give hot shot of retrograde gluatamate/aspartate encriched cardioplegia to volume of 10 mL/kg**
25. **DE-AIR THE HEART:**
    a. Head down (Trendelenberg)
    b. Root vent on max aspiration ("Vent way up!")
    c. Agitate ventricle

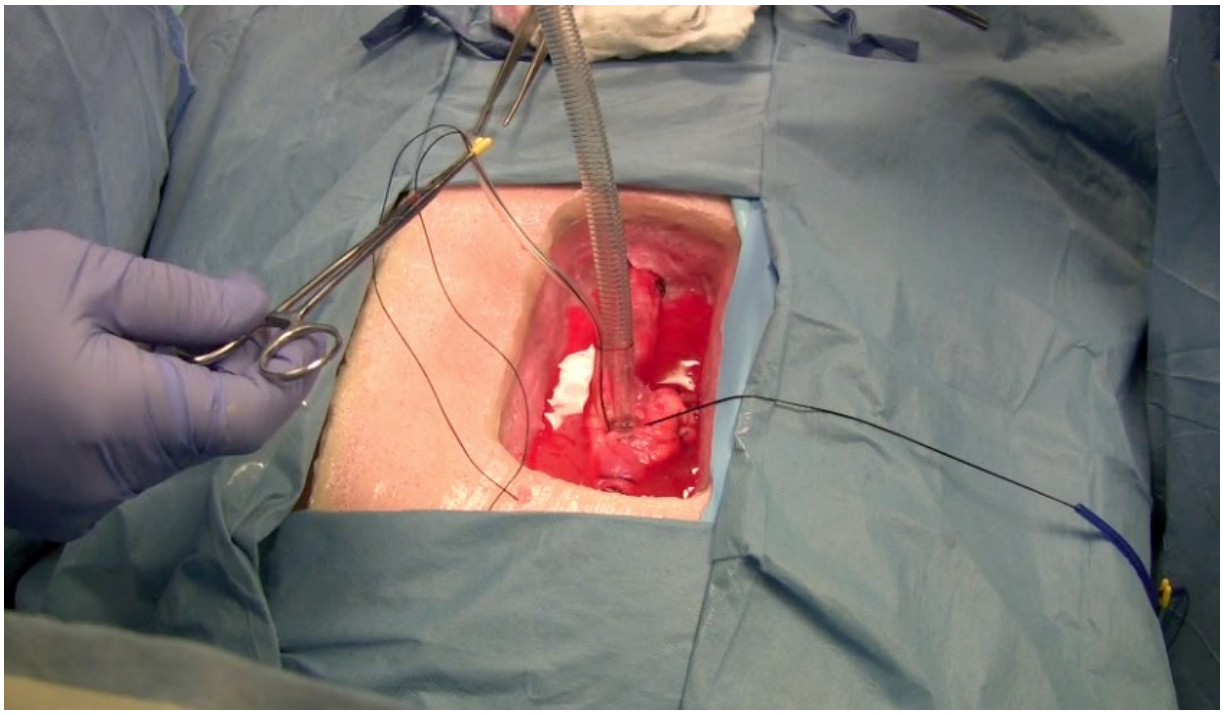
   d. (Optional) Ask anesthesia to give Valsalva x2
26. **REMOVE CROSS CLAMP**
   a. Ask the perfusionist to decrease flow to 0.5L/min ("Pump down!")
   b. Take the aortic cross clamp off
   c. Ask perfusionist to resume full flow ("Full flow!")
   d. Ask the perfusionist to take the volume back/empty the heart ("Take your volume back!")
27. **Remove retrograde line -** tie your stitch and oversew with another 4-0 Prolene (Come-backer)
28. **Assess rhythm:**
   a. Defibrillate as necessary
   b. Place V pacing wires
29. **Assess for surgical bleeding:**
   a. Examine your suture lines (especially distal anastomoses that are on the back of the heart)
30. **Assess temperature** (>36 C)
   a. When surgical bleeding controlled, sinus rhythm established, contractility adequate, anesthesia prepared with vasoactive agents in line and blood products and temperature = 36C may begin to wean CPB)
31. **Retard venous retrun/let the heart eject**
32. **RESUME VENTILATION**
33. **Wean CPB:**
   a. Full to ½ 1 lpm to off
   b. 5, 4, 3, 2, 1 lpm to off (alternate)
   c. Coordinate returning volume to the patient/adjusting vasoactive drugs with anesthesia and perfusion in 100-200 mL increments while observing the heart function both in vivo and on TEE
34. **Recheck for bleeding now that suture lines exposed to pulsatile flow**
35. **When off bypass clamp and remove the venous line -** cinch down the rummel after but DO NOT tie it yet.
36. **Coordinate further returning volume to the patient** with anesthesia and perfusion in 100-200 mL increments while observing the heart function both in vivo and on TEE.
37. **Check operative results/check suture lines**
38. **CONFIRM DEAIRING COMPLETE by TEE and remove aortic root vent/tie purse-string**
39. **Ask to calculate dose of protamine**
40. **Ensure both Anesthesia and Perfusion are comfortable with proceeding with protamine administration**
41. **Start giving protamine**
42. **Remove cardiotomy suctions from field and turn off**
43. **Monitor for protamine reaction (**systemic hypotension, pulmonary HTN)
44. **Remove aortic cannula**

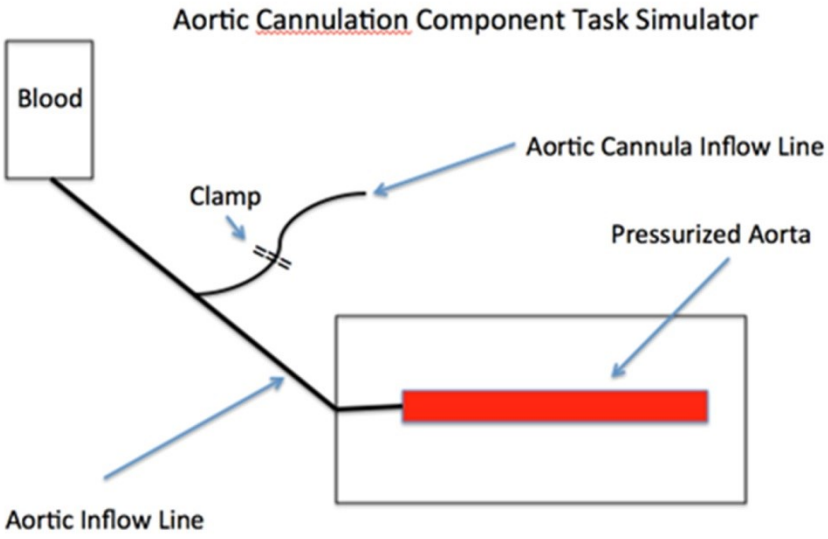
   a. Make sure that SBP is still 90 mmHg
   b. Once ½ to 2/3 of protamine is in, cut the rummel securing ties
   c. Remove the aortic line
   d. You tie 2 knots on the outer purse-string and assistant holds finger on insertion site
   e. Assistant ties the inner purse-string
   f. You finish tying the outer/pledgeted purse-string
   g. Re- examine the aorta
45. **Tie the right atrial appendage purse-string, reinforce with additional suture**
46. **Check ACT, check coags**
47. **Re-examine the operative field for bleeding**
48. **Close pericardium over aortic root, consider pericardial reconstruction**
49. **If dry, place chest tubes**
50. **Close**

CPB Components



Aortic Cannulation Component Task Simulator

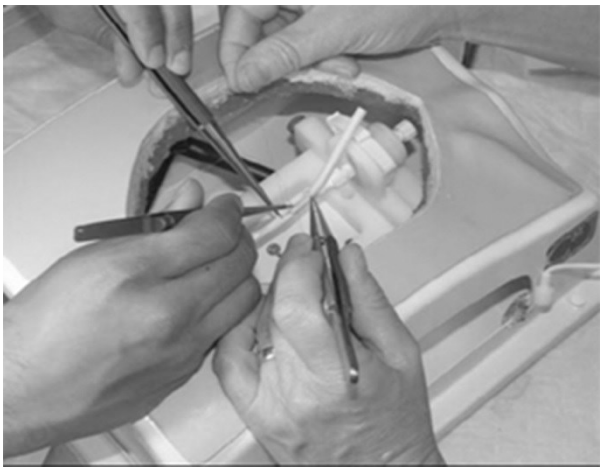




Heart Case (Chamberlain Group) Set-up

The Heart Case/equivalent model should permit sewing an end-to-side anastomosis at different angles in the shallow and deep pericardial space.

HeartCase and anastomosis attachment



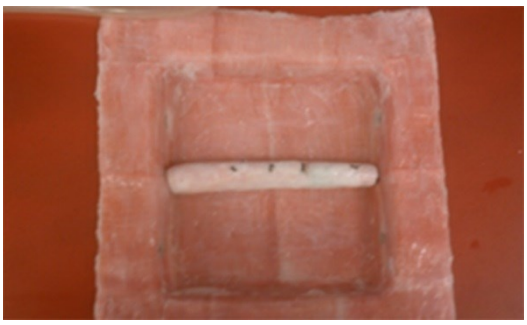
Aortic Cannulation/Repair Model

Acute Intra-operative Aortic Dissection Repair model, Blood preparation, Preserving solution

Aortic Dissection Repair

As part of the AIAD Module, each center has received two 28 qt containers (pre-drilled and pre-cut), two silicone trays (with holes for the aortas), two sets of tubing, four empty IV bags, and three aorta lengths. Dissected aortas will be sent which are cannulated with the male portions of quick connect connectors as part of the CPB . Each tube branch (one going to aorta and one going to aortic cannula) is 5 ft in length, which should allow for any particular setup that you want based on space. The plastic container has three holes drilled for the same purpose. The IV bags will need to be filled with blood, which unfortunately, is a slow process. I'm including a funnel and a separate ¼ inch tube with an IV spike connected to help with that. The ¼ inch tubing coming right off the IV bags each has a clamp you can use.

How to connect everything: One IV bag will be connected to the ¼ inch end of the tubing setup. These ends have IV spikes to connect to the bags. Clamp the white clamp so the blood doesn't spill everywhere. Clamp the tubing branch used in the aortic cannulation model of the CPB Module as this will not be needed during this session. To the aorta, place that 3/8 branch through one of the holes in the plastic container and hook the female portion of the quick connects (without silicone) to it. The aorta will go inside the red silicone tray. The male connectors tied to the aorta will go through the holes in the tray. Make sure it goes through the hole all the way. One of them will connect to the female component already connected to the tubing. The other end of the aorta will connect to the female quick connect at the other end that's plugged with silicone. This was the same setup at boot camp for those who saw it.



When connecting the aortas to the quick connects, make sure the connection "clicks" in place so there are no blood spills!