2/2/2021

THE DANCE STEPS

OPERATIVE SEQUENCE

FOR

CARDIAC SURGERY

This description covers important points to facilitate your orientation, confidence and safety during your cardiac anesthesia rotation. In addition, it covers many details of the nursing, perfusionist and surgical processes. One might ask, “Why do I need to know about these other things?” The reason is; cardiac surgery is all about teamwork. In order to “do the dance”, you should know what the other members of the team are doing. This document is an attempt to describe their “steps.”

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# OPERATIVE SEQUENCE FOR CARDIAC SURGERY

## **Initial Patient Preparation**

### **Some examples of how to use the preoperative data in your management:**

Low exercise tolerance: Consider low CO. Consider a gentle induction with either etomidate, low dose propofol, or with fentanyl and midazolam alone. Make sure you have vasopressors drawn up in the room.

EF < 30%:Same considerations as in low CO syndrome. Consider vasopressin during bypass run.

Increased creatinine level:Consider altered renal function. The perfusionist may use mannitol and/or furosemide during bypass. Maintain blood pressure within 20% of pre-ischemic baseline.

GERD:Consider rapid sequence induction.

Swallowing problems:Meticulous evaluation is necessary to find out possible contraindications to TEE.

Pacemaker is implanted:Get the information about the model. Consider interrogating the pacemaker pre-operatively and setting to asynchronous mode while in the operating room.

AICD is implanted: The defibrillator mode should be turned off and the pacemaker should be interrogated.

Patient has LBBB:Be aware that you can cause complete AV block and cardiac arrest when inserting wire for central line access or floating a PA catheter.

Patient is on ACE inhibitor (-pril) or on angiotensin receptor inhibitor (-artan): Be prepared for severe hypotension and consider having vasopressin in the OR.

Left main coronary artery stenosis: Avoid hypotension; maintain blood pressure within 20% of pre-ischemic baseline during induction and maintenance of anesthesia.

Severe 3 vessel disease:Avoid hypotension; maintain blood pressure within 20% of pre-ischemic baseline during induction and maintenance of anesthesia.

Coronary artery occlusion 100%:Complete occlusion of any coronary artery can lead to steal phenomenon with severe ischemic event. Avoid hypotension; maintain blood pressure within 20% of pre-ischemic baseline during induction and maintenance of anesthesia.

Severe AS: Avoid hypotension and tachycardia, maintain afterload, cardiac output, and coronary perfusion. Be aware that you can cause dysrhythmias when inserting wire for central line access or PA catheters. If VT or VF is caused by the PA catheter, a cardiac arrest may result. Immediately withdraw catheter, and be prepared to defibrillate with defibrillator pads placed prior to induction. A cardiac arrest in a patient with severe AS can be fatal.

Severe AI:Bradycardia and hypertension increase the ratio of the regurgitant volume. Avoid hypotension; maintain blood pressure within 20% of pre-induction baseline during induction and maintenance of anesthesia. Avoid bradycardia; be prepared to treat low heart rate episodes.

Severe MS:Low cardiac output syndrome which can be critical in patients with tachycardia. Avoid tachycardia and hypotension; maintain blood pressure within 20% of pre-induction baseline during induction and maintenance of anesthesia. Be prepared to treat tachycardia.

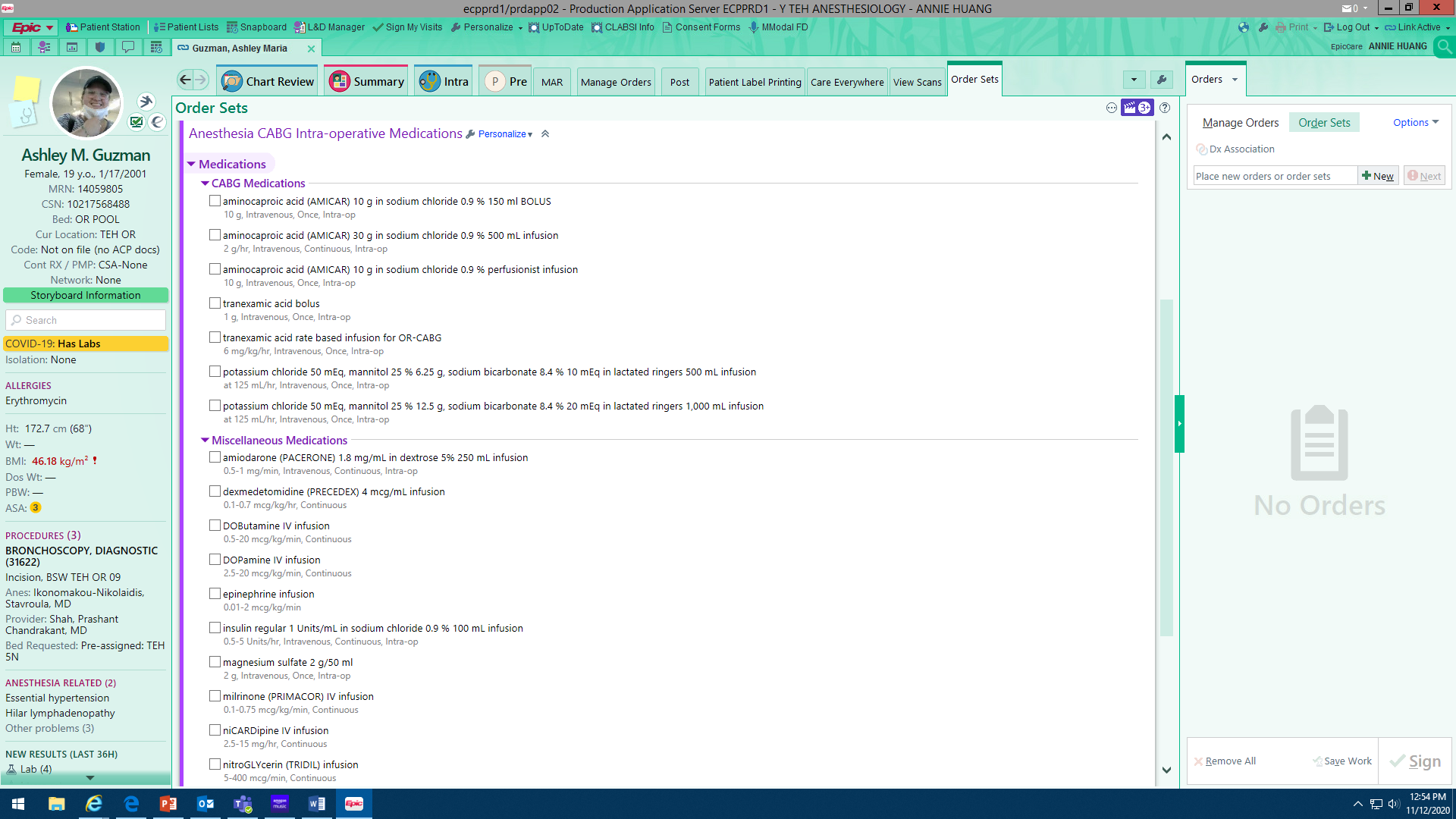
Severe MR:Bradycardia and hypertension increase the ratio of the regurgitant volume. Avoid hypertension; maintain blood pressure within 20% of pre-ischemic baseline during induction and maintenance of anesthesia. Avoid bradycardia; be prepared to treat low heart rate episodes.

Redo case:These cases have high bleeding risks because of scar tissue which bleeds on reopening the chest and potential for the saw to lacerate the right ventricle. Make sure that appropriate blood and products are in the OR in a cooler at the head of the bed and checked before incision. Attending anesthesiologist needs to be in the room for sternotomy. Surgeon may ask for bolus nitroglycerin at time of sternotomy. Consider monitoring pre-incision and on bypass TEG to guide therapy with appropriate blood product replacement. Also, the nurses should place external defibrillation pads on the chest for redo sternotomies.

## AM Process for the Cardiac Surgery First Case

1. Set up Room.
   1. Standard Machine checkout and setup.
   2. Medications/Infusions
   3. Triple transducer, cardiac output gun.
   4. Bolus line through fluid warmer.
   5. 9 Fr MAC introducer and PAC
   6. TEE - used in all CV cases unless contraindicated, have this ready in OR with patient data entered.
   7. Transport monitor charging.
   8. Transport oxygen with down hook.
   9. If Off Pump procedure, set room temp to 73 degrees.
2. Patient will arrive in day surgery at ~05:30 A.M.
   1. In-house patients go to Day Surgery for preparation.
   2. ICU patients on ventilator and emergencies from the cath lab go directly to the OR.
      1. If enough time, A-lines should be placed in ICU or cath lab. If true emergency, cath sheath can be used for A-line.
      2. Make sure IV access is adequate and have an extra free-flow IV set-up.
      3. IABP, ECMO, or other assist device – patient should be transported from ICU with perfusionists.
3. Day of Surgery (nurses typically done by ~6:10 A.M.)
   1. At least one large IV (>16g) started by Day Surgery nurses
   2. Interview the patient and review the pre-operative data.
      1. Standard pre-op exam.
      2. Confirm consents for General Anesthesia, Central Line, and TEE
   3. Premedication (used rarely)**:** (i.e. anxious patient request, physician preference, etc.)
      1. Midazolam 0.5-2 mg as necessary to facilitate arterial line placement.
   4. Make sure patient has continued their B-Blocker.
      1. If not, discuss dosing with fellow/staff.
   5. The patient should have the arterial line placed before 7:25 – do not miss morning lecture.
      1. If the arterial line is not in place by 7:25, defer further attempts until the patient is transferred to OR
      2. >2 attempts, change to ultrasound or get additional help from fellow/staff.
      3. Fellow is available to place a-line most mornings if you would otherwise be late to lecture.
4. Nursing staff will take patient into the room at approximately 7:25 AM for first morning start.
   1. OR nursing staff will position patient on OR bed. They need to place defibrillation pads, which will stay with patient until transferred to ICU. They will tuck arms after induction so you will need to check that your Arterial line draws back and PIV flows well.
5. Antibiotics
   1. SCIP requires that the antibiotic be given within one hour prior to incision; re-dose cefazolin every 4 hours, other antibiotics should also be redosed at appropriate intervals.
   2. Vancomycin started in holding or immediately upon entering the OR. The CV surgeons or physician assistants should place orders for the antibiotic administration. The second antibiotic, usually cefazolin, should be started just after central line insertion.
6. At 07:30 AM Anesthesiologist Care Team arrives (after Resident AM lectures). Assure ALL appropriate monitors connected and in place.

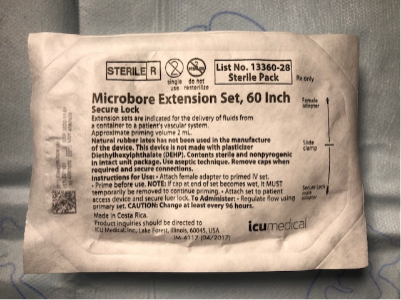
### Medications

1. Order desired infusions the night before case as discussed with senior anesthesiologist staff.
   1. Order Set: “Anesthesia CABG Intra-operative Medications” 
   2. Pharmacists may have basic orders in already. OR Pharmacy will prepare any drips deemed necessary as requested by the anesthesiology team. However, the OR pharmacy does not open until 6:30.
      1. Pick up drips from OR control desk for 1st start cases
      2. Add on cases will need a phone call to pharmacy 24-4759 /24-0380 and order set placed
   3. MgSO4 2 gm in 50mL will be available from Pharmacy for administration to all pump cases prior to weaning from CPB.
   4. All drips are primed on Plumb pumps prior to start of case in addition to bolus syringes of epinephrine (4mg in 250cc), norepinephrine (4mg in 250 cc), and phenylephrine (20 mg in 250cc).
2. Heparin and protamine for reversal of heparin post by-pass will be supplied by the perfusionist. Do not have protamine in your work space until after separation from bypass. ***DO NOT* give Protamine while on bypass, not even a test dose! *EVER!!***
3. **Diabetics**:
   1. Monitor blood glucose pre-operatively and intra-operatively.
   2. Perfusionist has I-Stat and glucometer in OR.
   3. Treat BS ≥180 mg/dL with insulin as per protocol outlined in this document below or similar protocol. Insulin will shift K+ intracellularly.
   4. Check blood glucose every 30-45 Min.
4. **Tranexamic acid**: Used as an anti-fibrinolytic. Evidence that it reduces post bypass bleeding. Some clinical reports of problems (left ventricular thrombus, arterial thrombi, etc). Have used aminocaproic acid in the past if TXA unavailable.
   1. Hold TXA if patient is found to be hypercoagulable on TEG.
   2. Process for tranexamic acid:
      1. 1000 mg IV initially over 10 minutes, given in 100 cc bag by pharmacy
      2. 6mg/kg/hr continuous infusion intraoperatively. 3 mg/kr/hr if renal disease or history of seizure/TBI
   3. Pharmacy will provide two admixtures:
      1. TXA 1000mg in 100 ml for initial IV dose and.
      2. TXA 3000 mg in 250 ml for infusion

### Set Up:

Standard room set up PLUS:

* Standard Machine checkout and setup.
* Medications/Infusions
  + Use Cardiac drug labels (draw all up).
  + Bolus vasoactive medications: phenylephrine, ephedrine, norepinephrine and epinephrine
  + Infusions connected to manifold and extension

L → R Top: |NS Carrier/TXA| |Phenylephrine|

L -> R Middle: |Norepinephrine| |Epinephrine|

L → R Bottom: | |Insulin | |Dexmedetomidine|

* Airway
  + Subglottic endotracheal tube
  + ICU ETT securement device (except Dr. Culp)
* Triple transducer, cardiac output gun.
* Bolus line on fluid warmer.
* Central Line Supplies –prior to case.
  + 9 Fr MAC introducer
  + Pulmonary Artery Catheter
  + Ultrasound probe cover and sterile gloves.
  + Extra gown and gloves for fellow.
* TEE - used in all CV cases unless contraindicated, have this ready in OR with patient data entered and 10 cc of US gel. Pink bite block available.
* Transport monitor is present and charging.
* Transport oxygen with down hook.

You or perfusionist will draw baseline labs and +/- Thromboelastogram (TEG) soon after patient arrival, preferably prior to induction.

Heparin needs to be drawn up into a syringe prior to induction. Confirm dose with perfusionist. If the patient needs to crash on bypass, there is no time to figure out how much, draw it up and verify the dose. Slam it in if it is an emergency!!

## Induction:

Induction and Intubation: **Never induce the patient without a surgeon available who can put the patient on bypass. Never induce without a perfusionist and a pump available.** They should be able to place the patient on bypass in less than 5 minutes if the patient arrests on induction. A member of CT surgery (i.e. PA) should be in the room for induction.

1. Limit pre-bypass crystalloid administration (optimally < 500 mL).
2. Proceed with anesthetic induction and endotracheal intubation as planned and discussed with your Staff.
   1. Fentanyl
      1. Fentanyl (High)100-200 mcg/kg (Medium) 20-40 mcg/kg (Low)1-5 mcg/kg
      2. Sufentanil (High)20-40 mcg/kg (Medium) 10-20 mcg/kg (Low) 1-2 mcg/kg (Rarely used)
   2. Benzodiazepine based on patient requirements and staff preference (dose range 0.05-0.1 mg/kg to achieve intraoperative amnesia).
   3. Propofol 1-2.0 mg/kg, or Etomidate 0.2-0.3 mg/kg
   4. Rocuronium or Succinylcholine for muscle relaxation
   5. Start inhalation agent.
   6. Intubate when appropriate anesthetic depth obtained.
      1. Tidal Volume: 6 ml/kg predicted body weight, 6-8 PEEP
   7. Titrate β-Blocker as needed for HR control.
3. Foley catheter with temperature probe is placed by the Circulating Nurse/PA.
4. Central Line
   1. Ultrasound guided CVC insertion following procedure time out.
      1. 3 minute chlorhexidine dry time prior to drape placement.
   2. Cover central line insertion site with CHG Tegaderm® as high on the neck as possible away from surgical field. Label the dressing with initials, date and time. Dressings may need to be replaced at the end of the case if it has been compromised/contaminated.
5. TEE insertion
   1. Attach upright and cross bars to OR table.
   2. Some Staff want an oral gastric drain tube placed prior to insertion of TEE to improve imaging.
      1. Remove the OG tube before placing the TEE probe.
6. Since all of our bypass cases use vacuum assist, the bypass machine must be positioned as close to the bed as possible. Be prepared to accept the retrograde cardioplegia tubing from the scrub tech, if retrograde cannula is going to be used. If used the perfusionist will give you a male-to-male connector. Attach male-to-male with 3 way stop cock to PA transducer (yellow).
7. Attach surgical drapes to bar structure
8. Obtain post-induction cardiac output (CO)/cardiac index (CI) by thermodilution if PAC is in place.

### Induction Goals for Valve Repairs:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Preload** | | **Afterload** | **Heart Rate** | **Rhythm** |
| **AS** (aortic stenosis) | | Keep it up | Maintain SVR | 50-80 | NSR | |
| **AI** (aortic insufficiency) | | Keep it up | Decrease SVR | 90-100 | NSR | |
| **MS** (mitral stenosis) | | Keep it up | Maintain SVR | 50-80 | NSR | |
| **MR** (mitral regurgitation) | | Keep it up | Decrease SVR | 90-100 | NSR | |

### Pre-bypass Hemodynamics:

Blood Pressure: Attempt to keep the blood pressure within ± 20% of pre-pathologic baseline blood pressure.

Heart rate: Avoid tachycardia in coronary artery disease. Discuss specific goals with fellow/staff the hemodynamic goal for each patient/pathology prior to case.

Cardiac Output/Index (CO/CI): Important to maintain adequate cardiac output (most providers will use cardiac index, so know the patients BSA). If you have hypotension or hypertension check cardiac output to guide appropriate treatment, contractility, heart rate, SVR, etc.

## Maintenance:

Fentanyl: additional boluses are usually necessary prior to skin incision and sternotomy.

Control hemodynamics with inhalation agent, vasodilator, or beta blocker as necessary.

### Diabetes Management:

Serum glucose management is very important for patient care and quality metrics. Manage serum glucose in diabetics using algorithm below. The blood glucose in patients with diabetes is managed according to the modified Portland protocol (below). Blood glucose levels between 110 to 200 mg/dl will be targeted. Blood glucose determinations should be made approximately each hour in patients who have received insulin.

|  |  |  |  |
| --- | --- | --- | --- |
| Blood Glucose  (mg/dl) | Intravenous Insulin Bolus (U) | **Non-Insulin Dependent DM**  Initial Insulin Infusion Rate (U/hr) | **Insulin Dependent DM**  Initial Insulin Infusion Rate (U/hr) |
| 120 - 179 | 0 | 1 | 2 |
| 180 - 239 | 0 | 2 | 3.5 |
| 240 - 299 | 4 | 3.5 | 5 |
| 300 - 359 | 8 | 5 | 6.5 |
| >359 | 12 | 6.5 | 8 |

Patients who have received insulin during their cardiac surgery should have a blood glucose determined at the time they arrive in the ICU after the completion of surgery.

### Early Extubation process criteria:

* Age < 75
* BMI < 35
* Isolated CABG
* Isolated Valve Replacement or Valve Repair
* EF > 35%
* On <0.05 mcg/kg/min of epinephrine or   
  <5 mcg/kg/min of dobutamine
* No mechanical cardiac assistance
* Systolic PA pressures < 40 or no severe pre-existing pulmonary disease
* No difficult airway
* No end stage renal disease
* With early extubation protocols consider reversing NMB if the patient is stable.

### Skin Preparation

Skin cleaned from area of incision outward.

For a CABG-chin to ankles; all other open hearts-chin to knees. Groin area is prepped to allow for utilization of femoral vessels, if needed.

3 minute drying time for chlorhexidine preps prior to draping.

## Operative Procedure, surgeon’s PERSPECTIVE (median sternotomy)

### Surgical Opening of the chest

1. Incision through skin and subcutaneous tissue.
2. Fascia overlying sternum scored in midline with the cautery
3. Tissue cleared beneath sternal notch
4. **Pneumatic power saw used to divide sternum (with ventilation momentarily stopped).** 
   1. Sternotomy: This is a stress inducing process that occurs after induction, make sure the patient is adequately anesthetized. Sometimes the surgeon will ask you to pause the ventilator during sternotomy; more often they will just test the sternal saw. Stop ventilating the patient before the surgeon opens the sternum and resume ventilation when complete.
5. Sternal periosteum and small bleeding points cauterized; larger vessels are tied or suture ligated.
6. Internal mammary artery (IMA, usually the left) may be taken down at this point. Consider decreasing tidal volumes without adding PEEP (480 ml, 0 PEEP) and increase respiratory rate to decrease lung incursion on the surgical field. You may be asked to assist with manual ventilation with small tidal volumes with visual timing of breaths to match surgeon’s moves; i.e., no breath when surgeon’s instrument is near IMA in apical region of chest.
7. Chest retractor applied and opened slowly
8. Tissue cleared from pericardium
   1. Pleura bluntly dissected
   2. Thymic remnants divided
   3. Innominate vein identified
9. Saphenous vein taken from one or both legs (see Section IX)
   1. You may be asked to administer a SMALL dose of heparin, usually 2,500Units (2.5mL). Confirm dose with surgeon prior to administration.
10. Pericardium opened (approx..25-50cc pericardial fluid suctioned out)
11. Pericardium pulled back with sutures.

Summary of Anesthesiology implications of Sternotomy: Attain an adequate depth of anesthesia at the time of sternotomy, and allow the lungs to deflate “lungs down” at the time of sternotomy. Consider ventilator adjustments to facilitate surgical IMA dissection.

## Saphenous Vein Harvest

1. Saphenous vein located in the groove just anterior to the medial malleolus
2. Endoscopic vein harvesting is commonly used. This allows the assistant to harvest the vein from the leg using only one incision.
   1. CO2 is pumped into the leg to inflate the area to allow for better visualization of the vein.
   2. Beware of CO2 embolism during this time.
   3. Respiratory acidemia from absorbed CO2. May need to increase minute ventilation.
3. Tissue around vein is carefully dissected, isolating branches
   1. Branches are carefully tied off with a 3-0 suture ligature through the adventitia and around the branch. The tie is close to the vein but must not impinge on the diameter of the vein’s lumen
4. The distal end of the vein has plastic cannula inserted and tied in place. The distal (ankle) end of the vein becomes the proximal anastomosis in the aorta, so the venous valves are going in the correct direction for blood flow
5. Heparinized Saline is injected into the vein to check for patency and leaks
6. Incision is closed being sure to catch the deepest layers of tissue. If the incision is very deep or a flap has been created, a deep layer of interrupted sutures is used followed by a running layer
7. The skin is closed in usual surgical fashion.

## Cannulation and Institution of bypass

#### Heparinization

* 1. Dose given by anesthesiologist in a central vein at surgeon’s request. Confirm dose with surgeon and perfusionist.
     1. Pump dose is 300-400mg/kg with goal ACT of 480 for bypass.
     2. Off-Pump dose is 2/3 of pump dose. Goal ACT > 350.
  2. Aspirate blood from the line before administering to ensure intravascular delivery.
     1. Announce to room “Administering heparin”
     2. Announce to room “Heparin is in”
     3. **Start timer and draw ACT at 3 minutes.**
  3. If the patient is on IV heparin infusion, D/C at this time if not already discontinued.

#### Preparation for Aortic Cannulation

* 1. The SBP should be about 90-100mmHg.
  2. Pump lines brought up to field.
  3. Arteriovenous pump line cleared of air and divided
  4. Aortic purse strings(s) placed.
  5. Target ACT 300 seconds for aortic cannulation.
  6. Stab made into aorta \*(avoid hypertension at this point, as increased B.P. can promote aortic dissection).

#### Aortic Cannulation

* 1. Aortic cannula is then placed
  2. Aortic cannula connected to bypass pump arterial line and purged of any air bubbles, lines secured to drapes
     1. \*care must be taken to avoid traction on drapes which could displace aortic cannula.
  3. Aortic cannula now available for transfusion if needed during atrial manipulation and cannulation. The surgeon will often check correct placement by asking the perfusionist to give a small amount of volume. If the line pressure is high beware of dissection.

#### Venous Cannulation

* 1. Atrial purse string placed in right atrial appendage (for single venous cannula) or two atrial purse strings placed-one near superior vena cava, one near inferior vena cava .
  2. Knife or scissors used to open atrium
  3. Venous cannula inserted for single venous cannula-the distal end is placed in the IVC, the proximal holes collect SVC blood from right atrium. Two venous catheters-one in IVC, one in SVC for bicaval cannulation (transplants and tricuspid valve surgery).

#### Adequate Systemic Heparinization

* 1. Confirmed by Activated Clotting Time. The perfusionist will also measure the heparin concentration in blood (HepCon) with the first ACT. This results faster than the ACT and may be used as a surrogate for ACT. The HepCon goal is 3.5mcg/kg.
  2. **ACT of >480 sec**, can go on bypass if necessary.
  3. Pump suckers>250,
  4. >400 to stay on bypass.

#### LV Vent Placement

* 1. Tissue opened between aorta and pulmonary artery;
  2. Purse-string placed in superior pulmonary vein (behind right atrium); \*some surgeons vent via P.A. or direct LV venting. Mitral valve surgery may allow limited LV venting in the operative field.
  3. Pulmonary vein incised with knife and dilated with a clamp; CPAP 15-30cm H20 often used to distend vein and minimizing possibility of air entrainment into left heart
  4. Decompression catheter (“LV vent”) inserted, threaded through mitral valve into the left ventricle to collect any returning blood that come from systemic arterial flow to the lungs; i.e., bronchial arteries (the left ventricle can also be decompressed directly through the LV apex).

#### Root Vent Placement

* 1. Purse string placed in aorta, cardioplegia/ventricular vent needle inserted proximal to the aortic perfusion cannula. Catheter is left in place as the needle is removed.
  2. Air carefully evacuated as cardioplegia line to the pump is attached to the catheter. Venting of the LV is accomplished by negative pressure from a pump head when antegrade cardioplegia is not being administered.
  3. **Venting to prevent cardiac distention is critical to cardiac perfusion, especially to the endocardium.**

#### Retrograde Coronary Perfusion Catheter Placement

* 1. May be placed by surgeon before or after initiation of by-pass. This catheter is placed in the coronary sinus to perfuse the venous side of the heart with cardioplegia.
     1. Indicated in severe left main disease, Aortic Insufficiency.
  2. Anesthesiology team will connect pressure monitoring line from the field to the PA transducer via the male/male connector furnished by the perfusionist and flush with saline.
  3. Central pressures then should be intermittently monitored when the retrograde line is not being perfused. With limited exposure technique, as sometimes utilized, TEE guidance of retrograde perfusion catheter is often requested.

#### Going on Bypass

* 1. Decreased ETC02 indicates decreased pulmonary blood flow with onset of CPB.
  2. Additional Rocuronium if needed based on neuromuscular twitches.
  3. Additional Fentanyl as discussed with Staff.
  4. Additional midazolam as discussed with Staff.
  5. **Turn off** ventilator, anesthetic vaporizer, IV fluids, vasoactive infusions, and pulse oximeter – Switch monitor Bypass Mode and put ventilator in Standby or Bypass Mode.
  6. Check venous drainage from head and neck
     1. Observe face and eyes for swelling.
  7. PA catheters may have to be withdrawn slightly to prevent over wedging and potential PA rupture.
  8. Empty urine collector. Ask circulating nurse to provide an empty saline bottle for urine collection.

1. If cooling is used, blood is cooled in the pump by the heat exchanger in CPB circuit.
2. Hemodynamics response to onset of bypass is a sudden drop in BP due to the decrease in blood viscosity resulting from the crystalloid prime and a drop in SVR.
   1. The perfusionist will temporarily increase pump flows to compensate and will administer phenylephrine in escalating doses of 250-1000 mcg as necessary to treat mean systemic perfusion pressure.
   2. Keep the MAP between 40-80 mmHg during the cold period of bypass (cross clamp on) and between 60-80 during warm bypass (cross clamp off).
      1. There will be exceptions such as patients with carotid vascular disease or chronic renal insufficiency that may need higher pressures (60-80 mmHg) for the entire pump run.
3. Urine output should be maintained at least 0.5mL/kg/hour.
   1. Pump prime contains 25-50 gm mannitol and perfusionist will add additional if urine output does not increase appropriately within the first 20 minutes. The administration of 0.5-1 mg/kg furosemide may be necessary but as little as 10-20 mg may result in adequate UOP.
4. Perfusionist will administer Isoflurane by vaporizer through the bypass circuit.
   1. Benzodiazepines, opiates and muscle relaxants may be given at the initiation of bypass, during rewarming and at appropriate intervals while on bypass. Anesthetic drugs can either be handed directly to the perfusionist to administer into the pump or may be given by central line with an appropriate flush. Rewarming should stop at venous temperature of 36-37 degrees, to avoid overheating the brain.
   2. Hypothermia increases drug half-life but amnesia cannot be assured unless volatile or IV anesthetic drugs are given.
   3. PSI and cerebral oximetry monitor is used by most Staff
   4. Hypertension on bypass should prompt evaluation of adequate anesthetic depth (check perfusion vaporizer on, consider bolus fentanyl)

## The Surgeon’s perspective: off Pump Coronary Artery Bypass Grafting

1. Special Equipment
   1. Pressure bag (300 psi) + 500 mL saline for the “Mister Blower,” which blows saline + CO2 into the field during the procedure to facilitate the surgery
   2. Switch the external cardioverter/defbrillator to the black internal pads across the drape (unplug external pads, plug into internal pads)
2. Temperature Management
   1. Keep the patient warm: for off-pump procedures, always ensure that the Bair hugger is on (no cardiopulmonary bypass means no warming via the bypass circuit) and monitor the patient’s temperature
   2. Keep the room relatively warm, usually 73 degrees F per Dr. Reddy (if the patient is >37 degrees C, you can turn the room temperature down a bit)
3. Neuromuscular Blockade
   1. Check ToFs and paralyze as needed to maintain ToF ¼ to ensure that the patient does not try to assist in their own surgery
4. Post-LIMA and vein graft harvest:
   1. Once they are finished harvesting the LIMA, you will hear the unilateral sternal retractors being taken down and bilateral sternal retractors being placed for pericardial retraction and epicardial exposure
   2. You will also hear the surgeon asking the PA if the vein looks good; this is a giveaway that they are finished with isolating the LIMA
   3. Another giveaway is the surgeon will ask for us to heparinize (100-200 units/kg, or two-thirds dose heparin)
      * How much heparin is up to the surgeon; always confirm dose with surgeon
      * “Full” heparinization is 300-400 units/kg, usually reserved for cardiopulmonary bypass
      * “Partial” is usually 100-200 units/kg, usually used for OP-CABs to ensure ACT 300-350 seconds
   4. This is a good time to text/call the fellow/attending to be in the room if they are not there
5. Anastomosis
   1. After pericardial retraction sutures are in and the epicardium is exposed, they will place a stabilization device around the LAD --> expect some hemodynamic instability
   2. You may see ST changes until the shunt is placed --> ensure adequate perfusion pressure (MAP 70-80) and diastolic pressure adequate for coronary perfusion (start NE gtt if needed)
   3. Once hemodynamics stabilize, they will work on the LIMA-LAD anastomosis
      1. They will ask for the Mister Blower and CO2 to be turned on (hook up the CO2 line to the 5-in-1 connector with suction tubing --> turn on CO2 to 4 L/min; hook up the saline line to the pressurized 500 mL saline bag at 300 psi)
   4. Avoid epinephrine gtt until LIMA-LAD anastomosis is complete
      1. Dr. Reddy will want to know if any drips are started, and he will want us to avoid boluses of pressors/inotropes if possible
6. Post-LIMA-LAD anastomosis:
   1. Giveaway that this portion is done: they will check the graft with the Flowprobe and save pictures via the circulator RN
   2. This is the period where you will have the MOST hemodynamic instability!
      1. Have the fellow/attending in the room BEFORE this step (5-10 minutes heads up)
   3. An apical suction device will be placed on the apex of the heart, and the heart will be lifted up, potentially kinking the SVC/IVC and causing significant hypotension
   4. Steps to avoid hypotension and facilitate the surgery:
      1. Trendelenburg position: will potentially unkink the IVC/SVC and increase preload to the heart during extreme positions --> this should be your first step! Place the head down! Rotating the table toward the surgeon improves exposure of the vessels of the lateral wall.
      2. Ensure euvolemia: have albumin 5% hanging and run the fluid about 5-10 minutes PRIOR to the apical suction device being applied --> this is your second step to mitigate hypotension
      3. Vasocontrictors/inotropes available: start low-dose NE/epi gtt if hypotension has been an issue; increase as necessary
7. COMMUNICATION IS KEY:
   1. If the patient is not tolerating the heart positioning despite these interventions, the surgeon needs to know!
      1. Increase trendelenburg positioning
      2. Make sure albumin is being given
      3. Ensure reasonable pressor use
      4. TEE assessment
   2. The last step to mitigate hypotension is to REPOSITION THE HEART
      1. Hypotension will usually resolve once the heart is back down
      2. Surgeon will reposition the heart to achieve optimal surgical conditions and achieve hemodynamic goals
      3. Work with them to determine optimal positioning and pressor/inotrope use
8. Post-SVG-distal graft anastomoses:
   1. Once the distal vein grafts are done, the surgeons will start working on the proximal grafts which attach to the AORTA
   2. AVOID HYPERTENSION (keep systolics 90-100) to avoid aortic dissection or graft disruption
   3. Surgeons will ask for the anesthesia attending to perform epiaortic ultrasound using the TEE machine --> have the fellow/attending in the room prior to this (5-10 minutes) to facilitate this in a timely manner
   4. Work on getting the pressure down prior to this step (5-10 minutes prior)
      1. Titrate NE/epi gtts down to achieve systolics 90-100s
      2. Increase volatile anesthetic if needed
      3. Give more narcotics, bolus nitroglycerin available
      4. Level the patient/take them out of trendelenburg --> headup if hypertensive
   5. Surgeons will hole-punch the aorta using HeartStrings or other devices
      1. High risk of aortic dissection --> if patient SBP >110-120s, ALERT THE SURGEON to stop to get the BP down prior to the aortotomy
9. Post-SVG-proximal anastomoses:
   1. Surgeon will again check the graft patency using the Flowprobe and save pictures via the circulator RN
   2. They will ask for us to give protamine at this point if the grafts are good
   3. Perfusionists will communicate the appropriate dose of protamine
   4. Give test dose protamine (10 mg or 1 mL) prior to starting (inform the room/surgeon when protamine is started)
   5. Alert the fellow/attending at this point
   6. Give protamine over 10-15 minutes as tolerated if the initial test dose is well-tolerated
   7. Inform the room/surgeon when protamine is completed --> start timer
   8. Draw post-protamine labs at 3 minutes (or 10 minutes if post-protamine TEG is desired)
   9. Ensure adequate acid-base status and resuscitation; give fluids/bicarbonate as necessary
10. Post-protamine
    1. Once grafts are determined to be patent and protamine is completed, the surgeons will work on closing the chest
    2. Dead giveaway that the chest is closed: sternal wires/fixators are in, and the surgeons will usually announce that the chest is closed --> pay attention to ST changes and hemodynamic changes during this period
11. Key Points
    1. Hemodynamic instability will be a big issue during off-pump coronary artery bypass (OP-CAB) procedures, especially during the vein grafting portions where the heart is lifted up using an apical suction device. HAVE THE FELLOW/ATTENDING IN ROOM prior to this portion and communicate with surgeon.
    2. Avoid epinephrine gtt until the LIMA-LAD anastomosis is completed; it is theorized that starting epinephrine prior to this anastomosis being completed induces more myocardial ischemia and increases myocardial oxygen demand
    3. **Always be prepared to emergently crash on bypass.** This means having heparin drawn up and ready. In an emergency, you will need to administer heparin rapidly while surgeon is cannulating for bypass.

## The Surgeon’s perspective: Coronary Artery Bypass Grafting (ON-PUMP)

Coronary arteries visualized, fat cleared away and sites chosen for bypass (usually the left anterior descending, its diagonal branches, the circumflex and its marginal branches, the right coronary or the posterior descending).

### Cross clamp applied to the aorta and cardioplegia given

1. Cardioplegia repeated approximately every 20 minutes.
2. Cardioplegia is injected down grafts also.
   1. Solutions typically contain K+ to relax the myocardium and may vary with the particular surgeon.
3. PA will be positioned to hold the heart.
4. Coronary artery opened with small blade and fine scissors

#### Distal Anastomoses

1. Anastomosis of the graft to the coronary artery is accomplished with fine double-ended prolene suture-“distal anastomosis”
2. One graft may bypass more than one coronary artery [sequential grafting]’the side of the graft is incised and sewn into another accessible artery-“side to side” anastomosis

#### Re-Warming

1. Begins as the last distal anastomosis is completed (usually the IMA).
   1. Perfusionist should avoid over warming due to CNS implications. Re-warming normally continues until venous pump temp reaches 37 C.

#### Proximal Anastomoses

1. Small punch made into aorta for each “proximal anastomosis” site, aortic punch used to make an even circular opening
   1. Vein length and position assessed and vein cut
   2. Veins secured to aorta by an end to side anastomosis
   3. Send fellows an FYI message to inform them when proximal grafts are being completed.

### Cross clamp removed

1. If not already administered:
   1. Administer 2g magnesium
2. Unless there is a reason to avoid stimulation, cardiac stimulating drugs such as epinephrine may be started after the aortic cross-clamp is off when the pacer wires are being placed according to prior Staff discussion.
   1. Avoid MAP ↑ that could result in aortic dissection or dislodging the partial clamp.
3. Check the pacer box to ensure the batteries are functioning. (The Medtronic pacemaker when you see a picture of a battery in the upper left hand corner, the batter is low and should be replaced.
   1. Set to synchronized pacing at 84 bpm.
4. Check last iSTAT electrolytes, glucose, and Hct.
   1. K+
      1. >6.5-7 mEq/L, it may be necessary to take steps to ↓ the K+ level.
         1. CaCl2 administration may be all that is necessary.
         2. 10 units insulin with 25 gm dextrose may also be used.
         3. It’s advisable to check blood glucose as it may be elevated if the patient is a diabetic, on epinephrine, or taking steroids.
         4. In extreme cases (K+ > 7meq/L), the perfusionist may also ZBUF to remove excess K+.
      2. 4.0-5.0 ideal
      3. <4.0
         1. Discuss infusion of K­+ with Staff.
   2. CaCl2 >4.5 desired
      1. Have 1 amp CaCl2 ready for injection when weaning from bypass.
   3. HCO3+ - perfusionists may treat with Sodium Bicarbonate
      1. If acidotic and HCO3+ <20, discuss administration with Staff.
   4. Hct <21, have RBCs in room and checked ready for transfusion.

## Separation from Bypass and Decannulation

Note: this is a very important time for the whole Operating room team. It is especially important to have open communication between all team members during this period. Active communication and closed loop communication (repeating back request and orders) are helpful to assure that what is said is correctly noted, and acted upon. No unnecessary communication during this time.

Checklist:

1. Is the patient anesthetised and paralyzed?
2. Check your monitors, lines functioning?
3. Morgan MArino’s Poem
   1. “Rhythm, Rate, ventilate
   2. check the labs, get them straight
   3. warm the patient, cut the flows
   4. come off pump, shoot a CO”

#### Defibrillation

1. (5-50 Joules) directly to myocardium if necessary when venous temperature is greater or equal to 34 C. Surgeon may have the perfusionist give Lidocaine.
   1. Inform surgeon of ventricular fibrillation or other arrhythmia on EKG.
   2. Surgeon will select charge.
   3. Based on rhythm, may consider amiodarone bolus vs lidocaine vs other interventions.

#### De-Air

1. Check on TEE for intra-cardiac air.
   1. Air may be evacuated by aspiration of beating left ventricle through the aortic vent usually after valve surgery; atrium and left ventricle manually massaged to release trapped air and ventilation of the lungs resumed. Perform Valsalva maneuver to displace trapped air from pulmonary veins.
2. A temporary pacemaker wire is placed in the right ventricular myocardium and brought through the skin. If there is any rhythm disturbance, the ventricle can be paced at an appropriate rate or the wire can be covered and used later if necessary
   1. A pacing wire may be placed in the right atrium. If the conduction system is intact, the atrium can be placed alone, otherwise the atrium and ventricles are paced sequentially. A temporary pacing system may not be necessary if the patient has a permanent pacemaker.
3. Have appropriate inotropes and vasopressors ready to go (epinephrine, norepinephrine, phenylephrine, esmolol, nitroglycerin, etc)

### Separation from Bypass, things to check:

Calcium Ready: 1g calcium chloride syringe ready for administration.

Normothermia: What is the nasopharyngeal, bladder and/or the pump venous line temp? At least 360C

Rhythm: Is the patient in NSR or do you need to pace? Is the rate adequate? Pacing wires in place? Verified to capture?

Ionotropes: Start after aortic cross-clamp is off and pacer wires placed.

Ventilation: Give the patient a few manual positive pressure recruitment breaths (hold CPAP at 35-40 cmH2O for 30-40 seconds then release to 10-20 cmH2O and repeat). Turn on the ventilator. Easy to forget. Surgeon may periodically ask you to stop breathing after separation. Use closed loop communication, make sure apnea alarms are on.

Monitors: Turn them back to “off bypass” if you switched the monitor to “on bypass” at the initiation of bypass. Central venous pressure, arterial catheter, and pulmonary artery catheter functioning?

Vasoactive Infusions: Ready?

Functioning Pacer Box: Turned on with appropriate settings?

Carrier Fluid: Line running at appropriate rate?

Perfusion: What is the pump flow? Begin appropriate inotropes and vasopressors when the pacemaker wires are being sewn in, this gives the heart time to recover after the cross-clamp is removed and still have a few minutes for the inotropes to begin to work. Make sure the carrier line is running.

### Post Bypass Hemodynamics:

blood pressure Goal is to maintain adequate perfusion pressures while avoiding excessive bleeding.

* Systolic greater than 80 mmHg is generally acceptable.
* Systolic pressure between 100 and 120 mmHg is desired to avoid bleeding.
* If systolic pressure is greater than 120 mmHg the patient is hypertensive and there may be excess bleeding.
* Maintaining diastolic and mean pressures are important in ensuring adequate coronary and other end-organ perfusion.

Heart rate and Rhythm: Sinus rhythm with rate of 70-90 is generally desired to maximize cardiac output with adequate diastolic filling and coronary perfusion time. This may change depending on the clinical situation prior to bypass, discuss with fellow and staff.

If pacing is required, ensure adequate capture, appropriate mA, and proper mode – during sternal closure cautery may inhibit pacing if in DDD mode, consider changing temporarily to DOO or ASYNCHRONUS mode as indicated. You must be certain to return this programing to a sensing mode prior to ICU handoff once electrocautery use is complete. With LVH or diastolic dysfunction, atrial synchrony is particularly important in maximizing cardiac output – surgeons may place both ventricular and atrial pacing leads – ensure proper capture prior to chest closure.

Cardiac Output/Index (CO/CI): Important to maintain adequate cardiac output (most providers will use cardiac index, so know the patients BSA). If you have hypotension or hypertension check cardiac output to guide appropriate treatment. Assess contractility, heart rate, rhythm, SVR, preload, etc.

* CI = CO/BSA, often surgeons and perfusionists are targeting CI >2, but this does not take into account efficiency of individual contributing variables such as heart rate, rhythm, contractility, stroke volume, SVR, preload – evaluate and continually re-evaluate the patient throughout the post-bypass period.
* Contractility and myocardial dysfunction can be assessed by vigilant monitoring of invasive waveforms and TEE. Select appropriate ionotropic agents accordingly with fellow and staff.

Volume status: There are multiple considerations including anemia, hyper/hypovolemia, coagulation, etc. In general the goal is euvolemia. If you are hypovolemic prior to sternal closure you will have difficulties maintaining adequate blood pressure and cardiac output during and after sternal closure.

### Protamine:

There are allergic, anaphylactic, and histamine responses. Dose is variable but protamine 10 mg will equalize heparin 1000 units. Protamine comes as 10 mg per mL so if you used 30 mL of heparin, 30 mL of protamine will neutralize it. You are forming a salt between a base and an acid. You’re titrating the response. You need to give the dose and then check the response by measuring the ACT in 5-10 minutes.

Use closed loop communication when giving protamine. Communicate with the surgeon and perfusionist directly and clearly when administering protamine. Make sure they acknowledge your communication before proceeding. Some communication examples include:

1. “Starting protamine test dose. “
2. “Protamine half in.”
3. “Protamine finished/completed.”

Protamine Administration: Give 10 mg = 1 mL and check for allergic response manifested as hypotension, bronchospasm, rash, or pulmonary hypertension. Stop administration for problems. You can get severe hypotension from protamine, be ready with phenylephrine, norepinephrine, or epinephrine. Steroids, H1 & H2 blockers, vasoconstrictors, inotropes, and returning to bypass can help. Allowing the heparin to spontaneously be metabolized is another option for severe reactions. Then give the rest of the dose slowly. What is slowly? If you follow the PDR it would be about 2 hours. Over 20 minutes is not unreasonable.

Protamine may be administered in small (1-2mL) bolus’ at a time, monitoring for hemodynamic effect. Another option is to dilute the full reversal dose in a 100mL saline bag and delivered as an infusion through a micro dripper. Discuss with staff for their preference.

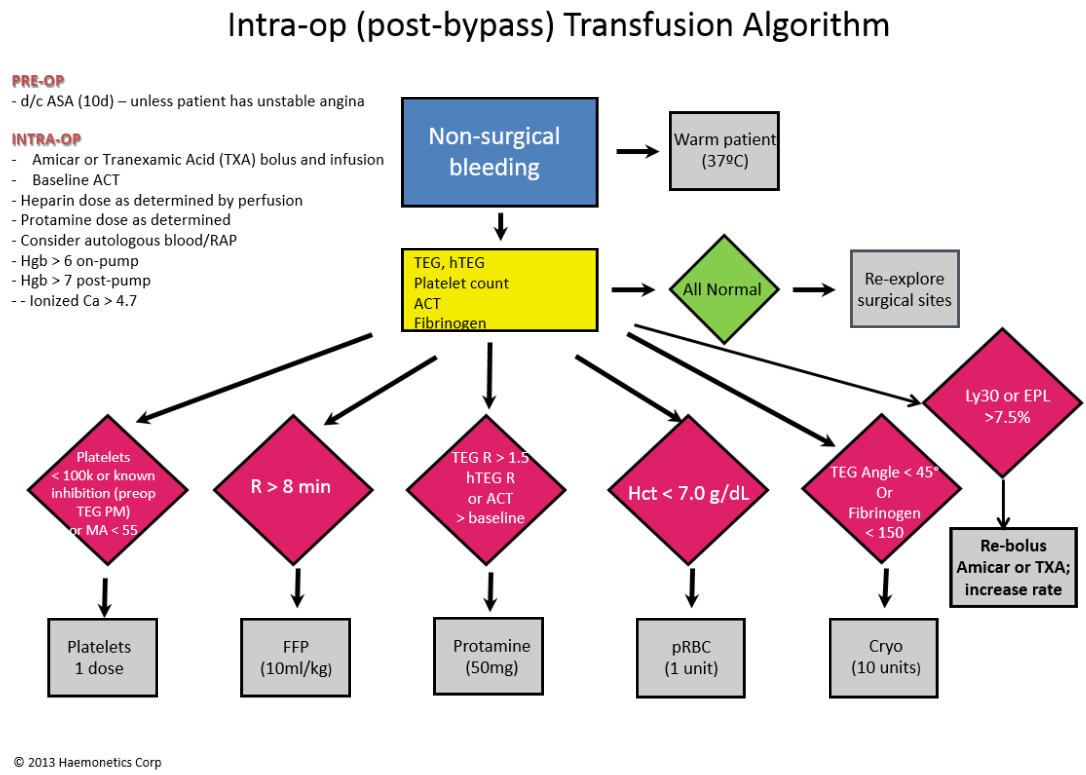
Our routine is that **when 1/2 of the protamine is in, tell the perfusionist so that they can stop the pump suckers** and avoid clotting the pump. **Ensure that the perfusionist acknowledges this and has turned off the pump suckers**. If you clot the pump you will be unable to return to bypass. Once **all** the protamine is in, tell the surgeons and perfusionists, and then check an ACT and possibly TEG in 5-10 minutes. ACT should return to baseline (120-130). If it has not, give more protamine. If you administer pump blood after this point you may need to give additional protamine. You can only find this out by measuring the ACT. Draw post bypass TEG and ACT approximately 10 minutes after the complete dose of protamine has been administered.

### Returning to Bypass:

If there is severe hypotension, bleeding, low cardiac output, other problems, you may need to return to bypass. If you have given the protamine, give another dose of heparin at 300 U/kg and check an ACT. Before the aortic cannula is removed, you should make a decision about whether you may need to return to bypass. If you are having severe problems maintaining the pressure despite inotropes, tell the surgeons. They will delay removing the aortic cannula, place an intra-aortic balloon pump, immediately return to bypass, consider ECMO, or may consider RVAD/LVAD placement. It is very bad for the heart to be dilated by high filling pressure and then have low coronary perfusion pressure.

### Post-Bypass bleeding:

Medical or surgical bleeding occurs commonly after separation from bypass. In patients you expect to have bleeding (oozing) after separation from bypass, consider drawing blood for coagulation studies and TEG after protamine reversal. The Thromboelastogram (TEG) is used routinely in CV cases. In addition to the TEG, a useful algorithm for managing post-bypass bleeding is below:



## Sternal Closure and Transport to CTICU

### Sternal Closure

Volume Ensure adequate volume resuscitation prior to sternal closure. As emphasized above, hypovolemia will lead to hemodynamic instability upon sternal closure.

Surgeons will ask for vent to be held prior to closure as they are cauterizing any bleeding along the sternum, ensure adequate ventilation, oxygenation, and perfusion are maintained.

The surgeons will use various methods to close the sternum including wires, plates, zip ties, or other devices.

Vigilance is required during this time, changes may be associated with intravascular volume, intrathoracic pressure, occlusion or kinking of grafts, etc. These changes may include blood pressure, ventilation, rhythm, EKG, bleeding, CO/CI, SVR, PVR, tamponade, etc.

* Monitor trends in blood pressure, CVP, PA pressures, SpO2, EKG, BIS, cerebral oximetry if used, etc.
* Repeat thermodilution CO/CI, record in Epic and report to surgeons.
* Repeat TEE exam with emphasis on volume status, contractility, regional wall motion abnormalities, valvular changes, fluid collections, etc.

### Patient Transport

ICU Sign Out Sheet should be filled out during bypass; final information should be recorded prior to transport including: fluid totals, infusions, last antibiotic, last paralytic and if reversal has been given, last and total opiate, last sedative, ventilator settings, recent ABG/Hgb/Hct/ACT/Heparin/TEG, and any other pertinent labs.

Medications should be organized and prepared for transport. Adequate sedation should be ensured. Syringes of emergency drugs should be readily available including epinephrine, norepinephrine, phenylephrine, ephedrine, nitroglycerin, esmolol, propofol, fentanyl, midazolam, and any other necessary bolus medications. Check twitches and bring reversal drugs for reversal in ICU, if appropriate. Infusions should be checked for appropriate doses and sufficient volumes including the carrier. Determine where emergency medications will be administered prior to transport. Ensure IV pole has been lowered to fit through the door.

TEE Removal is one of the last things prior to transport. A final evaluation should be made of function, volume status, and fluid collections including pericardial and pleural collections. Fellow/staff will remove TEE. OG should be placed and secured after TEE removal.

Lines should be organized, keep CO syringe attached but remove electric cable. Remove fluid warmer attachment (useful to keep sterile and readily available in case of an emergency). Invasive monitors and lines should be secured to patient prior to moving to decrease risk of losing vascular access on transport. Ensure dressings are in place over central line and other lines or monitoring sites – if soiled or peeling perform sterile dressing change prior to transport. Date/time/initial CVC dressing. Also ensure all injection ports are capped before arrival in CTICU. Place OG tube unless contraindicated after TEE removal and secure to patient with tape.

Ventilation and oxygenation should be planned in advance by ensuring full oxygen tank and either transport bag, Ambu bag, or transport ventilator.

Monitors must be continued upon transport. Ensure proper zeroing and that the monitor is freely visibly during transport. Also check to make sure adequate battery supply is available during transport. Regardless of need for pacing, if pacing wires were placed the patient should be transported with the pacer box. Routinely continue monitoring invasive pressures, EKG, pulse oximetry, as well as maintaining clinical vigilance to patient ventilation and position. Leave CO cable and temperature cable in the OR.

Debrief is a formal opportunity to discuss issues with the surgical and nursing teams. Take the opportunity to do a similar debrief with the anesthesiology fellow and staff after transport is complete – this will greatly enrich your learning and experience doing cardiac cases.

Departure to CTICU should be called to CTICU desk by the circulator. Ensure anesthesiology staff is aware and present for transport. With transporting multiple monitors and frequently discharged beds it is helpful to stay in neutral for transport through the halls. Be prepared to stop or perform additional resuscitation during the transport.

### CTICU sign-out

Upon arrival in the CTICU the expectation is that the anesthesiology team maintains control of the patient’s ventilation until placed on the ventilator with confirmed ventilation and hemodynamics until sign-out is complete. Assist in transferring monitor cables to the monitor in the room, ensure labeling and level of transducers are correct and that the patient is relatively hemodynamically stable prior to sign-out.

Sign-out is a very critical step in the transfer of patient care. Speak loudly and clearly so the ICU staff, surgeons, nurses, respiratory therapists, and others in the room hear the report. The surgeon or usually physician assistant will give report first followed by the anesthesiology team. Use the ICU sign-out form to guide complete sign-out, include pertinent positives and negatives and your concerns regarding continued patient care.

Cleanup before leaving by collecting oxygen tank, medication syringes, or other supplies. Return monitor and cables to the proper location for cleaning. Return unused albumin and other medications to the Pyxis machine or designated areas. Complete the “Anes Handoff” note, “Anesthesia Stop”, and “Post Evaluations” for all patients.

# CARDIAC ROOMS 4 AND 5 – BYPASS CASES Quick Guide

## Room Set-Up:

### MACHINE and Equipment CHECK

* Ambu Bag and transport oxygen tank
* Machine checkout, leak test, volatile anesthetics filled, and CO2 absorber
* Suction
* Monitors (NIBP, EKG, Pulse ox, temp cable, A-line, CVP, PAC with cable)
  + Triple setup primed
  + Cardiac Output gun + cable
  + TEE: Enter patient info, connect probe, make sure there is jelly in 10cc syringe and bite block
  + A-line piece with 10cc syringe + included stopcock filled with saline
  + PSI
  + Circ Arrest cases – Cerebral oximetry with 2 pads
* Airway: ETT, blades, oral airway, tape/strap, adjuncts PRN
* Hotline with blood tubing, TURNED ON
* Carrier line with manifold and 60 inch 2 mL extension tubing.
* Introducer kit (9Fr), PA catheter, gloves, US probe cover on procedure table.
* 6 Plumb pumps minimum
* Blue towel at head of bed, foam donut, spider straps
* Orogastric tube available

## MEDICATIONS:

### Pre-Induction:

* Albumin 5% 250mL – 4 bottles
* Fentanyl 250mcg – 4 vials
* Midazolam 5mg – 2 vials
* Propofol/Etomidate
* Rocuronium 100mg
* Succinylcholine
* Lidocaine 2% - 100 mg (5mL) [Not with WCC].
* Esmolol
* Nitroglycerin: 50mcg/mL – 2.5mL NTG with 7.5mL NS
* Ephedrine – dilute to 5mg/mL
* Phenylephrine (80mcg/mL). Syringe: 80mcg/mL, 20mL. Gtt: 20mg in 250mL, rate 15mL/hr, VTBI 230mL
* Norepinephrine (16mcg/mL). Syringe: 8mcg/mL in 20mL (50/50 NE and NS). Gtt: 4mg in 250mL, rate at 0.02mcg/kg/min, VTBI 230mL
* Epinephrine (16mcg/mL). Syringe: 8mcg/mL in 20mL (50/50 Epi and NS). Gtt: 0.05mcg/kg/min, VTBI 230mL
* Tranexamic Acid (TXA) – Bolus 1g, then start gtt @ 6mcg/kg/hr
* Magnesium 2g/50mL – administer over 10 minutes after cross clamp removed.
* CaCl 1gm – have in line when coming off bypass
* Dexmedetomidine/Propofol for transport sedation.

### Other possible Infusions:

* Vasopressin: 20units/100mL (0.2units/mL). gtt @ 0.02-0.04 units/min
* Milrinone: 20mg/100mL – 0.2mg/mL. Bolus 1-4mg from vial (1mg/mL) ♦FJV: If pump run is >2h, have perfusionist give 20-25 mcg/kg bolus 3min via the bypass pump before coming off bypass. If EF <30%, give bolus and start infusion when coming off bypass.
* Dobutamine: 500mg/250mL (2mg/mL). gtt @2.5-10 mcg/kg/min
* Dopamine: 800mg/250mL (3.2mg/mL). gtt @2-20 mcg/kg/min
* Nicardipine: 50mg/250mL (200mcg/mL). gtt @5-15 mg/hr
* Nitroglycerine: 50mg/250mL (200mcg/mL). gtt @5-20 mcg/min
* Clevidipine: 25mg/50mL (0.5mg/mL). gtt @1-6 mg/hr. Bolus 0.25 mg every 60-90 seconds to effect.
* Insulin: 100 units/100mL. gtt @1-14 units/hr, with boluses as needed.

## Patient Transport

### IF PICKING PATIENT UP FROM CVICU:

* Take ICU transport monitor and cables
* Bring bolus drugs (pressors, midazolam, fentanyl, and paralytic)
* Bring O2 tank and Jackson-Reese bag
* Transport with perfusionist if VAD, ECMO, or IABP – **ALWAYS**.
* If on high PEEP consider transport with respiratory therapist and transport ventilator.

#### Once in CTICU:

* Free flow IV attached to patient
* Write down Vent settings
* Write down gtts, ask if patient on scheduled antibiotics and when they need to be re-dosed
* Make sure none of the gtts are imminently about to run out
* If on ECMO, find out what they’re flowing at
* Make sure blood is available, ask how many blood products they’ve received in last 24hrs

## Lines

### Arterial line

* Place pre-operatively.
* Generally in left radial, exceptions should be discussed with fellow/staff (In arm with highest NIBP if large discrepancy).
* Sterile prep with gloves and towels.
* Do not attempt more than 2 times without getting ultrasound, fellow, or staff.

### CVC (9fr mac)

* 2 chloraprep scrubs, wait 3 minutes to dry
* Place drape
* US cover
* Place wire and confirm line placement
* Dilate and place catheter after wire placement confirmation
* Suture and place CHG Tegaderm high and away from sternal notch.

### PA Catheter:

* White to carrier/infusion manifold
* Red to syringe for balloon
* Blue to CVP/CO gun
* Yellow to PA

## DURING TEE EXAM:

* Ensure antibiotics administered (cefazolin + vancomycin) Note: incision must be within 1 hour of cefazolin
* Collect baseline arterial blood gas and ACT, 3 mL to perfusionist, 10 mL if running baseline TEG.
* Bolus TXA
* Shoot baseline CO
* Chart drugs, LDAs, and procedures

## PRE-BYPASS:

* Redose fentanyl and paralytic prior to sternotomy
* Sternotomy: pause ventilator and open APL.
* Decrease TV & increase RR to allow surgeon exposure during IMA dissection
* While PA performs saphenous vein harvest, watch for CO2 embolus
* Giving heparin: using central line aspirate blood into syringe before giving heparin, give heparin, and SET TIMER.
* Check ACT after 3 min
* If surgeon using a retrograde coronary perfusion catheter: connect to PA transducer w/ male:male connector, do not flush until asked by surgeon
* Try to keep pre-bypass crystalloid fluid totals to <1L
* SBP goals during aortic cannulation: 100-110, 110-120 after cannulation

## GOING ON BYPASS:

* Turn off vent, set O2 flow to ~0.2L
* Turn off volatile, tell perfusionists when you do so and make sure they turn on isoflurane
* KVO IVF
* Give additional dose of fentanyl/midazolam/Rocuronium as needed.
* Empty Foley bag
* Turn off all gtts except for TXA, insulin, and vasopressin if needed
* Check eyes/face for swelling

## ON BYPASS:

* MAP 40-80 for cold bypass unless carotid disease or CKD (then 60-80). MAP 60-80 for warm bypass
* Monitor for PA pressures >15, CVP>5, if elevated bring to attention of perfusionists and surgeon.
* Monitor for EKG electrical activity, you want complete arrest (asystole) during bypass, inform perfusionists and surgeon if activity noted.
* UOP goal at least 0.5mL/kg/hr; update perfusionists about UOP.
* Prepare medications for coming off bypass and begin hand-off sheet.
  + Magnesium – in-line, CaCl – available,
* Make sure pacemaker box is available and has adequate battery life.

## Coming Off Bypass

### CROSS-CLAMP RELEASE:

* Re-dose fentanyl, midazolam, Rocuronium as necessary
* Make sure all gtts, lines, and monitors work
* Give Magnesium 2g
* If using retrograde cardioplegia, turn transducer back to PA/CVP
* **Page staff/fellow**

### SEWING PACING WIRES:

* Start inotropes + vasopressors but avoid large increases in SBP or MAP (risk of aortic dissection)
* Calcium chloride in-line but not pushed yet
* What is rhythm –
  + Does patient require pacing?
  + Defibrillate directly to heart for Vfib refractory to lidocaine given by perfusion once venous temp reaches >34⁰
* Is patient warm (>36⁰)?
* Treat K of <4 when coming off pump, goal of 4-5.
* Re-recruit lungs when asked by surgeon, then turn on vent to lower TV but no agent yet

### COMING OFF BYPASS:

* **DO NOT COME OFF BYPASS WITHOUT STAFF IN ROOM**
* Make sure PA catheter isn’t wedged – if it is pull it back a few cm
* Calcium chloride 1g
* Turn monitor back to normal from bypass mode
* Turn on agent if hemodynamically stable
* Shoot CO

## Off Bypass

### continued vigilance

* Goal SBPs 100-120
* CI >2.1, HR 70-90, MAP >65 (unless discussed otherwise with surgeon or staff).
* Tell perfusionists total bypass UOP

### Protamine and hemostasis

* Give protamine when asked, never while on bypass!
  + Announce Test Dose – 1 mL (10mg) and wait for 45-60 seconds.
    - Watch for hypotension, pulmonary HTN, anaphylaxis
  + **Announce “Protamine Halfway”** or something very similar and clear
  + Announce “Protamine Complete”
* Set timer and draw ACT/labs after 4-10 min
  + May send TEG if concern for coagulopathy (long pump time, anticoagulants pre-op, etc) – 10 mL to perfusionists

## Sternal Closure

* Watch for hemodynamic changes and pre-load sensitivity
* Shoot additional CO after sternal closure, report to surgeon
* Complete ICU handoff sheet
* Appropriate transport sedation and preparation
* Check for twitches and reverse neuromuscular blockade if possible

## TRANSPORT:

* Make sure O2 & transport monitor in room and charged
* If running nitric oxide, page RT at 24-7774 to help transport
* Bring emergency transport drugs
* Check carrier to ensure there is enough fluid for transport
* Disconnect hotline tubing from bolus line
* Organize lines and monitors, ensure sterility of ports and dressings
* Page staff prior to moving to transport bed

# Transcatheter Aortic Valve Replacement (TAVR)

TAVRs are performed every Tuesday (OR 23) and every other Friday (OR 1) if not in the cath lab. TAVR emails with patient specific information procedure plan (ie, access site, pacing site, sentinel) is emailed to staff and fellows. Contact fellows for this information the night before the procedure.

Generally, we are moving away from doing cases in the OR and doing central lines unless medically necessary. Proceduralist will give us access to their venous line for central venous access. Have fluids ready to hook up to extension tubing if using their central access.

## Location:

OR 23 – have AAA help turn the room set up around so the patient’s feet are near the door, will need to move anesthesia machine and anesthesia cart.

Cath Lab 2 – have AAA bring down Plumb pumps, anesthesia cart and move an anesthesia machine into the room. Don’t forget fluid warmer! Will need both cardiac & general medical box from main OR Omnicell.

## Set up:

4 Plumb Pumps connected to manifold with Carrier, Phenylephrine, Norepinephrine, and Dexmedetomidine . Have a bag of epinephrine (16mcg/ml) on back table but do not spike.

Dual Hemopod if not planning for central line

Full cardiac set of push drugs (only need ~100 mcg of Fentanyl, no midazolam)

Emergency airway supplies

2nd IV set up/hot line infusion with blood tubing

Secondary tubing for antibiotic (generally vancomycin)

Simple face mask with end tidal CO2, O2 extension if needed, blue disk viral filter

Central line – 7 or 8 Fr double lumen

Have heparin drawn up.

Ensure protamine is in the room.

Lead apron for you and your staff

## Pre op:

Standard preop exam

Consent for GA/MAC, TEE, and Vascular Access for all patients.

Click consent for blood in Epic anesthetic plan

A-line in preop (if cardiology plans for sentinel device you need to avoid right radial artery)

## Intra-op:

Turn on sedation as soon as patient is in the room. Titrate to effect. Standard ASA monitors, plug in infusions and bolus lines. May place central line depending on patient comorbidities and staff preference (Most often 7Fr or 8Fr dual lumen CVC).

TTE Pre-scan by cardiology echocardiographer

Arms tucked by circulator, defib pads applied

### Surgical Access:

Generally, the proceduralist will access both femoral arteries (for valve and pigtail) and one femoral vein (pacing wires). Ask for venous access if no other central line placed. Consider small bolus of fentanyl during femoral line procedure. Dilation of femoral vessels can be quite painful as well as injection of local anesthetic. The right radial artery may be cannulated by the procedural team if sentinel device is used for cerebral protection.

### Anticoagulation:

Cardiologist will tell you the dose of heparin to give. Draw ACT 3-5 min after. Practice closed loop communication. Cath lab RN, Karissa, or Colleen can run. Otherwise will need to call AAA.

### 2nd time out:

They are almost ready to deploy the valve. Make sure staff is aware so they can be present for valve deployment.

### Valve position/ valvuloplasty/ deployment:

When the wire is across the aortic valve, this can cause a lot of ectopy and hemodynamic instability due to loss of sinus rhythm. Be ready to assist the systolic blood pressure.

Rapid ventricular pacing : Done by Cardiology RN (typically Karissa). Ensure capture of every beat (failure of capture during deployment could lead to embolized valve). There will essentially be no CO or SBP during rapid pacing. Be ready to augment blood pressure quickly if the patient does not recover after ceasing pacing.

Reassure patient during valve deployment that they may feel shortness of breath and chest pressure

### Post-deployment:

Echocardiographer will TTE to assess valve placement, valve gradients, paravalvular leaks, etc.

Potential for new bundle branch blocks or complete heart block, be vigilant of EKG changes

If valve assessment is normal will give protamine to reverse heparin (give over 5-10 minutes)

Turn off sedation, avoid hypertension, place PACU orders and fill out PACU handoff sheet like standard case

Edited 2/2/2021 by Annie Huang and Phillip Morris