Syllabus for Cardiac Anesthesia

Preoperative evaluation

This handout will help you to prepare yourself for the most challenging cases in anesthesia practice. The patients are unstable and fragile. The first meeting with the patient is a very important moment. The history and physical provide vital information about the patient's exercise tolerance and co-morbidities. Your anesthesia management is based on the issues addressed in the preoperative evaluation. In cardiac anesthesia, besides the usual preoperative information, the preoperative evaluation must contain:

1. **laboratory data**
2. **echo**
3. **stress test**
4. **catheterization results**
5. **pulmonary function results**

At this level of training a complete anesthetic plan should be established based on the preoperative evaluation.

Preoperative preparation of the patient

In most cases the patient is prepared for surgery in the holding area. The preparation means H/P and IV line placement. A-line placement can be done in different ways. If there was any concern about the hemodynamic stability of the patient monitors should be used to check the vitals regularly. If decision was made to use Versed and/or Fentanyl, nasal O_2 should be administered. The key for the successful A-line placement is good local anesthesia with Lidocaine. The time is limited to establish the lines. If there are difficulties, the anesthesia attending should be notified to discuss the next step. The A-line can be started in the OR before or after induction of anesthesia depending on the stability of the patient and the preference of the attending.

If the patient is transferred from MICU or SICU the preparation should be the same. An appropriate IV line (18-14 G catheter, IV tubing with hand pump and extension) should be established. The patient should be transported with a running IV. The IV lines in the ICU-s are regulated by pumps and too slow for appropriate anesthesia management. If a new IV line could not be started the patient should be disconnected from the pump and a running IV with our tubing should be established. Phenylephrine, Epinephrine, Lidocaine and Nitroglycerine syringes should be available during the transport. If the patient is seemingly unstable, preparation should be made for intubation at any time.

Keep in mind: bad things can happen during transport but appropriate preparation can give a chance for survival.

General considerations for cardiac anesthesia management

The anesthesia resident has a big responsibility in the cardiac OR. The resident has to be aware of the patient's vital signs at all times. Even if the anesthesia attending is in the room the resident should be ready to react to changes in the vital signs. During establishment of the A-line, central line, or other duties (like setting up pumps or filling out the anesthesia record), the resident should react or tell the attending what medication should be given to keep the BP and heart rate at a certain level. The patient's hemodynamic stability is the responsibility of the anesthesia resident. To keep the patient stable vasoactive drugs and drips should be prepared or be available in the room. The anesthesia team should be ready to go on CPB at any time.

Monitors

- ASA non-invasive monitors.
- ECG: 5-lead. Do not forget the 3-lead ECG for the Echo machine.
- A-line: usually on non-dominant arm but it can be variable in difficult situations.
- Pulmonary Artery Catheter (PAC): R IJ is the usual site to introduce. The second most appropriate site is the R subclavian approach to be on the same side. If both were unsuccessful L IJ, L subclavian or femoral approaches are the choices. Placement of the PAC can be a point of discussion with the surgeon. Patient for ASD closure, tricuspid valve repair, CABG with good LV function do not necessarily need PAC. However, the introducer should be placed in these patients so we can introduce a PAC at any time. The other aspect of the PAC is that we have a simple pressure catheter ($ 50) or an oxymetric catheter ($ 250). If the patient is stable and no sign of low CO we can choose the simple pressure catheter.
    - Patients with severe valvular stenosis or with left bundle branch block have a high risk of life threatening hemodynamic situations if arrhythmias or complete heart block occur. In these cases holding the PAC at 20 cm until the cannulation of the aorta is a safe way to keep the patient stable. For example, a catheter induced atrial fibrillation can be life threatening in severe AS or MS. CPR can be also very difficult and ineffective in these cases.
- TEE: the patient is paralyzed so we do not need the bite protector. The probe is placed usually by the attendings but at a certain level of the training the resident can put it in. Certain attendings (Drs Seres / Weitzel) want to place the probe before the establishment of the central line. The rationale is to see the position of the guide wire before the placement of the introducer. If the introducer is placed into the carotid artery then surgical repair is required along with case cancellation. The goal of the TEE training is to teach the basic images and calculations which can be useful in cardiac or general anesthesia practice. The door is open for everybody to spend extra

time and review cases in the echo databases with an attending or with the cardiac anesthesia fellow.

- BIS: Although there debates about routine use of the BIS monitor in cardiac surgery it can be a helpful tool to keep the anesthetic and analgesic agents at minimal level especially in patients with hemodynamic instability. In context with other clinical data the BIS monitor can help to diagnose CNS damage in certain situations like massive air embolism.

- TEG: It can be used in cases where significant bleeding is expected. The TEG can be checked before Heparin in cases where the patient is taking Coumadin, Plavix or Aspirin, or was on Heparin infusion, to evaluate the coagulation status and predict changes after the cardiopulmonary bypass.
    - TEG can be taken on bypass using tubes with Heparinase. Unfortunately there are false R elongation results in these cases so it is not useful for evaluating the coagulation status.
    - TEG taken after Protamine tested with and without Heparinase can give a good picture about the presence of Heparin and the effectiveness of the coagulation system (platelets, coagulation factors and their interaction). The details should be checked in the accompanying references.

Preparation of drugs for cardiac anesthesia management

You have to prepare certain medications in 10 cc syringes in the OR to react to changing situations:

Epinephrine	10 mcg/ml,
Phenylephrine	100 mcg/ml,
Nitroglycerine	20-50 mcg/ml,
Ephedrine	5 mg/ml
Atropine	0.1 mg/ml
Glycopyrrolate	0.2 mg/ml

Heparin 30,000 U/syringe, two syringes should be prepared.
Heparin is one of the most important drugs in cardiac anesthesia. One syringe with 30,000 U of Heparin should be available at any time!!!

Drips:
Please setup a Baxter pump with the following drips:

Sodium Chloride 0.9% 500 ml, as a carrier at the rate of 50 ml/hr
Epinephrine 4mg/250 ml, at the rate of 0.05 mcg/kg/min

At the preparation of these drips please run them for a couple of minutes to be sure that the pump is actually working.

Dopamine, Dobutamine, Milrinone, Vasopressin, Nitroglycerine and / or Sodium Nitroprusside should be available in the room for particular cases. In case you have to use them the initial doses are:

Dopamine:	0.5-2 mcg/kg/min for renal dose 3-10 mcg/kg/min for beta receptor effect >10 mcg/kg/min for combined beta and alpha receptor effect
Dobutamine:	5 mcg/kg/min
Milrinone:	Loading dose: 50 mcg/kg or a reduced 2 mg dose IV during 5-10 min. Maintenance: 0.375-0.75 mcg/kg <0.3 mcg/kg/min in case of renal failure
Vasopressin:	6 U/hr (0.1 U/min) as starting dose and titrate down appropriately. On the Baxter pump we use U/hr rate.
Nitroglycerine:	0.1 – 0.5 mcg/kg/min
Nitroprusside:	0.1 mcg/kg/min

Antifibrinolytic agents

With the recent removal of Aprotinin from the market, Amicar is now the fibrinolytic used at our institution. In off-pump CABG cases, antifibrinolytics are not typically used.

Previous indications for Aprotinin included:
Redo cases (relatively big raw surface for bleeding)
Heart transplantation (high incidence of severe bleeding)

Predicted long CPB run:	double valve cases CABG and valve cases
Concern about coagulation:	Use of Aspirin or Plavix less than a week before the surgery

Aprotinin was removed from the market due to the following results from the Canadian trial evaluating the three available antifibrinolytics. This is the FDA early communication about Aprotinin in the: Blood conservation using antifibrinolytics: A randomized trial in a cardiac surgery population (BART) study. The preliminary findings suggest that, compared to the antifibrinolytic drugs, epsilon-aminocaproic acid and tranexamic acid, aprotinin increases the risk of death.

Protocols:

Amicar: Seven vials (5g each) should be available.
5 g is going to the perfusionist for the CPB circuit.

5 g IV from syringe slowly during 5-10 minutes after Heparin administration. It can cause severe hypotension.
Continuous drip: 20 g in 500 ml Sodium Chloride at the rate of 50 ml/hr or 10 g in 500 ml Sodium Chloride at the rate of 100 ml/hr which is the rate of 2g/hr. This will be our carrier solution and it will run during the CPB.

Heparin

Heparin dose is calculated in the following way:

Heparin dose = BW (kg) x 300 (U)

Heparin should be administered slowly because can cause severe hypotension. The effect of Heparin is measured by ACT usually 3 minutes after the administration. The Heparin dose is appropriate if the ACT is >480 sec measured in the presence of celite as an activator of coagulation.

Protamine

The dose of Protamine is determined by the perfusionist based on the amount of Heparin given during CPB. The calculation is:

Heparin given during CPB in U/ 100 = Protamine (mg)

Protamine should be administered slowly. Protamine can cause different side effects:

1. Transient hypotension (Histamine release)
2. Anaphylactic reaction (IgE mediated)
3. Hypotension with increased PA pressure (Prostaglandine release)
4. Noncardiogenic pulmonary edema (Prostaglandine and Complement release)

Because of these reactions 1-2 ml test dose should be given to exclude anaphylactic reaction. During Protamine administration Calcium and Epinephrine vials should be ready.

Management of Anesthesia

Induction-Maintenance

Induction of anesthesia can be challenging. The information about the hemodynamic status of the patient is important to plan the anesthetic management. Vital signs in the

chart, in the holding area, the Echo data, the catheterization results and the laboratory data characterize the hemodynamic and metabolic status of the patients.

In most cases Etomidate combined with 200-250 mcg Fentanyl provides safe induction for these patients.
Signs of heart failure might change the induction plan. The combination of Ketamine, Scopolamine and low dose Fentanyl can be a safe choice in those cases.

Many of today's patients for cardiac surgery are relatively stable. Anesthesia can be maintained with a combination of a narcotic, versed and anesthetic agent like Isoflurane or Desflurane. There can be differences in induction and maintenance based on the preference of different attendings so the plan should be discussed with the attending.

Heart Transplant Cases

These are usually challenging cases. Patients have low ejection fraction (< 30%) and low cardiac output. The induction of anesthesia can be difficult. The induction should be smooth with the least possible impact on hemodynamics. Etomidate is a good choice for induction with either Fentanyl or Versed. Combination of Fentanyl and Versed in these cases could cause critical hypotension. Vasoactive agents should be immediately available during the induction and maintenance of anesthesia. It can be a good practice to give a small dose of Phenylephrine or Epinephrine with the induction agents. Patients with low CO will have a late reaction for these agents so the preventive dose will mask the hypotensive effect of the induction agents.

Patients with manifest CHF can have cardiac arrest even with induction with Etomidate. Scopolamine 0.4 mg IV and reduced dose of Etomidate or Ketamine IV with Succinylcholine 100 mg IV can be a choice for induction. Scopolamine in combination of Fentanyl or Versed can be a choice also.

Some of the patients are on IABP. These patients are relatively stable. Induction with Etomidate and Fentanyl works well.

Some of the patients are on LVAD or other assist devices. These patients are relatively stable during induction with Etomidate and Fentanyl. However, these patients are very sensitive to fluid deficits. Maintenance of appropriate volume status is the key point in their management.

The **maintenance of anesthesia** depends on the hemodynamic status of the patient. There are situations where anesthetic gases are not tolerated. Using the BIS monitor and using the minimal analgesic and amnestic doses of medications are suggested. Scopolamine, Fentanyl and Ketamine can be a good choice in these serious situations.

Coming off bypass is usually challenging. Contractility can be altered, vasodilation can cause severe hypotension, and severe bleeding complications can cause problems. At UCHSC the combination of Epinephrine (0.05-0.1 mcg/kg/min), Dopamine (5 -10 mcg/kg/min) and Milrinone (0.375-0.5 mcg/kg/min) is used for the transplanted heart

with a good success rate. There can be differences in attending preferences. The plan should be discussed with the attending and the surgery team.

There are cases where the transplanted heart is not working properly. The right ventricle is particularly sensitive to high pressure or excessive volume load. IABP, LVAD, RVAD or rarely LVAD and RVAD placement is necessary. There is a higher risk for severe bleeding in these cases.

To help the right ventricle and/or improve the oxygenation NO can be used in certain cases in 20 ppm concentration.

At the end of the case the patient should be transferred to the SICU with vigilant observation and pressure management.

Thoracic Cases

The room preparation is the same as for general cases except the preparation for double lumen tube (DLT) placement. Left sided DLT is used for the majority of the cases. The surgeons may ask for right sided DLT in cases where the left main bronchus is involved by a tumor or other disease. Keep in mind that no matter what the diameter is, the length of the DLT is the same. Taller patients will have larger diameter bronchi, and this is why we use larger tubes. Larger tubes will provide better stability in the placement. However, most of the cases can be managed with relatively small tubes. The DLT is positioned under direct fiberoptic guidance with the bronchoscope.

If the DLT cannot be placed because of difficulty with the airway, intubation with a number 7 single lumen tube is sufficient. The placement of a DLT using a tube exchanger can be attempted. If this is not successful a number 8 tube can be placed and a bronchial blocker can be used for lung separation.

Monitors: ASA monitors are used routinely. A-line placement is not routine even in open thoracotomy cases. It depends on the cardiac history and stability of the patient, and on the expected blood loss or possible hemodynamic compromise during the case. It should be discussed with the attending and the thoracic team.
BIS monitor can be helpful in these cases also for appropriate administration of the analgesic and anesthetic agents.
Two big IVs are necessary for open thoracotomies. Right IJ introducer placement can be necessary in certain cases with high risk for severe bleeding.

Induction: It is similar to general cases but can be modified based on the clinical situation.

Maintenance: Combination of Fentanyl, Dilaudid, Ketamine and anesthetic gases are usually the main players with adjusting them for the cases with different expected pain levels. Whenever the chest is closed and on suction spontaneous breathing should be initiated for evaluation of the effectiveness of breathing and the pain level. Different attendings may have different approach in this aspect of the anesthesia management.

Suction of the DLT is necessary for effective breathing.

Conclusion: At the end of these cases patients should be extubated. Positive pressure ventilation is not good for these patients causing leakage of the fresh connections. The patients should be transferred to the PACU.

Epidural: The surgical technique is changing. Even lobectomies can be done with small chest excisions.

VATS cases can be done without epidural.

Lobectomies with VATS can be a debate. Although they have a small chest incision many times these patients do well without an epidural. The pain team should be also involved. Many times they can place a paravertebral block in the PACU if necessary.

Open thoracotomy cases usually benefit from epidural catheter placement for post-operative pain control. The pain team or the thoracic resident can start the epidural. It can be an arrangement between the attending, the resident and the pain team. The effectiveness of the epidural should be checked by 3-5 ml Lidocaine 1.5 % with epi. If a level is not obtained, consider replacement of the epidural. If there is a difficult epidural placement, consider starting the case without an epidural with effective combination of Ketamine and narcotics, and place a paravertebral block in the PACU. There is no way to put down every combination of problems and opportunities. The goal here is to show flexibility and an effective communication with the attending, thoracic surgery team, and the pain team. Nothing is written in stone. A fine balance between patient safety, pain treatment and effective and timely anesthesia management should be considered.

The epidural catheter can be used intraoperatively. First it is used to give the epidural dose of the Fentany, Dilaudid or Morphine. For these cases Dilaudid 200-300 mcg is sufficient without causing respiratory depression. Morphine is not recommended in these high thoracic epidurals. Fentanyl has too short effect for these cases.
At the end of the case 6-10 ml Bupivacaine (0.125 %) can be titrated.

Lung Transplant Cases

These cases can be extremely challenging. The room preparation is similar to the heart cases. It can be variable by attendings but usually we use Nitroglycerin and Epinephrine on the pump with NaCl as a carrier. Nitroglycerine can help in pulmonary hypertension. Epinephrine can be helpful in hypotension.

A-line and at least one big IV are important for the management of these cases. Right IJ introducer and pulmonary artery catheter placement is routine in our Institution.
TEE can be used based on the specific problems of the case. It is not used routinely.

Double lumen tube (DLT) should be available in the appropriate size. We use left sided DLT for every case. It works well even for a left side single lung transplant. If DLT

placement is unsuccessful bronchial blocker placement is the next choice in single lung transplant cases. For double lung transplant DLT placement is critical.
It is important to evaluate the patient frequently on one lung ventilation.

Oxygenation, peripheral blood pressure, CO, and pulmonary artery pressure are important parameters in decision making about the necessity of cardiopulmonary bypass.

As a general rule we administer minimal amount of crystalloid or other fluid to these patients. If the patient requires fluid, Albumin is the first choice. **We have an agreement with the surgical team not to give Hextend.** There was an ICU observation that the patients who were given Hextend had pulmonary edema and other signs of reperfusion injury more frequently. It is not published but the experience was convincing enough not to give Hextend in these cases.

Induction: These patients have small oxygen reserve and they might have high PA pressure. A rapid sequence induction can be ideal in these cases to avoid a trouble with difficult ventilation. Propofol, Etomidate in combination with Fentanyl and/or Versed can be the choice with Succinylcholine or Rocuronium. The choice and combination of the induction agents based on the hemodynamic status of the patient. DLT placement can be challenging due to anatomical deformities and secretions which alters the visibility and the stability of the tube. Frequent suction and frequent use of the bronchoscope will help for stabilizing the airway.

Maintenance: Anesthetic gases in combination with Fentanyl work well. As mentioned, fluid administration is minimized in these cases. In the case of low blood pressure Phenylephrine boluses or drip as well as Epinephrine boluses or drip can be considered.

Low oxygenation (< 70-75 %) with low CO can be an indication to go on cardiopulmonary bypass.

High PA pressure with right ventricular failure can be also the sign to initiate cardiopulmonary bypass.

In certain cases there is significant surgical bleeding after the transplantation of the lung and cardiopulmonary bypass should be initiated to solve the problem.

These are the most frequent causes for going on cardiopulmonary bypass. The appropriate steps should be made to keep the patient stable during preparation for bypass.

Conclusion: At the end of the transplant the DLT should be replaced by a single lumen tube. A safe and conservative approach is to use the exchange catheter as the long surgery often results in significant airway edema.

After DLT tube exchange, the patient will be transferred to the SICU.

This syllabus will help to establish your anesthesia practice in cardiothoracic anesthesia. It does not cover everything so you should review the textbooks and the literature for further reference. Use the articles of your cardiac anesthesia folder to understand the

clinical situations you face in the cardiac and thoracic OR. Using the TEE and the TEG can be a valuable skill in your future practice. Here is an outline of their use during your residency training.

Using TEE in the cardiac OR

In the 2nd year you should learn primarily the clinical management of the cardiac cases. During the second year you will learn gradually the role of TEE in the clinical management. The goal is in this year to recognize the basic views and corresponding heart structures. The skills can be further developed in the 3rd year. You can learn basic calculations for evaluation of systolic and diastolic function. Furthermore, based on the Friday morning lectures and OR practice you can learn the evaluation of different valve diseases. To help for this process you will find basic articles about TEE practice and a collection of normal and abnormal parameters which can be obtained in different clinical situations. The description of the continuity equation and the PISA technique will help in 3rd year to evaluate valve diseases and hemodynamic changes.

Using the TEG in the OR

Thromboelastography is a useful tool for evaluation of altered coagulation states. There is a summary about the method and its clinical use in your package. Generally the TEG can be used to indicate administration of blood products or evaluate the coagulation after administration of blood products. The goal is to normalize the TEG parameters. Severe bleeding with normal TEG parameters suggests either surgical bleeding or microvascular bleeding with severe endothelial and tissue factor pathway dysfunction. This situation can be an indication for FVIIa administration.

Enjoy your rotation:

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