ANESTHESIA LIVER PROTOCOL
Revised 4/05/16

GUIDE TO A SAFE ANESTHETIC

1. Vascular Access
--At least 2 introducers (9-french) with an optional large-bore peripheral. Preferred: MAC in RIJ with CCO PA catheter. Second introducer: 9 Fr in double stick of RIJ is most common. Alternate is either a 8.5 Fr Rapid Infusion Catheter (RIC) in the antecubital or other peripheral vein OR a 9 Fr introducer in the subclavian vein. The initial peripheral IV can be converted to a RIC over a wire.

--All CVP line insertions should be ultrasound-guided.

--Two arterial lines are now a standard part of our monitoring setup. These are preferably on opposite sides of the body. A femoral arterial line is sometimes necessary to meet this guideline. The rationale is to increase the chances that at least one A-line will be working accurately in an emergency, and to eliminate the down-time caused by lab blood draws.

--For special high-risk situations, i.e., polycystic disease, a third introducer is recommended.

--The Arrow Two-Lumen Dialysis catheter (12 Fr for females, 14 Fr for males) is a convenient and fast way to get two extremely large-bore catheters in one insertion and involves only one extra dilation maneuver compared to standard sheath insertion.

--Use Belmont Infuser on the MAC sideport, 9 Fr introducer or Arrow dialysis catheter; use a Hotline fluid warmers on the other introducer. The Level 1 can be used on the RIC or third introducer if patient is at high risk for massive blood loss, i.e., polycystic disease.

--Pulmonary artery catheter with continuous cardiac output capability is expected. Treat high PA pressures early if they occur with intravenous dobutamine, milrinone, inhaled Flolan, or nitric oxide. (See #9 below for RT contact numbers and details.)

--Discuss all high PA pressures with the surgeon at time of PA catheter insertion.

2. Induction
A rapid sequence induction with cricoid pressure is recommended. Midazolam, propofol and etomidate are all reasonable induction agents. Succinylcholine for muscle paralysis is expected unless potassium is significantly elevated. In that case a non-depolarizer like rocuronium is an acceptable alternative.
Narcotics: Minimize or eliminate narcotic analgesics until the end of the procedure. Narcotics potentiate the profound vasodilatation inherent in end-stage liver disease. They also can contribute to a functional impairment of the sympathetic nervous system, making hemodynamic stability more difficult to achieve.

Hypotension: strict attention to hypotension, especially post-induction, is important. This usually appears during inconvenient times like line insertion. Trendelenburg position and the usual short-acting pressors are all acceptable. Keep mean BP > 60 and SBP > 100.

3. Maintenance
--Sevoflurane or isoflurane. Neuromuscular blockade is with a non-depolarizer of your choice. Atracurium infusion at 5-9 mcg/kg/min provides predictable blockade independent of liver and kidney function. Many academic centers, however, recommend pancuronium (if available) due to length of case. The modern NMBs are not a problem in liver failure, but use a train-of-four twitch monitor.

4. Volume Status
--Keep patient as euvolemic as possible to avoid right heart failure and to reduce the visceral swelling that may occur during the procedure. Large-volume crystalloid infusion is associated with visceral edema that makes abdominal closure difficult and is generally not good for the donor liver.

--Give more 5% albumin than saline. The maintenance fluids should be FFP and albumin. Administration of 1-2 liters of 5% albumin during liver transplant is not unusual. If coagulation continues to be an issue (long r value on TEG), use FFP instead of albumin. (See Coagulation section below.)

--6% hetastarch (Hespan) is contraindicated due to potential coagulation problems and fraudulent published studies. Hetastarch has been linked in recent studies to elevated risk of post-operative kidney failure and death. It is not used.

--A reasonable goal is a CVP 10-12 throughout the case and on arrival in ICU. Most patients have a PA diastolic pressure “sweet spot.” The pre-anhepatic phase is a good time to observe the patients blood pressure response to various PA diastolic loading conditions.

5. Coagulation
--Decisions for FFP and platelets are guided by TEG results and pre-operative values. Open the TEG application on the computer to see a developing TEG curve in real time on our monitors. Ask a monitoring tech about how to sign into the application.

--We ran a pilot project for ten consecutive OLTs starting in September 2014. Five TEGs and five coagulation panels were obtained together during each OLT or liver-kidney case:
pre-op baseline in the ICU, at induction, in early anhepatic phase, early neohepatic phase, and one hour post-reperfusion. A final TEG during closure of the abdomen may be indicated in liver-kidney transplants or if still in the OR after a lengthy post-reperfusion phase. The results show decreased use of all blood product components after instituting the more frequent measurement of the thromboelastogram. Coag panel kits have been assembled and are available in the module. There is an extra blue-top (citrated) tube in the kit for an optional TEG that can be run in the ACL labs if needed. The sample is good for two hours from time of draw.

Please refer to the **Coagulation Algorithm** at the end of this document for additional info. The following are guidelines; clinical situations may require different therapy.

---Give FFP for r value > 10
---Give platelets for MA < 50
---Give cryoprecipitate for $\alpha < 45$ degrees or fibrinogen level less than 150 mg/dL. Cryoprecipitate is supplied 5 units/bag.
---Maintain a hematocrit between 26 and 30, but do not over-transfuse PRBC's.
---A coagulation panel includes: CBC (no diff), INR, PTT and fibrinogen; for the final sample, send the it to the lab so the results will be available on arrival in ICU.

6. **Reperfusion**
---Increase FiO2 to 1.0 and turn down the inhaled anesthetic to about 0.5 MAC or less about 5 minutes prior to reperfusion.
---Have “code drugs” immediately at hand: epinephrine 1 mg and atropine 1 mg in boxed syringes. The surgeon will ensure that sterile defibrillator paddles are immediately available in the OR.
---Have at least 3 units of RBCs in the reservoir of the Belmont infuser prior to unclamping. It takes at least this much to fill the new liver.
---Epinephrine 10-30 mcg IV boluses, starting 1-2 circulation times prior to unclamping to induce a hyperdynamic state. The goal prior to unclamping is SBP about 160-180. For patients that do not respond vigorously to epinephrine, increase norepinephrine or give 1-2 units of vasopressin if necessary. If running dopamine, you may wish to briefly increase the rate to 20 mcg/kg/min. When correcting post-reperfusion hypotension with volume, use the PA catheter and TEE to guide fluid therapy and avoid right heart failure.
---Bicarbonate 50 mEq and calcium chloride 1 gm, boluses of each prior to unclamping and after reperfusion for treatment of acute hypotension
---Vasopressin 1-2 U IV boluses as needed for hypotension in early reperfusion phase

7. **Metabolic Acidosis and Hypocalcemia**
---Aggressive use of bicarbonate for treatment of acidosis.
---THAM is unavailable but is very useful for treatment of metabolic acidosis when sodium exceeds 145 from sodium bicarbonate therapy. The dose of THAM is 1-4 bottles as needed (500 ml glass containers).

---Stay ahead of metabolic acidosis and hypocalcemia:
Keep bicarbonate > 24
Ionized calcium > 1.1
--As a guideline, the ratio of bicarbonate amps to calcium chloride amps is roughly 1:1. Stay on top of your point-of-care laboratory testing.

8. Potassium Management
Prior to reperfusion, obtain potassium level to make sure it is below 4.0. Reperfusion can increase K+ transiently by 2 mEq/L which can lead to cardiac arrest. If the potassium is above 4.0, administer regular insulin 10 Units and 25 gm of dextrose about 10-15 minutes prior to reperfusion.

9. Pressors
--Vasopressin, norepinephrine and epinephrine are the mainstays when a pressor is necessary. Keep the SVR > 500 and mean BP > 60.
--Have 20 mL of 1 U/mL vasopressin available for brief hypotension episodes; 1-2 U IV as needed.
--Begin norepinephrine early, for SVR persistently < 500 and associated SBP < 90 with reasonable anesthetic depth. Communicate with the the surgeon if you are contemplating starting norepinephrine.
--Small doses of epinephrine are recommended for reperfusion (10-30 mcg) as described above.
--The surgeon can often occlude the abdominal aorta transiently to give you time to restore order with medications and judiciously controlled volume infusions.

10. High PA Pressures
Pre-operatively, consider TEE probe placement in patients with a history of RV or LV dysfunction, elevated PA pressures, significant cardiac valve pathology, ASD or VSD. Do not hesitate to begin inhaled Flolan, at 50 ppm for elevated PA pressures. Advise the surgeon that you are doing so. The pharmacist will advise the infusion rate required on the IV pump that RT sets up that will deliver this medicine through the ultrasonic nebulizer spliced into the anesthetic breathing circuit. This drug works quite well, and can help reduce the sequellae of post-reperfusion syndrome should it occur.
--Page Lead RT at 81-4673 or 222-0799 and request a Flolan nebulizer set up
--Call or page the pharmacist to get Flolan prepared and sent to the OR
--preparation time is likely to be 30 minutes in an acute situation for delivery of the nebulizer and drug so call early
--Do not discontinue the Flolan during patient transport.

For severe pulmonary artery hypertension, especially with known RV dysfunction, consider starting nitric oxide early in the case as an alternative to inhaled Flolan. Page the lead respiratory therapist at the number above to get the NO equipment into the OR.

Other maneuvers may or may not be appropriate:
-Reverse Trendelenburg position
-Nitroglycerin infusion at low dose
-Milrinone load and infusion
-Adenosine
-Methylene blue 10 mL for vasoplegic syndrome
-Insertion of TEE probe for evaluation of volume status, right and left heart function.
Surgeon can partially clamp aorta transiently to increase brain and heart perfusion at the expense of increased afterload, which may be problematic for a failing heart.

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This is a working protocol. Questions and suggestions can be sent to rwhitney@aawsc.com.

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