ADVANCED EP PROCEDURES CHECKLIST

Preoperative Evaluation

- Discuss home medications: anticoagulation, anti-platelet agents, rhythm control agents, antihypertensives
- Recent labs and studies: CBC, coags, EKG, Echo
- Type and Screen / ABO confirmation
- Appropriate for TEE? Query history of dysphagia, esophageal or gastric surgeries / complications

OR Setup

- Standard anesthesia machine check and resuscitation equipment
- Extensions on all lines and circuits
- Available hot line + arterial line transducer
- TEE machine
- Defib pads and machine
- Blood in room (at least 2u pRBC)
- Confirm availability of CT surgery and/or Cardiology for echo

Useful Medications

- Avoid preoperative anxiolytics
- Discuss antibiotics (especially if endocarditis)
- Norepinephrine (8 or 16mcg/ml) bolus syringe + Norepinephrine 16mcg/ml infusion (or premade bag)
- Epinephrine (8 or 10 mcg/ml) bolus syringe + Epinephrine 16mcg/ml infusion
- Vasopressin 1 unit/ml bolus syringe
- Calcium chloride 100mcg/ml bolus syringe
- Heparin 1000 units/ml bolus syringe

EP LAB - LEAD EXTRACTION

PATIENT DEMOGRAPHY

- Patient present for multiple indications for lead extraction: nonfunctional leads, systemic or local infections of device, or thrombus adherent to leads
- Depending on the indication for device and extraction, patients may present with a variety of diseases including CHF, CAD, HTN, sudden cardiac arrest, sick sinus syndrome, and endocarditis
- Patients may have an underlying need for pacing or ICD therapy, which complicates he periprocedural management of patients requiring device removal, or in the case of infection "device holiday" until a new permanent device may be installed

DISEASE BACKGROUND AND PROCEDURAL DESCRIPTION

- Leads for devices are initially secured by a screw mechanism into the endocardium, but fibrosis after 6 months makes older leads nontrivial to unscrew and remove
- Procedure is performed under GA with TEE guidance for assessment of vegetations/thrombus, and early detection of pericardial effusion
- Simplest case will involve leads which will "unscrew" requiring no further manipulation, this is common in new or infected leads in which the tissue is inflamed and of poor quality
- Usually, the primary removal method is via a extraction sheath from the device pocket, where it strips tissue from the lead as it advances along the lead
- Proceduralists obtain femoral venous access to introduce additional tools. These can include temporary pacing wires, and snares. Snares can stabilize the lead as it is pulled, improving the geometry of extraction and reducing the hemodynamic effect of pulling on a lead within the heart

PRE-OPERATIVE ASSESSMENT

- Patients should have a routine evaluation of relevant medications (particularly anticoagulants, anti-platelets, antihypertensives, and rhythm control medications)
- Preoperative bloodwork should be evaluated, with focus on CBC, coag status, CXR, and EKG
- Patient's history should be obtained, with particular interest in previous cardiology procedures, heart surgeries, and vascular surgeries
- Patients history regarding issued with dysphagia, esophageal and gastric problems should be assessed for TEE placement

PRE-OPERATIVE PREPARATION

- Routine checks of anesthesia machine, extension circuit, emergency airway equipment, suction and resuscitation medications are imperative because access to additional equipment and anesthesia providers are limited. Usually, two infusion pumps and an invasive pressure transducer are available in each lab. At UCSF, a glidescope is located outside in the hallways of the 5^{th} and 12^{th} floors. Contact the off-site anesthesia technician if you need any additional equipment (46939 or 46938).
- Blood products: are required, with two units routinely available in the room. Platelets and FFP may be requested based on the patients preoperative medications
- **Antibiotics** are indicated, and often include treatment for endocarditis and/or vancomycin therapy
- **Echocardiography and Cardiothoracic surgery support** should be confirmed prior to the procedure. Interventional cardiology support for a emergency percutaneous pericardiocentesis is often also available

ACCESS/FLUIDS

- At UCSF, the EP nurse will start a peripheral IV in the pre-op holding area, usually 20 gauge (left arm).
- **Additional several large bore IVs are recommended**. However, remember that the introducer sheaths placed by the proceduralist may be used for central venous access. This is a discussion best had at the beginning of the case, as it may affect approach and placement of these sheaths for anesthesia access.
- **Anticipated blood loss** is usually 50-100cc, usually associated with bleeding into the pocket. Hot line should be available in case of need of transfusion.
- Vaspressor and inotrope use is common in particularly sick patients, even in the absence of procedural complications. A vasoactive drip line is recommended to facilitate additional medication drips as needed. Bolus medications (vasopressin, epinephrine, calcium) are useful to have prepared.

MONITORS

- **Standard ASA monitors**: The EP lab staff will assist you in placing radiolucent ECG leads to ensure that they do not interfere with the fluoroscopic images or the rest of electrophysiology monitors.
- **Invasive arterial monitor**: The patient's cardiopulmonary co-morbidities should determine whether pre-induction arterial catheter is necessary. Invasive arterial pressures are mandatory for this procedure, and usually best obtained from a dedicated radial arterial line placed by anesthesia
- **Temperature**: May be performed with a foley temperature or nasopharyngeal temperature. Esophageal temperature will not be possible due to the placement of the TEE probe.
- **Urinary bladder catheter** is usually performed due to extended duration of this procedure
- **Defibriilation** pads for defibrillation/cardioversion/temp pacing
- **TEE** probe which is placed and monitored by echo lab or cardiac anesthesia

ANESTHETIC TECHNIQUES

- **Anxiolytic premedication** should not be given routinely in the holding area as most ambulating patients (at UCSF) are expected to walk into the Cath lab and position themselves while monitors and patches are placed.
- Broncho-dilator, anti-reflux medication and antacid should be given as indicated by the anesthetic technique and the patient's co-morbidities.
- **The anesthetic of choice for lead extraction will be GA to facilitate TEE monitoring.** The choice of **maintenance** of anesthesia is up to the anesthesia provider. The local anesthetic infiltration significantly decreases the amount of pain of the vascular access, so minimal intra-operative and postoperative opiate is needed. The goal is to maintain hemodynamic stability. The choice of agent has little effect on the procedure itself.
- **Emergence**: Following anti-coagulation reversal, removal of the venous sheaths, and manual hemostasis, most patients are extubated in the procedure room. Special caution should be made to avoid excessive coughing, vomiting, and bending at the waist during extubation immediately following hemostasis. EP staff often applies additional manual compression during extubation.
- **Recovery after GA** will be in the 5th floor cath holding for low risk MAC/GA patients, 4th floor for higher risk GA patients, and 6/10 ICC for highest risk patients, particularly those requiring pacing with a temporary pacing wire. Patients who had MAC or GA may be recovered in the EP holding room unless the anesthesia provider feels that additional monitoring is necessary in the PACU or ICU due to co-morbidities or intra-operative events. In general, patients with potential vasopressor need should recover in the PACU. Depending on the size of the sheath and the use of anti-coagulation, the patient will need to remain supine with the hips straight for 4 to 6 hours because of risk of bleeding.

KEY PROCEDURE-RELATED POINTS

- Once patient is anesthetized, and line/monitors placed, the EP doctors will begin by obtaining femoral venous access.
- Once pocket is opened, attempts will be made to simply unscrew the leads (low risk). If unsuccessful, the lead will be prepared by attaching a long wire along which the extraction sheath will be deployed.
- Transient hypotension is common as leads are pulled upon (endocardial traction), but this should be short lived
- **Hypotension of uncertain etiology == pericardial effusion until proven otherwise**
- Once lead(s) are removed, a ten minute timer is set to observe for hemodynamic and TEE derangement potentially seen in pericardial tamponade. After that period TEE and CT surgery backup may be relieved.
- After device removal, a new device may be implanted in the same or opposite side of the chest. A peripheral IV in the arm for potential contrast in the new location can be useful.

POTENTIAL COMPLICATIONS

- **Local damage of subclavian** vessels as the extraction sheath enters
- **Pericardial effusion** leading to tamponade as the leads are pulled from the endocardium. Anesthesia team should be familiar with techniques to manage a patient in tamponade, including volume resuscitation, vasoconstrictors, and inotropes. Tamponade is usually indicated by persistent hemodynamic instability unrelated to the induced arrhythmia and refractory to routine vasoconstrictors and fluid. Emergent pericardial drain placement can be performed by the interventional cardiologists or surgical decompression by CT surgeons. Real blood loss can be quite small, as even small amounts of blood in the pericardium can cause hemodynamic collapse. Liberal use of volume and constrictors as temporizing measures is still recommended until drainage is performed.
- **Arrhythmia** that is hemodynamically significant is always a risk. It is usually very transient and associated with catheter tips, but is occasionally sustained in a critically ill patient

SPECIAL ERGONOMIC CONSIDERATIONS

- The TEE machine typically resides on the patient's right side, with the TEE probe stabilized near the head of the bed with the aid of the airway tree or reference frame for support
- **Hazards to the anesthesia provider:**
    - **Equipment is in motion!** Be aware of the C-arm when it is in motion as it can move quickly and endanger heads and shins and may snag loose wires and tubings.
    - **Ionizing radiation:** Consider time (limiting exposure), distance (inverse square law), and shielding (both garments and barriers) when in ionizing radiation environments. Particular attention should be granted to protecting the lens of the eye, thyroid, hematopoietic centers in long bones, and reproductive organs as these are particularly sensitive to ionizing radiation. The exposure is greatest as it exits the collimator (the part below the table) in path to the image intensifier (the part above the patient). However, scatter radiation is produced as the X ray encounters items in its path (the patient). Areas on the body that are often overlooked ("weak spots") include neck, shoulder/arm pits, and back. Lead (radiation protective) garments should cover the neck to the knees and are designed to be worn when facing the source.

DURATION 3 - 8 hours (simple removal vs complex removal/reimplantation)

EP LAB - WATCHMAN/LARIAT

PATIENT DEMOGRAPHY

- Patients with persistent atrial fibrillation and also intolerant to long-term blood thinners may be candidates for percutaneous left atrial appendage (LAA) closure
- Patients may present with a variety of cardiac comorbidities associated with atrial fibrillation, including CHF, CAD/HTN, valvular disorders, thyroid disease

DISEASE BACKGROUND AND PROCEDURAL DESCRIPTION

- Both procedures are performed under GA with TEE guidance for assessment of LAA thrombus, transseptal puncture, device deployment, and monitoring for complications
    - The procedure will be canceled if a LAA thrombus is discovered
- The Watchman device is a self-expanding occlusion device deployed via an endocardial procedure. The proceduralist will obtain femoral venous access and access the left atrium via transseptal puncture. TEE guidance is helpful for transseptal puncture and guidance of the wire into the left upper pulmonary vein or LAA as needed by the proceduralist. The Watchman device is then deployed into the LAA.
    - Anticoagulation is necessary for at least 45 days post-procedure, as there is still risk of thromboembolism until the body forms scar tissue around the Watchman device
    - Of note, other percutaneous LAA occlusion devices exist, but only Watchman has demonstrated superiority in RCTs compared to anticoagulation therapy in preventing stroke
- The Lariat device is a soft-tissue closure device originally developed for other surgical procedures and adapted for LAA closure via an epicardial procedure.
    - First, the pericardial space is accessed via micropuncture needle. Serial dilations are performed over a wire to insert a pericardial sheath. Second, femoral venous access with a transseptal puncture is established to place a magnet-tipped guidewire at inside the tip of the LAA. A second magnet-tipped guidewire is inserted into the pericardial sheath and a Lariat snare device is advanced over this wire to occlude the LAA. TEE is used to guide transseptal puncture and confirmation of LAA closure. A final suture is deployed to finalize the LAA closure.
    - Anticoagulation is usually not necessary for patients post procedure
    - Prior open heart surgery is usually a contraindication (heart needs to be freely mobile within pericardium)
    - Long-term complications unique to Lariat includes pericarditis and Dressler syndrome
- Long-term complications for both devices include residual stumps and leaks, though the Lariat device is associated with lower rates of leaks at 1 year.

PRE-OPERATIVE ASSESSMENT

- Patients should have a routine evaluation of relevant medications (particularly anticoagulants, anti-platelets, antihypertensives, and rhythm control medications)
- Preoperative bloodwork should be evaluated, with focus on CBC, coag status, CXR, renal function, and EKG
- Patient's history should be obtained, with particular interest in previous cardiology procedures, heart surgeries, and vascular surgeries
- Patients history regarding issued with dysphagia, esophageal and gastric problems should be assessed for TEE placement

PRE-OPERATIVE PREPARATION

- Routine checks of **anesthesia machine, extension circuit, emergency airway equipment, suction** and **resuscitation medications** are imperative because access to additional equipment and anesthesia providers are limited. Usually, two infusion pumps and an invasive pressure transducer are available in each lab. At UCSF, a glidescope is located outside the EP control room. Contact the off-site anesthesia technician if you need any additional equipment.
- Blood products: are required, with two units routinely available in the room. Platelets and FFP may be requested based on the patients preoperative medications
- **Antibiotics** are indicated, discuss with surgeon
- **Echocardiography and Cardiothoracic surgery support** should be confirmed prior to the procedure. Interventional cardiology support for a emergency percutaneous pericardiocentesis is often also available

ACCESS/FLUIDS

- At UCSF, the EP nurse will start a peripheral IV in the pre-op holding area, usually 18 or 20 gauge (left arm).
- **Additional several large bore IVs are recommended**. However, remember that the introducer sheaths placed by the proceduralist may be used for central venous access. This is a discussion best had at the beginning of the case, as it may affect approach and placement of these sheaths for anesthesia access.
- **Anticipated blood loss** is usually 50-100cc, but pericardial effusion risk is nontrivial, especially for Lariat. Hot line should be available in case of need of transfusion.
- Vaspressor and inotrope use is common in particularly sick patients, even in the absence of procedural complications. A vasoactive drip line is recommended to facilitate additional medication drips as needed. Bolus medications (vasopressin, epinephrine, calcium) are useful to have prepared.
- **Fluid resuscitation** is at the discretion of the provider in consideration of the patient's comorbidities and underlying cardiac function. Extreme hypovolemia may falsely underestimate the size of the LAA (important for Watchman device sizing).

MONITORS

- **Standard ASA monitors**: The EP staff will assist you in placing radiolucent ECG leads to ensure that they do not interfere with the fluoroscopic images or the rest of electrophysiology monitors. Sometimes, the anesthesia ECG leads can be connected to the mapping system directly.
- **Invasive arterial monitor** is placed due to concerns of perforation and pericardial effusion. The patient's cardiopulmonary co-morbidities should determine whether pre-induction arterial catheter is necessary.
- **Temperature**: May be performed with a foley temperature or nasopharyngeal temperature. Esophageal temperature will not be possible due to the placement of the TEE probe.
- **Urinary bladder catheter** is usually performed due to extended duration of this procedure
- **Defibrillation** pads for defibrillation/cardioversion/temp pacing
- **TEE** probe which is placed and monitored by echo lab or cardiac anesthesia

ANESTHETIC TECHNIQUES

- **Anxiolytic premedication** should not be given routinely in the holding area as most ambulating patients (at UCSF) are expected to walk into the EP lab and position themselves up-right on the table while monitors and patches are placed.
- Broncho-dilator, anti-reflux medication and antacid should be given as indicated by the anesthetic technique and the patient's co-morbidities.
- **The anesthetic of choice for PVI performed at UCSF is GA**, due to the length of the procedure and lower incidence of pulmonary vein reconnection. **Induction of GA and secure the airway with ETT** according to the patient's history and exam**.** In the absence of any contraindication, either succinylcholine or a nondepolarizing agent can be used.

    - The advantage of succinylcholine is that, in the case of left atrial (appendage) thrombus discovered on the TEE exam, the patient can be awoken quickly without residual paralysis.
    - The advantage of a non-depolarizing agent is that the patient will be paralyzed and this decreases the risk of bucking or biting during TEE probe insertion. Usually the TEE exam is comprehensive and takes 15 to 45 minutes, which is enough time for twitch to appear and the muscle relaxation reversed.
    - Alternatively, the TEE can be performed under MAC, if the suspicion of thrombus is high and the patient is sick, before deciding if GA and ablation are indicated.
- The choice of **maintenance** of anesthesia is up to the anesthesia provider. The local anesthetic infiltration decreases the amount of pain of the vascular access, so minimal intra-operative opiate is needed. The goal is to maintain hemodynamic stability. The choice of agent has little effect on the procedure itself. Consider utilizing IV acetaminophen.
- **Emergence**: Following anti-coagulation reversal, removal of the venous sheaths, and manual hemostasis, most patients are extubated in the procedure room. Special caution should be made to avoid excessive coughing, vomiting, and bending at the waist during extubation immediately following hemostasis. EP staff often applies additional manual compression during extubation. Attention to suctioning the oropharynx and ET tube, prophylactic antiemetic treatment. Alternatively, in the absence of contraindications, deep extubation is an option.
- **Recovery after GA** will be in the 4th floor PACU. Depending on the size of the sheath and the use of anti-coagulation, the patient will need to remain supine with the hips straight for 4 to 6 hours because of risk of bleeding.

KEY PROCEDURE-RELATED POINTS

- Once patient is anesthetized, and line/monitors placed, the EP doctors will begin by obtaining femoral venous access.
- **Hypotension of uncertain etiology == pericardial effusion until proven otherwise**
- Prior to transseptal puncture, proceduralists may ask for heparin (usually 100 unit/kg, goal ACT > 250 seconds)
    - Transseptal puncture will require combination of fluoro and TEE guidance
- Watchman: Positioning of device may induce arrhythmias and complications include LAA rupture
    - Positioning includes appropriate sizing of device and placement within LAA. Once positioned, an anchor is deployed and tested (i.e. gently tugged to ensure appropriate tension)
    - Repositioning and retrieval of malpositioned device is possible, but risk of embolization becomes higher
- Lariat: Pericardial puncture + serial dilations can induce arrhythmias, significant reductions in preload, and tamponade
    - Deployment of Lariat snare over LAA can induce arrhythmias and decrease preload to LV
- Discuss with proceduralist whether protamine is indicated at the end of the procedure

POTENTIAL COMPLICATIONS

- **Arrhythmia** that is hemodynamically significant is always a risk.
- **Vascular complications** at the access site are not uncommon and range from self-limited site hematoma to retroperitoneal bleeding requiring urgent/emergent vascular surgery interventions. Resuscitation with fluids, blood products, and vasoactive medications may be necessary.
- **Cardiac tamponade** may occur during pericardial approach (Lariat) or transseptal puncture (both). This is usually indicated by persistent hemodynamic instability. The EP team should be informed when this is suspected. Blood products should be ordered immediately. Consider reversing anticoagulation in consultation with the proceduralist. One or more of the femoral sheaths can be used for volume resuscitation. The management of effusion varies:
    - "Wait-and-watch" approach when the effusion is small and self-limiting

    - Emergent pericardial drain placement
    - Rapid mobilization for surgical decompression of the tamponade.
- **Stroke** is possible: the trans-septal access creates a temporary path for paradoxical embolism.
- **Other considerations for hypotension** if pericardial effusion or bleeding has been ruled out:
    - Watchmen device embolization (too small)
    - Air embolism

SPECIAL ERGONOMIC CONSIDERATIONS

- **Extensions** on breathing circuit, oxygen supply, IV tubing, and infusion tubing are necessary to allow the unobstructed movement of the fluoroscopy equipment. Consider consolidating and securing monitors, circuits, and tubing such that they clear the C-arm, biplane and avoid tangling. Tourniquets and blue clamps are often useful. The patient's arms will be secured, padded and tucked, limiting our access. One should consider attaching two pre-flushed infusion lines that can be used for anesthetic agents such as propofol or remifentanil, and vasoactive agents.
- **Hazards to the anesthesia provider**
    - **Equipment is in motion!** Be aware of the c-arm when it is in motion as it can move quickly and endanger heads and shins and may snag loose wires and tubings.
    - **Ionizing radiation:** Consider time (limiting exposure), distance (inverse square law), and shielding (both garments and barriers) when in ionizing radiation environments. Particular attention should be granted to protecting the lens of the eye, thyroid, hematopoietic centers in long bones, and reproductive organs as these are particularly sensitive to ionizing radiation. The exposure is greatest as it exits the collimator (the part below the table) in path to the image intensifier (the part above the patient). However, scatter radiation is produced as the X ray encounters items in its path (the patient). Areas on the body that are often overlooked ("weak spots") include neck, shoulder/arm pits, and back. Lead (radiation protective) garments should cover the neck to the knees and are designed to be worn when facing the source.

DURATION

1 - 5 hours (diagnostic vs complex intervention)

REFERENCES

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5. Mobius-Winkler S et al. "Percutaneous left atrial appendage closure: Technical aspects and prevention of periprocedural complications with the Watchman device." World J Cardiol. 2015. 7(2): 65-75. doi.org/10.4330/wjc.v7.i2.65