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Hold My Compass: Tools and Tips So That YOU Don't Get Lost in the EP Lab

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Stem Case and Key Questions Content

Fresh and cheerful after a lovely weekend playing with the family, you stroll in at 7 in the morning to find that you have been assigned as the anesthesiologist in the Electrophysiology (EP) lab at your busy university teaching hospital. You have been assigned two rooms to cover in the EP lab.

Your first case is a 56 y.o. male, a self-described "weekend warrior" with chronic atrial fibrillation for a pulmonary vein isolation procedure. He tells you that he is 5'9" and weighs 250 lbs. (113 Kg). His BMI is 37. His wife states that he snores, but does not use Continuous Postive Airway Pressure (C-PAP). He has been in atrial fibrillation off and on for almost 2 years. Multiple medications have been attempted including trials of Metoprolol (Lopressor) and Amlodipine (Norvasc). He has been anti-coagulated with Rivaroxaban (Xarelto). Over the past 6 months, he notices that his periods of atrial fibrillation have been increasing. He is often short of breath after exertion when not in sinus rhythm, to the point where he is limited to one flight of stairs before he needs to stop and rest. He has been cardioverted 3 times over the past 2 years, but he has always reverted back to atrial fibrillation. He has a history of Hypertension (HTN), borderline Diabetes Mellitus (DM), a Mallampati III airway, short thyromental distance, and multiple crowns. He stopped smoking tobacco 12 years ago. Hgb: 14 K+ 3.9 Bun/Cr 19/0.9
Your case in the other room is a 67 y.o. female who is a scheduled under Monitored Anesthesia Care (MAC) case for an ablation procedure to treat her ventricular tachycardia (VT).

Questions:
1) What are the unique risks to the patient, and the anesthesiologist, in the EP lab? How do you mitigate these risks?

2) What are the medical indications for this procedure in the EP lab?

3) Are you satisfied with the pre-op assessment of this patient? What further information do you require? Labs? Echocardiogram?

You bring the patient into the room at 7:30. As you load the patient onto the table, the electrophysiologist tells you that he thinks this will be a difficult case because the origin of the arrhythmia lies close to the pulmonary vein. He adds that he will definitely need to ablate trans-septally. He suggests that you put the patient to sleep after the catheter is trans-septal. You decide to intubate the patient "up front" after induction of anesthesia in the beginning of the case.

Questions:
1) What anesthetic technique do you choose? How do you decide between General Anesthesia (GA) and MAC? What are the advantages/disadvantages for each technique?

2) What are the advantages and disadvantages of intubating at the beginning of the case? What are the advantages and disadvantages of waiting to intubate until after cardiac mapping is completed?

3) Would you paralyze this patient? Why/ why not?

4) How do you secure the airway? Do you use a video laryngoscope? Why?

5) What monitors do you choose? Invasive monitoring?
The case proceeds uneventfully through the electrophysiologic mapping of the heart. Mapping confirms that the origin of the arrhythmia lies close to the pulmonary vein. The electrophysiologist tells you that he needs a "quiet field" for the ablation.

Questions:
1) What anesthetic drugs do you choose? Why/ why not? How do these drugs affect the normal conduction pathways of the heart?

2) What is the role of the jet-ventilator in the EP lab?
The electrophysiologist wants to test the ablation. The patient is given isoproterenol (Isuprel) and you respond to the drop in the patient's blood pressure with a phenylephrine (Neo-Synephrine) infusion. However, the cardiologist ends the trial quickly and without warning. Immediately afterward,there is a rapid but temporary increase in the patient's blood pressure to 196 systolic, which gradually dissipates after the phenylephrine is stopped. Although the patient seems to have weathered the storm, approximately 15 minutes after the challenge, the patient's blood pressure drops precipitously.

Questions:

1) What is "the Isuprel Challenge"? How does it work? What are complications of the Isuprel and how to manage them?

2) What is your differential diagnosis for a drop in blood pressure or suddenly unstable vital signs? How do you check for perforation?
In the other room, you are providing the anesthetic for the ablation of the Ventricular Tachycardia. During the procedure, the cardiologist needs to convert the patient back into a normal sinus rhythm.

Questions:
1) What are the considerations in choosing MAC or general anesthetic for this particular case? Compare those to a pulmonary vein isolation case?

2) What drugs do you give for this MAC cases? How do they affect cardiac arrhythmias?

3) How do you prepare for cardioversion in these MAC cases?

4) Under what circumstances would you convert a MAC case to a GA?

Model Discussion Content

In the EP lab, procedures such as radiofrequency ablation of atrial fibrillation with pulmonary vein isolation are accomplished with greater safety and less invasively than in the past. Improvements in technology now allow us to treat many of the older, sicker, high risk patients that would have previously not been candidates for surgical intervention.

Over 14 million Americans suffer from cardiac dysrhythmias every year, and of those 40,700 die from either their arrhythmia(s) or related co-morbidity.[1] This increase in the number of patients diagnosed with arrhythmias combined with the improvements in technology has combined to greatly increase the number of patients treated in the lab. The presence of anesthesia personnel allows EP cases to proceed faster and more effectively.[2] Our ability to manage these patients with major co-morbidities make us invaluable members of the team.

Arrhythmias are disorders of impulse generation, impulse conduction, or both. They are described or classified based upon characteristics such as rate or rhythm, the origin of the impulse, a description of the impulse conduction (complete heart block), ventricular rate, or unique characteristics of the rhythm, such as pre-excitation. The consequences of these arrhythmias are decreased cardiac output, myocardial blood flow, or progression to a more serious arrhythmia. Such cases have long been treated with medical management, anti-coagulation therapy and cardioversion. A patient who has a documented history of a symptomatic atrial fibrillation that does not respond or improve with medical management is a candidate for catheter ablation. These procedures are effective, with some reported success rates as high as 90 percent.

A Non-Operating Room Anesthesia site (NORA) presents many challenges to the delivery of patient care. The distance from the NORA suite to the main operating rooms means that logistics of communication, supplies, cart medications and emergency drugs must all be worked out before the first patient is treated. Details and protocols must be worked out, such as how the room is set up, what monitors are needed (ASA standards), what to do in a code, or how to transfer care after the procedure is finished.

Each electrophysiology suite is uniquely designed for the electrophysiologist or proceduralist in mind. Physical obstacles such as fluoroscopy can make access to the patient airway difficult. Small spaces and a darkened room require attention to lighting. Strong magnets may require special equipment, and personnel may need to rely on the circulating nurse for messages because pagers and cell phones must be left outside of the room. In the EP lab, loud noise prevents normal communication, and often headsets with speakers are given to the care team to facilitate communication. And finally, exposure to radiation from fluoroscopy exposes the anesthesiologist to high levels of radiation.

Patients presenting for procedures in the EP lab need to be evaluated by an anesthesiologist during a pre-procedural visit. A careful history should be elicited. Patient co-morbidities should be evaluated and, if possible, addressed.

A review of lab results is vital to patient care. An echocardiogram provides important information to the anesthesiologist regarding the patient's myocardial contractility, anatomy, left ventricular function, and fluid status. An echocardiogram can also rule out a thrombus, which can lead to stroke if the patient is cardioverted. A baseline electrocardiogram (ECG) should be obtained. The rhythm and rate should be noted, as well as any signs of previous infarction or ischemia. Blood work is evaluated as well. Even a "simple" procedure in the EP lab has the potential for major blood loss so a baseline hemoglobin or hematocrit, as well as a type and screen, should be obtained. Coagulation studies should be performed pre-procedure because many patients are on an anticoagulant regimen. Creatinine and blood urea nitrogen (BUN) studies are helpful in assessing renal function, which is important because of the administration of contrast dye as well large amount of fluids given over the length of a long ablation case. Serum electrolyte and thyroid studies may also be helpful in the diagnosis of some of the underlying reasons for cardiac arrhythmias. A chest x-ray may also be used as a baseline measurement, or it can show heart failure, cardiomegaly, or a previously implanted device. Imaging such as Magnetic Resonance Imaging (MRI) or Computerized Tomography (CT) can also be helpful to the cardiologist in defining the anatomy of the pulmonary veins.

Most patients are on multiple medications to control their arrhythmia. These medications have anti-arrhythmic or negative inotropic or chronotropic effects that can alter the ability of the electrophysiologist to induce an aberrant rhythm. Most cardiologists will have patients stop taking these medications 4-7 days before the day of the procedure.

Patients that are considered for MAC are usually Supraventricular Tachycardia (SVT) or Ventricular Tachycardia (VT) cases, where the arrhythmia is caused by a discreet re-entry circuit that require the ablation of a few lesions. These cases are often shorter, lasting only 2-4 hours. The goal is to provide patient comfort with minimal movement while preserving adequate ventilation. Advantages to MAC are rapid recovery and early discharge after procedure. Fewer agents used in the procedure help to minimize the effect of the anesthetic on the induction and treatment of the arrhythmia. Risks associated with intubation are eliminated. Anesthetic drugs are chosen for these cases are based upon their ability not to interfere with impulse conductivity or sympathetic tone, as well as their ability for rapid onset and recovery. Another advantage is that patients can communicate with the team, which is helpful both in feedback from the patient, as well as monitoring neurologic status. During these procedures, patients will describe substernal "burning" pain associated with the ablation. This pain usually will resolve a few seconds after the ablation. A change in the nature or severity of the pain can be an early alert to the team to consider complications such as esophageal perforation or myocardial ischemia. A change in the patient’s affect, alertness or slurred speech can alert the care team to the possibility of stroke.

A General Anesthetic (GA) should be considered for longer (4-12 hour) or more complex procedures such as radio-frequency ablation for atrial fibrillation. These cases require extensive mapping, and it is necessary to provide a quiet field for the proceduralist so that energy is delivered to within 3-5mm of the offending targeted tissue. It is important to minimize diaphragmatic and respiratory motion in these patients, and it is here that the jet ventilator has become an effective tool to the anessthesiologist. These procedures also require larger areas of the heart to be ablated. Because these are longer procedures, it is important for the patient to be well padded to prevent sores or nerve injury. These patients should also be kept warm, and the temperature should be monitored with an esophageal stethoscope.

The decision of when to intubate the patient, "up front" or delayed, during the procedure is based upon several factors. Careful consideration is given to the potential ease or difficulty of securing the patient's airway. A thoughtful examination of the airway, including Mallampati score, is mandatory. Also to be weighed is the timing of the infusion of heparin, the length of the procedure, the mental status of the patient, and the availability of additional help should an emergency situation arise.

Early intubation has the advantages of controlling the intubation conditions, the ability to arrange for extra assistance with difficult airway, and of decreasing the risk of soft tissue oral trauma, dental injuries, bleeding, and eye damage, that can be associated with intubating a fully anticoagulated patient.[3,4,5]

The ability to monitor that patient's mental status and response to pain sensation experienced during the case is the major advantage to delayed intubation during the procedure. The concern that some general anesthetic agents will interfere with the ability to identify atrial triggers of arrhythmias during the Isuprel challenge is used as a reason to intubate after the procedure has begun. A major disadvantage to this practice is that the risk of severe of trauma to the airway is much greater when an anticoagulated patient is intubated, and seemingly trivial brushes against the airway have resulted in major bleeding or hematomas.

Tidal volumes with normal or mechanical respiration are associated with chest movement that can interfere with the mapping and ablation process of an ablation case. A new method proposed in 2006 combined the use of high-frequency jet ventilation (HFJV) with a general anesthetic. A retrospective study looked at 36 patients undergoing atrial ablation using jet ventilation and 36 patients with conventional positive pressure ventilation. The benefits of jet ventilation were immediately apparent. It with was noted that ablation times were shorter with fewer incidences of ablation electrode dislodgement. Changes in pulmonary venous flow velocity and motility, as well as changes in left atrial pressure and volume, were significantly less. The study was stopped in the belief that jet ventilation was significantly better for patient care.[6] More recent studies confirm the benefits of HFJV in patient undergoing atrial fibrillation (AF) ablation.[7] HFJV improved the freedom from atrial fibrillation from 66 to 74 percent, and this affect was attributed the quiet, stabilizing effect of this type of ventilation on the the stability of the ablation catheter.

Total Intravenous Anesthesia (TIVA) should be used in conjunction with HFJV. Inhaled agents, as well as end-tidal CO2, cannot be measured accurately when HFJV is employed. Arterial Blood Gases (ABGs) should be measured at regular intervals, usually hourly, to insure adequate ventilation. Transcutaneous monitoring of CO2 PtcCO2), non-invasive alternative to arterial blood gases, may have some utility in the EP Lab. Although not as accurate as an ABG, continous transcutaneous measurement offers the advantage of providing a history of CO2 trends. The application of PtcCO2 may be limited, however, by either technical (improper placement or sensor malfunction) or patient (low cardiac output, shock, hypothermia) factors.[8,9,10] The jet ventilator may be less effective in patients with severe Chronic Obstructive Pulmonary Disease (COPD), and conventional mechanical may be needed.

ANESTHETIC AGENTS:
The ideal anesthetic agent in the EP lab would have no effect on autonomic nervous system or cardiac conduction. It would have both rapid onset and recovery. Any drug given in the EP lab should be considered for its potential effect on the mapping and ablation of the heart. Anesthetic agents can indirectly affect the heart by altering the sympathetic tone of the patient, or directly on the heart itself, through effect on impulse conduction at the sinoatrial (SA) or atrioventricular (AV) node, or through the myocardium.

There are many different ways that inhalational agents affect myocardial impulse conduction. Inhalational agents cause a dose dependent decrease in myocardial contractility, a prolongation of the Q-T interval, and can affect the AV node and His-Perkinje system.[11,12] Some of the "older" agents, such as Halothane (Fluothane) or Isoflorane (Forane), are known to enhance activation of wandering atrial pacemakers by increasing automaticity of secondary pacemakers.
Of the newer agents, Desflurane (Suprane) has a rapid on- and offset which is an attractive feature in the EP lab. Desflurane can mildly increase sympathetic tone, but it can be irritating to the airway of some patients with a reactive airway disease, making it a less than ideal choice for an ablation induction. Sevoflurane (Ultane) has been found to be a suitable agent because it has a minimal effect on the SA node, AV node and accessory pathways of conduction. Sevoflurane does not irritant the airway on inhalation induction, making it is suitable for airway induction of anesthesia.

Diprivan (Propofol) is a widely used drug in the EP lab because of both pharmacologic and pharmakinetic properties. Propfol has very little effect on impulse conduction. Propofol allows for rapid recovery after a procedure, making it a useful drug for both long (ablations) and short procedures (cardioversions). Propofol has been associated with both brady- and tachy-arrhythmias. Hypotension has also been associated with the use of propofol, but this is thought to be a part of overall inhibition of the sympathetic nervous system. An important aspect of propofol's drug profile is that it seems to not effect accessory pathway conduction, or appear to trigger SVT or VT arrhythmias in patients undergoing ablation procedures. Amidate (Etomidate) is a useful drug in the EP lab because it does not depress myocardial function in patients with cardiac damage or low ejection fraction. Etomidate also has a rapid onset and recovery. However, myoclonic jerking motion is noted in almost 40 percent of patients given Etomidate, raising the concern that such motion could interfere in the interpretation of an electrocardiogram during a cardioversion procedure.[13]

Remifentanil (Ultiva) is a drug well suited for the EP lab because of those properties that allow for a rapid change in the depth of anesthesia. Remifentanil has a rapid time-to-peak effect (90 seconds) and short half-life (3-4 minutes), regardless of how long it has been administered.[14]
It works in combination with other sedatives to lower the dosage of propofal or midazolam (Verzed), and is advantageous in that it leads to an earlier return to awareness after the procedure.[15] Remifentanil has been known to produce bradycardia, but it does not appear to affect arrhythmogenesis. Importantly, remifentanil does not interfere with the ability to induce ventricular-tachycardia in patients with structural heart disease.

Midazolam is not the best choice of an anesthetic drug in the EP lab. High levels of this drug are needed to produce adequate sedation. Midazolam has too slow of an onset of action to be effective in the EP lab. A retrospective study of EP procedures showed that advanced airway support was needed in 40 percent of patients.[16] Patients may need to be quickly defibrillated in cases where a ventricular rhythm may be induced, and yet must wake up quickly to neurologically evaluated. Another retrospective study of patients receiving midazolam or diazepam for elective cardioversion in ablation cases showed the time needed to produce adequate sedation for shock to be an average of 5 minutes. Additionally, 20 percent of these patients had hypotension.[17] In the EP lab, a 5 minute delay in cardioverting an unstable atrial or ventricular fibrillation patient is impractical, even without the hypotension. Midazolam is not well suited for these types of procedures.

Ketamine (Ketalar) has analgesic properties that maintain an adequate depth of anesthesia and it preserves respiratory function. Ketamine can increase sympathetic tone which can be used in the induction of arrhythmias. Disadvantages of Ketamine can be this sympathetic tone increase, as well as increased drooling and delirium with hallucinations upon emergence.

The Isuprel Challenge:

The Isuprel Challenge is a test used by the cardiologist to test the ablation. After the patient has been mapped and the offending origin of the arrhythmia has been destroyed, the cardiologist will attempt to re-induce the tachyarrhythmia again with Isuprel. If an arrhythmia is able to be induced, the area can be remapped and the site of the offending rhythm can be destroyed. Isuprel is a pure beta-1 and beta-2 agonist, so as the dose of Isuprel increases the cardiac output and heart rate, it also increases the chance of inducing a tachyarrhythmia. Isuprel is started at a low dose (2 mcg/min) and is increased to effect. An effect of the beta-2 stimulation from Isuprel is a rapid decrease in the Peripheral Vascular Resistance (PVR) of the patient. As the dose of Isuprel increases, there can be an anticipated dramatic drop in the blood pressure. When Isuprel is introduced, a phenylephrine infusion is also started to prevent the drop in blood pressure. The goal is to titrate the infusion of phenylephrine to match the effect of the Isuprel. After the Isuprel is discontinued, there can be a severe episode of rebound hypertension. The goal is to maintain the blood pressure in a normal range, and this is accomplished with proper communication with the electrophysiology team and anticipation of the event. A complication of the severe rebound hypertension associated with the Isuprel challenge is that it can unmask a perforation of the myocardium and blood can be forced though a rent into the epicardial space causing a tamponade. Any instability in the patient's vital signs, such as a sudden drop in blood pressure, should communicated to the cardiologist so that the patient may be evaluated by echocardiography.

During some MAC cases, the need will arise to cardiovert an “awake” patient. It is important to anticipate tachyarrythmias in the EP lab, and the ability to rapidly increase and then decrease the anesthetic depth is important. Usually, a bolus of propofol of etomidate is given by the anesthesiologist for cardioversion in the EP lab. Communication is important when these drugs are administered to prevent the cardiologist from shocking an awake patient. It is important to maintain the airway at all times. Appropriate airway support and resuscitative drugs must be immediately available.

The rate of complications in the EP lab is under 3 percent.[18] Complications may be early or delayed, and may occur as a result from nerve compression, placement of lines and stents, radiation, the ablation, puncture of the atrium or ventricle, damage to the vasculature, trauma to the airway from intubation, and as a result of anticoagulation. Examples of early manifestations of complications include myocardial puncture and cardiac tamponade, stroke or embolism, damage to the phrenic nerve leading to paralysis of a hemi-diaphragm, pneumothorax or death. Anticoagulation is associated with a number of complications in the EP lab, because heparin is administered to the patient to raise the ACT level over 325. For most routine intubations in our lab, the use of a Glidescope for placement of the endotracheal tube has decreased the amount and severity of oral trauma. Perforation of the atrium or ventricle while the patient is heparinized can result in cardiac tamponade, especially after a large increase in blood pressure (as a result of the Isuprel challenge). The anesthesiologist must remain vigilant for perforation, and any instability in vital signs such as blood pressure should alert the care team to this possibility. Treatment may be supportive and reversal of the anticoagulation, to proceeding with the draining of the tamponade, to full resuscitation if the patient has a cardiac arrest. Any hospital that performs EP procedures must have the appropriate facilities and personnel available should the patient require an open cardiac procedure.

Patient movement is another major concern in the EP lab and may lead to vascular trauma, perforation, or ablation of the phrenic nerve. To facilitate intubation, a short acting paralytic agent, such as succinylcholine, may be used. However, in cases where the ablation may take place near a nerve, such as during pulmonary vein isolation, it is important that the patient is not paralyzed so that the phrenic nerve may be evaluated.

The esophageal stethoscope is important not just to monitor the patient's temperature, but also the rate of change of the temperature. An increase of 0.2 C during ablation could mean that the electrophysiologist is burning at or near the esophagus, which could lead a perforation or fistula. It is important for the anesthesiologist to remain alert to these changes, and to communicate to the rest of the care team.

Risks to the anesthesiologist in the EP lab are due to increased noise and to radiation exposure. Noise in the EP is usually overcome by issuing headphones to personnel to both protect hearing and to facilitate communication during the procedure.

The danger from radiation is related to the dose of received over a lifetime. Radiation may cause cancer, cataracts, bone marrow suppression and sterility. If the anesthesiologist is pregnant, danger to the fetus includes congenital malformations, genetic damage, growth retardation and death.[19] Prevention of damage basically consists of the having the lowest possible exposure for the lowest possible time. Overall exposure is a function time, distance, and barriers. The anesthesiologist cannot control the first variable, but can control the other two. Barriers to exposure that anesthesia personnel should wear lead include leaded aprons and leaded goggles to minimize exposure. Whenever possible, the anesthesiologist should also stay behind a leaded protective screen. A dosemeter on the apron is needed to track cumulative exposure. Distance is an important variable that may also be controlled by the anesthesiologist. Exposure from radiation is reduced the further one is from the radiation source. The radiation beam attenuates based on an inverse square law (1/d2).[20,21]

CONCLUSION:
The EP lab is a recent addition and growing field in the practice of anesthesia. The decisions we make in the care of these patients will determine how we respond to the challenges, and opportunities, of this new and exciting area.

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