Utility of Echo in the Cath Lab for Laser Lead Extraction & Other Cases

Recent advances in technology have allowed cardiac catheterization laboratory procedures to expand their role from diagnostic testing to increasingly invasive interventional therapies. This lecture will discuss the role of echocardiography in patients undergoing laser lead extraction, other electrophysiologic procedures, as well as other common interventional procedures.

Transesophageal echocardiography can help exclude left atrial appendage (LAA) thrombus in patients undergoing electrophysiologic procedures such as atrial fibrillation ablation and electrical cardioversion. Two-dimensional echocardiography with color flow Doppler can interrogate this structure for thrombus. In addition, in a study of 500 patients pulse wave Doppler flow velocities < 20 cm/sec were associated with an incidence of thrombus in 29% of patients, whereas a cutoff value of 55 cm/s had a high negative predictive value\(^{(1)}\). Also, three-dimensional echocardiography has been reported to be useful in excluding a bilobar LAA from a LAA thrombus\(^{(2)}\).

Transesophageal echocardiography can be useful in patients undergoing pacemaker and implantable cardioverter-defibrillator (ICD) lead removal by: assisting in assessment of lead calcification, fibrosis, and/or vegetation, and early detection of complications such as pericardial effusions from cardiac rupture and traumatic tricuspid regurgitation\(^{(3-7)}\). Leads are most often removed due to infection or mechanical failure and terminology used to describe lead removal is as follows: Lead removal is defined as removal of a pacing or defibrillator lead using any method or technique. Lead explant is defined as removal of a lead that has been implanted for less than one year via the implant vein using tools typically supplied for lead implant with the addition of manual traction. Lead extraction is defined as removal of a lead with the assistance of specialized
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equipment regardless of the implant duration, removal of a lead from a route other than via the implant vein, or removal of a lead that has been implanted greater than one year (8,9). Indications for lead removal are classified as: Class I, II and III (8,9). Class I describes indications for which there is general agreement that the lead should be removed. Class I indications included:

- Sepsis
- Retained lead posing an immediate or imminent threat to the patient
- Life-threatening arrhythmias secondary to retained lead fragment
- Clinically significant thromboembolic events caused by a retained lead
- Leads interfering with operation of another implanted device

Sepsis that results from a documented infection of any intravascular part of the pacing system, or as a result of a pacemaker pocket infection when the intravascular portion of the lead system cannot be aseptically separated from the pocket constitutes a common class I indication, and should result in urgent lead removal. Class II includes indications for which leads are often removed but there is a divergence of opinion as to the benefit of removal. Class II indications include:

- Occult infection for which no source can be found, and for which the pacing system is suspected
- Chronic pain at the pocket or lead insertion site refractory to other therapy
- Leads that pose a threat to the patient that is not imminent or immediate
- Traumatic injury to the entry site of the lead in which the lead may interfere with the reconstruction of the site
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- Non-functional leads young patients
- Leads preventing access to the venous circulation for newly required implantable devices

Class 3 includes indications for which there is general agreement that lead removal is not necessary. Class 3 indications include:

- Any situation where the risk posed by removal is significantly higher than the benefit of removing the lead
- Any normally functioning lead that may be reused at the time of pulse generator replacement provided the lead has a reliable performance history.
- A single non-functional transvenous lead in an older patient

Relative contraindications for transvenous lead removal include presence of calcification visible by x-ray involving leads in the atrium or superior vena cava, known anomalous placement of lead through structures other than the normal venous and cardiac structures such as the pericardial space or subclavian artery, and patients who are unsuitable for emergency cardiothoracic surgery should severe complications occur (8,9). Procedures for lead extraction involve freeing the lead, and often require complex techniques due to adherence to fibrosed and calcified cardiac structures. Emergency cardiothoracic surgery must be available as a rescue option and large venous access and intensive monitoring should be routine.

Complications include: traumatic tricuspid regurgitation (TR), tamponade from cardiac rupture, and death. Traumatic TR following right ventricular lead removal was evaluated in a single-center prospective study involving 208 patients (10). Traumatic TR occurred in 19 patients (9.1%) and was severe in 14. Of these 14, nine developed new
right-sided heart failure, two required tricuspid valve repair, and two died. Three independent risk factors for traumatic TR were identified by multivariate analysis: female sex, use of a laser sheath, and use of both a laser sheath and lasso. Echocardiographic features of severe TR include holosystolic hepatic venous flow reversal, a vena contracta width of greater than 7 mm, and a color flow Doppler jet area of 10 cm$^2$ (table 1) (11).

Table 1: Grading Tricuspid Insufficiency (11)

<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
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<tbody>
<tr>
<td>CWD Jet Density</td>
<td>Soft</td>
<td>More Dense</td>
<td>Very Dense</td>
</tr>
<tr>
<td>Jet Area (cm$^2$)</td>
<td>&lt; 5</td>
<td>5-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Vena Contracta width</td>
<td></td>
<td></td>
<td>&gt; 7mm</td>
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<tr>
<td>Hepatic Venous Flow</td>
<td>Systolic Dominance</td>
<td>Sys Blunting</td>
<td>Sys Reversal</td>
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A study of laser sheath extraction of 2561 pacing and ICD leads in 1684 patients at 89 institutions found that ninety percent of leads were completely removed and major complications including hemothorax, tamponade, pulmonary embolism, lead migration and death, occurred in 1.9 percent (3,9). Minor complications occurred in 1.4% and included: avulsion of vein or myocardium, arm swelling, laceration, and pocket hematoma. Echocardiography assists in evaluating the degree of cardiac compression from pericardial effusions and can help guide placement of pericardial drains. In a single-operator study involving 975 lead extractions in 498 patients between 2000-2007, laser assistance for extraction more common for ICD leads and leads implanted longer than 3.4 years (7,9). 98% of leads were completely removed, and major complications occurred in 2 patients (0.4%). The two patients both suffered cardiac tamponade and one requiring
surgical repair of a right ventricular tear. Minor complications occurred in 3 patients and no deaths occurred. Tamponade is a clinical diagnosis consisting of: low cardiac output (hypotension), elevated venous pressures (distended neck veins), and pulsus paradoxus (12). Echocardiographic features consistent with tamponade physiology include: moderate-large pericardial effusion, right atrial systolic collapse (during greater than 1/3 of systole), right ventricular diastolic collapse, reciprocal respiratory changes in RV and LV volumes and inflow velocities, and inferior vena cava plethora (12).

Echocardiography offers assistance for many other interventional catheterization procedures, including percutaneous closure of atrial septal defects (ASDs). There are four types of atrial septal defects (ASDs): ostium secundum, ostium primum, sinus venosus, and coronary sinus. Ostium secundum defects occur in the fossa ovalis and are the most common (75%). They are associated with mitral valve prolapse and often have a surrounding “rim” of septal tissue making them amenable to closure with percutaneous devices(13). Primum defects, located near the atroventricular (AV) valves, are associated with cleft AV valve leaflets, AV canal defects (14) and trisomy 21. Sinus venosus defects are located near the superior or inferior vena cava and are associated with anomalous pulmonary venous drainage (13). Coronary sinus ASDs are rare and are associated with a persistent left superior vena cava.

Percutaneous device closure of an ASD is a generally safe and effective alternative to open surgical closure with decreased trauma and a shorter hospital stay(15). Embolization following transcatheter ASD device placement is a rare (<2%(16), 0.55%(15) but potentially lethal complication. Others possible problems include device erosion (0.1%), residual shunts (<4%), atrial arrhythmias (<5%), device size mismatch
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(<5%), cerebral infarcts (rare), infective endocarditis, and vascular access complications(15,16). TEE assists in determining if percutaneous closure is reasonable.

The ideal ASD for transcatheter closure is small (<20 mm) with large (>5 mm) firm rims of septal tissue separating the ASD from the surrounding structures (AV valves, superior and inferior vena cavae, right upper pulmonary vein, coronary sinus)(15,16). Very large ASDs (>40mm) have been closed with devices, but the catastrophic risk of erosion (cardiac perforation) increases as device size increases (16). Although the mechanism for erosion is not fully understood, the only known independent risk factor from a survey of all reported erosions was an oversized device (15). Device embolization, can cause significant ventricular arrhythmias, obstruction to flow, and valvular insufficiency.

Although percutaneous retrieval of stray devices has been reported (17), many consider this a cardiac surgical emergency. In cases of device embolization, TEE is useful for determining the location of the stray device, detecting associated pathology (such as LVOT obstruction) and ensuring appropriate ASD closure and deairing postbypass.


