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Special Article

Transvenous Lead Extraction: A Clinical Commentary for Anesthesiologists

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With increasing use of cardiovascular implantable electronic devices, the need for lead extractions has increased to an annual volume of more than 10,000 extractions worldwide. This article provides a focused clinical commentary on the perioperative management, identification, and treatment of life-threatening complications associated with lead extractions. In addition, a summary of indications, techniques, and lead extraction complications is provided. Although uncommon, lead extractions are associated with a consistent rate of major procedure-related complications and mortality. Major life-threatening complications include vascular laceration, cardiac avulsion, hemothorax, pericardial effusion, and cardiac arrest. Comprehensive preoperative risk assessment and adequate planning and preparedness are crucial to decreasing all procedure-related adverse events. The location of the procedure (electrophysiology suite *v* hybrid operating room) and the nature of cardiac surgical backup are determined after meticulous risk stratification. In addition to decisions on vascular access, invasive monitoring, and modality of rhythm support, transesophageal echocardiography plays a crucial role in early diagnosis, timely management, and potential prevention of these complications.

Key Words: pacemaker; lead extraction; electrophysiology; implantable cardioverter defibrillator; perioperative management; transesophageal echocardiography; hybrid operating room

WITH INCREASING USE and expanding indications for cardiovascular implantable electronic devices (CIEDs), the need for lead extractions[*] and revisions has increased. Annually, more than 10,000 lead extractions occur worldwide.[1] Even though these procedures typically are uneventful, they are associated with a consistent rate of significant procedure-related complications and mortality.[2] Cantillon et al reported complications in almost 1 in 6 patients by 3 years.[3] The Heart Rhythm Society (HRS) has put forth consensus guidelines for indications, facilities, and training required to safely perform lead extraction procedures, in addition to guidelines regarding implantable device lead management and extraction.[4,5]

Despite the increasing volume of lead extractions, there is a paucity of literature regarding the perioperative management. This article aims to give a focused clinical commentary on preoperative assessment, intraoperative management, and

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[*]Lead extraction definition per 2017 Heart Rhythm Society guidelines: "Lead removal procedure where at least one lead removal required the assistance of equipment not typically employed during lead implantation or at least one lead was implanted for greater than 1 year."

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Table 1
Indications for Transvenous Lead Extraction

- Infection
- Lead malfunction
- Thrombosis
- SVC/venous stenosis or occlusion
- Life-threatening arrhythmias due to retained leads
- Facilitate access to MRI
- Abandoned leads
- Recalled leads
- Lead perforation
- Severe tricuspid regurgitation
- Radiation treatment
- Chronic pain

Abbreviations: MRI, magnetic resonance imaging; SVC, superior vena cava.

identification and treatment of life-threatening complications associated with lead extraction. In addition, a summary of indications, techniques, and complications is provided.

Indications

According to the 2017 HRS consensus statement on lead management and extraction, indications for CIED lead extractions include infection, recalled leads, the presence of associated venous thrombosis or occlusion, fractured lead posing a significant threat to the patient, need for magnetic resonance imaging, chronic pain, lead perforation, severe tricuspid regurgitation, radiation treatment, among others (Table 1).[5] Infection is the most common indication, followed by lead malfunction.[2,6] A complete removal of all components of the device, including intravascular and subcutaneous hardware, is recommended, particularly in cases of infection. The proceduralist, either electrophysiologist or surgeon, faces various challenges during removal of CIED leads, especially long-standing leads. CIED leads are foreign structures in the venous system and result in an inflammatory reaction of the vessel wall or endocardium with which they are in contact. In long-standing leads, this process may progress to various degrees of fibrosis; adhesions; and in extreme cases, calcification.[7] Removal of such adherent leads can result in life-threatening complications and should be performed by an experienced operator in the presence of a well-prepared team.

Procedure

Various methods exist for lead extraction. Once the device pocket is opened, the vascular entry point of the lead is exposed. Typically, the initial attempt to remove a lead is made by applying light traction. With increasing or anticipated difficulty in extraction, more sophisticated means are used. These are divided broadly into nonpowered (locking stylet and dilator sheaths) and powered (laser or electrosurgical dissection sheath) tools, depending on whether an energy-based cutting device is used.[7] A locking stylet is inserted through the lumen of a lead and advanced to its tip, where it is locked into position, allowing traction to be applied directly to the tip of the lead. Dilator sheaths, often telescoping inner and outer sheaths, are advanced over the CIED lead to free the lead from the encasing fibrous tissue. Lead liberation is achieved in part by counterpressure along the lead body and ultimately by applying countertraction at the lead electrode-myocardial interface. The locking stylet provides traction force on the lead as the sheath is advanced over the lead and through or over the fibrosis. Depending on the judgment and experience level of the operator, mild traction without sheaths; nonpowered metal, polytetrafluoroethylene (Teflon), or polypropylene sheaths; or powered sheaths are used. Experienced operators often start with powered tools, particularly when significant fibrosis is anticipated. Powered tools also are advanced over the lead, but have a source of energy at the distal tip of the sheath. This disruptive energy can be rotational motion, electrosurgical cautery, or excimer laser energy. Regarding laser therapy, fiberoptic fibers enveloped in the advancing sheath conduct excimer light to the fibrous tissue. Pulses of energy are delivered, which divide the fibrous adhesions around the leads. Powered tools reduce the need to disrupt the fibrosis with manual force, are useful in challenging extractions, and reduce the frequency of lead fracture or the ability to remove the entire lead.[8] When using manual or powered sheaths, it is possible to lacerate the venous vessels or the heart, resulting in life-threatening hemorrhage.[9] Occasionally, additional intravascular snares may be introduced through the femoral or internal jugular veins during difficult extractions or to retrieve broken leads.[10] In fact, transfemoral extraction of pacemaker leads using a gooseneck snare has been shown to be safe and effective.[11] The gooseneck snare is introduced with a steerable ablation catheter to provide additional traction and, at times, grasp a cut lead.[11] Considering the various methods for extraction, it is not surprising the tools and methods followed for extraction are not standardized and vary among physicians and institutions.[8]

Complications and Risk Factors

The reported incidence of major complications occurring from lead extractions ranges from 0.19% to 1.8%, with a reported mortality of less than 0.4%.[2,5,12–14] These complications include vascular laceration, cardiac avulsion[†], hemothorax, pericardial effusion, cardiac arrest, and tricuspid regurgitation, among others.[2,14] Blood loss requiring transfusion is estimated to occur in 0.5% to 1.17% of patients.[2,12–14] In a series of 2,405 lead extractions, cardiac avulsion occurred in 0.62% and vascular injury requiring intervention in 0.41% of patients.[14] Major life-threatening cardiovascular complications can occur from damage to structures adherent to the CIED lead along its course from the device pocket through the central veins and up to the endocardium (Fig 1). A tear in a

[†]Avulsion: injury in which normal myocardium is forcibly removed or torn away from the heart.

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