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Complications following Placement or Extraction of Endovascular Pacemaker and Defibrillator Leads—Cardiothoracic Surgical Intervention: Case Reports

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ABSTRACT

Complications related to the insertion or removal of permanent pacemakers and implantable cardiac defibrillators are rare events. However, when adverse events occur, their severity may be life threatening. Rapid recognition of a problem followed by prompt consultation with a cardiothoracic surgeon is necessary to stabilize potentially catastrophic events. The immediate availability of surgical instruments as well as a formalized algorithm for management is necessary to control hemorrhagic situations. Four case reports illustrate these points.

INTRODUCTION

In recent years, permanent pacemakers (PPMs) and implantable cardiac defibrillators (ICDs) have shifted from the surgeons and operating rooms to the cardiologists and laboratory suites. In addition to the placement of these devices, the exchange and/or removal of them have also become a part of the electrophysiologist's world. In particular, lead extraction has recently become a popular method by which to remove or replace endovascular electrodes. Special instruments and skill are required to perform this procedure, such that the practice of this technique is limited to a small number of specialists. Although the likelihood of a complication is low, the severity of such a complication can be life threatening and require the involvement of cardiothoracic surgery. The purpose of this report is to describe the complications from the placement or extraction of endovascular pacing or defibrillating electrodes and to offer a protocol by which to manage them.

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CASE 1: SUPERIOR VENA CAVA PERFORATION FOLLOWING BALLOON ANGIOPLASTY/STENT FOR SUPERIOR VENA CAVA SYNDROME

A 21-year-old woman with a history of syncope was found to have recurrent atrial tachycardia. She had undergone multiple sinus node ablations with the recurrence of symptoms. She was admitted to the hospital, whereupon she underwent successful radiofrequency ablation of the sinus node followed by implantation of a permanent DDD (dual-chamber) pacemaker. Several days following the procedure, the patient began to experience shortness of breath and bilateral arm swelling. A chest radiograph showed bilateral pleural effusions. An ultrasound examination of the upper extremities showed diminished flow of the central venous system. Clinically, a diagnosis of superior vena cava (SVC) syndrome was made, and the patient was placed on heparin and arm elevation therapy. Subsequently, a venacavograph showed obstruction of the SVC at the junction of the right atrium. A percutaneous balloon angioplasty of this region resulted in some improvement. However, the upper-extremity edema and the dyspnea persisted. One week later, the patient underwent removal of the PPM leads, repeat angioplasty of the SVC, and stent placement. Prior to the reimplantation of the PPM, the patient developed cardiorespiratory distress. An angiograph of the SVC showed a perforation. The patient was intubated, and cardiothoracic surgery consultation was obtained. The patient was rapidly transported to the operating room as volume resuscitation was instituted. A sternotomy was followed by the opening of a tense pericardium. Evacuation of the hemopericardium resulted in restoration of the vital signs. Digital control of the laceration in the SVC prevented further blood loss. A local repair of the SVC was performed with mattress-pledgetted suture material. No attempt was made to remove the stent, which was firmly embedded in the wall of the SVC. The pleural spaces were opened, and effusions were evacuated. Finally, epicardial pacing leads were positioned on the right atrium and the right ventricle (RV). The patient had an uneventful postoperative course.

The upper-extremity edema disappeared along with the patient's shortness of breath. She was discharged on the eighth postoperative day.

CASE 2: RV PERFORATION FOLLOWING PPM INSERTION

An 87-year-old woman was admitted to the hospital for syncope. A PPM was inserted for sinus node dysfunction. Following placement of the RV lead, the patient became hemodynamically unstable and required the institution of cardiopulmonary resuscitation. The patient was intubated, and cardiothoracic surgery consultation was obtained. A presumptive diagnosis of cardiac tamponade from RV perforation was made. In the electrophysiology (EP) laboratory, the sternum was quickly prepared with povidone-iodine (Betadine), and a subxiphoid incision was made. The pericardium was identified and opened, allowing relief of the hemopericardium. The vital signs were instantly restored, and preparations were made to travel to the operating room. During the period of arranging transport, it became readily apparent that there was no further bleeding and therefore no further need for exploration. A pericardial tube was placed, and the patient was transferred to the cardiothoracic intensive care unit (ICU) for observation. A chest radiograph showed a significant pneumothorax for which a chest tube was placed. The patient was observed in the ICU, extubated, and transferred to the telemetry floor on the third postoperative day. The pleural and pericardial tubes were removed several days later. The patient was discharged to home.

CASE 3: RV PERFORATION WITH AN EXTRUDING RV LEAD FOLLOWING PPM INSERTION

An 85-year-old man underwent placement of a PPM for syncope secondary to bradycardia from sinus node dysfunction. He was discharged the following day in stable condition. Three days later, the patient was admitted to his local hospital after having woken up from his sleep with pleuritic chest pain and shortness of breath. An echocardiograph showed perforation by the RV electrode with associated pericardial effusion. The patient was admitted to the hospital in stable condition. The cardiothoracic surgery department was consulted, and emergency exploration was planned. With the patient under general anesthesia, a median sternotomy was performed. The tense pericardium was opened, and a dark bloody effusion was released. We observed a hole in the RV with the electrode protruding through it. A pledgetted suture was placed over the perforation and was tied down after the EP team removed the electrode. After the defect was closed, a new RV electrode was placed with the aid of fluoroscopy while the chest was still open. The sternum was closed, and the patient was transported to the cardiothoracic ICU. The remainder of his hospital course was unremarkable, and the patient was subsequently discharged to home several days later.

CASE 4: SVC INJURY FOLLOWING ICD LEAD EXTRACTION

A 50-year-old man with a history of coronary artery bypass grafting in the remote past and a nonfunctioning ICD/pacer was admitted to the hospital for removal of the ICD generator and leads. In the EP suite, the generator was removed, and an attempt to remove the electrodes was made. Initially, there was some trouble with the lead extraction at the level of the SVC; however, further manipulation was successful. Shortly after lead removal, the patient became hypotensive, and we administered dopamine therapy. Clinically, the patient was initially asymptomatic. The cardiothoracic surgery department was consulted when a fluoroscopic examination demonstrated a right effusion. The patient's blood pressure continued to drop, the dopamine level was increased, and volume resuscitation was instituted. At this point, the patient became lethargic. The anesthesia department was called, and the patient was intubated. A right thoracostomy tube was placed, and approximately a liter of venous blood was obtained. The patient deteriorated further, cardiopulmonary resuscitation was instituted, and bleeding continued through the chest tube. An emergent right thoracotomy was performed. The chest was full of blood. The bleeding site could not be visualized, and the patient went on to expire. A postmortem examination showed a large tear in the high extrapericardial SVC and a smaller injury in the left subclavian vein.

DISCUSSION

The history of PPMs and ICDs is shared by cardiologists and cardiothoracic surgeons, because both disciplines found it necessary to manage heart block and arrhythmias in their respective patient populations. In the beginning of their development, PPMs and ICDs were predominantly placed by surgeons in the operating room. As the technology improved, particularly with respect to the downsizing of the hardware, these devices began to be placed by nonsurgical physicians. At present, most PPMs and ICDs are placed by electrophysiologists, who manage the devices and replace them when necessary. On occasion, it becomes necessary to completely remove the device or exchange it for a newer model. In the past, the generator was removed or replaced, with the older electrodes left alone or additional ones added to the system. The obvious disadvantages of this approach are the concerns with the inability to place additional leads because of "crowding" in the central veins (eg, cephalic, subclavian, jugular, and superior cava) from the older leads and because of the related issue of central vein stenosis or obstruction from the collection of too many electrodes. A solution to this problem is lead extraction with or without lead replacement, depending on the need for a new electrode.

The placement or removal of PPM or ICD electrodes, although commonly performed, is not without risk. Several reports [Fort 1965, Moss 1966, Martin 1967, Mechstroth 1967, Hirose 1968, Meyer 1968, Mullen 1968, Ohm 1976, Phibbs 1985, Parsonnet 1989, Spittell 1992, Chauhan 1994, Aggarwal 1995, Byrd 1999, Kay 1999, Gershon 2000] have

described the complications related to lead placement and lead extraction. In a large series of PPM implantations from a tertiary referral center [Aggarwal 1995], a detailed account of early complications was reported. Overall, the risks were low for a complication, including pneumothorax (1.8%), arterial puncture (2.7%), electrode displacement (1.4%), pocket infection 0.9%), and generator erosion (0.5%). Catastrophic complications were not mentioned. Similarly, in a report of a large collection of lead extractions (3540 in 2338 patients at 226 centers) [Byrd 1999], the incidences of major and minor complications were 1.4% and 1.7%, respectively. Furthermore, for the centers with experience with more than 300 cases, the incidence of a major complication was less than 1.0%. In general, the 2 most serious cardiovascular complications are RV perforation and central vein injury during placement or extraction.

As a general rule, the art and science of PPM placement has progressed so far that cardiothoracic surgical backup or standby is not necessary. However, prompt recognition of a complication, such as RV perforation during lead placement, should automatically result in an emergent surgical consultation. A suspicion of cardiac tamponade should be appreciated if a deterioration in the patient's clinical and/or hemodynamic (vital signs) status is observed. If such a condition presents itself, the usual resuscitation maneuvers, including ensuring an adequate airway and the delivery of sufficient oxygen, need to be instituted. As the airway, breathing, and circulation essentials of resuscitation are initiated, preparation for surgical intervention is made, including the opening of instruments necessary to perform pericardiocentesis, pericardiostomy, sternotomy, or thoracotomy. An open-chest tray must be readily available in the EP suite for such emergencies so that there is no delay when the surgical team arrives. Simultaneously, the anesthesia department and the operating room need to be notified, and blood must be sent to the blood bank for typing and cross-matching. The timing of intervention is crucial, such that prompt relief of the hemopericardium should immediately follow establishment of the airway and access for volume transfusion. If the electrophysiologist is skilled with pericardiocentesis, this procedure may be attempted prior to the surgeon's arrival, after which a catheter can be placed or a drainage tube can be inserted. If pericardiocentesis is not an option or if the procedure was not successful, rapid access to the pericardium can be achieved with either a subxiphoid or a left anterolateral approach. In general, a subxiphoid approach is simpler in the setting of the EP laboratory because the rib cage and lungs are not in the way. A simple opening of the tense pericardium is performed, and this action often results in an immediate restoration of vital signs. If the heart is fibrillating, electrical defibrillation is performed. An important observation is the color of the blood, because dark blood confirms the suspicion of RV injury and presents the possibility for spontaneous sealing of the injury. Red blood, on the other hand, is a more ominous sign, and its presence requires further exploratory investigation. In the event that the blood is dark and the blood loss has subsided with the stabilization of the vital signs, it is not mandatory to perform a formal sternotomy and repair of the RV injury. Rather, a pericardiostomy tube is placed, and the intubated patient is placed under observation in the surgical ICU. If the bleeding continues to subside, the patient can be safely extubated and observed; the pericardiostomy tube can be removed when the drainage has ceased altogether. In the event that bleeding continues or intensifies, further exploration can be performed in a more controlled setting. If operative intervention is necessary, a full sternotomy is performed with cardiopulmonary bypass on standby. A thorough inspection of the heart, great vessels, cavae, and central veins is performed. Most often, the bleeding point is identifiable along the wall of the RV. Occasionally, the pacemaker lead protrudes from the injury site. If this is the case, a decision must be made either to remove the lead from its origin at the generator or to reposition the lead back into the RV and oversew the defect. If the lead is removed, an epicardial lead can be placed and tunneled to the generator. If the lead is repositioned, it needs to be refixated in the RV endocardium. The repositioning requires fluoroscopy and lead testing, which may or may not be available at the time of the emergency.

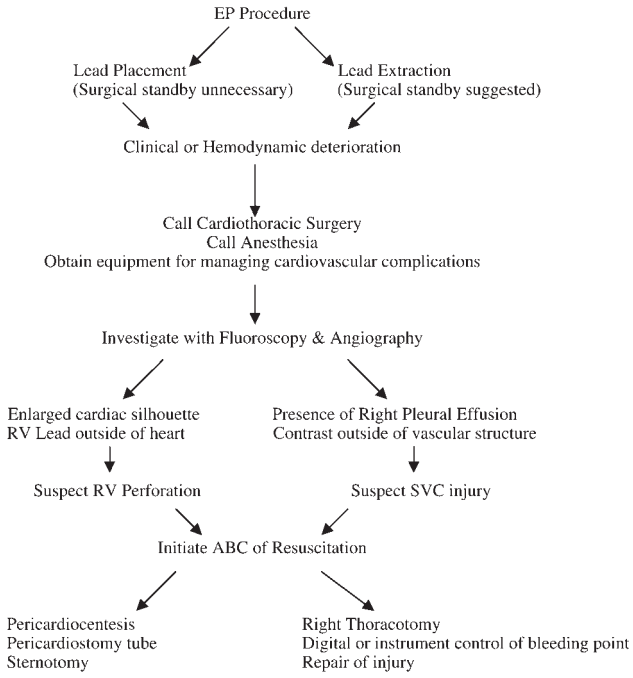
The complications of lead extraction are similar to those of lead placement except that the concern for central vein injury is higher and the need for operative intervention is much more of a possibility with lead extraction. As illustrated in the cases described in this report, injury at the SVC site resulted in cardiac tamponade. The problem with SVC injury is that this site will not close spontaneously, so that simply relieving the hemopericardium will not be enough. Furthermore, injury of the SVC above the pericardial reflection can result in exsanguination into the right chest. In case 1, the problem was intrapericardial SVC injury with tamponade. In case 4, the problem was extrapericardial SVC injury with ongoing blood loss into the right chest. The management strategies for these 2 situations were very different. In the first case, a sternotomy, a pericardiotomy, and a repair of the SVC were performed. In case 4, a right thoracotomy was performed after the placement of a chest tube. Unfortunately, 2 mistakes were made in case 4: (1) delay in treatment and (2) placement of a chest tube (which resulted in a delay of treatment). For SVC injuries with a right hemothorax, an emergent right thoracotomy must be performed with digital or instrumental (a clamp, such as a side-biting vascular clamp) control of the injured site once the airway and access are established. Then, once the hemodynamics and vital signs are restored with volume resuscitation, the repair of the injury can be performed. Placement of a chest tube simply allows an escape route for the hemorrhage and does not address its source.

In summary, complications from PPM or ICD lead placement or extraction are rare but are potentially life threatening. For lead placement, surgical standby is not necessary, but if a complication is suspected, surgical consultation should be immediately obtained. For lead extraction, surgical backup should be obtained, and an open-chest instrument tray should be readily available. The equipment necessary for immediate use is listed in the Table. RV perforation can be managed with pericardiocentesis or a pericardiostomy tube placed from either a subxiphoid or an anterolateral thoracotomy approach. Further exploration should be performed

Equipment Necessary in the Electrophysiology Laboratory to Manage Cardiovascular Complications

Equipment for intubation (eg, laryngoscope, endotracheal tubes, oxygen supply)
Large-bore intravenous access kits (eg, introducer kits)
Bovie (grounding pad and wand)
Suction equipment (tubing and Yankauer tip)
Open-chest tray (with chest and sternal retractors, chest tubes)
Vascular tray
Suture material
Code cart
Chest pack (draping material, sponges, bowls, gowns, etc)
Sterile gloves, hats, masks

once the tamponade is relieved, if the bleeding is red in color or fails to slow down. Complications arising during lead extraction should prompt immediate surgical consultation and should raise the concern for central vein injury, which definitely requires open intervention. Depending on the location of the injury, a full sternotomy or a thoracotomy is likely to be required. Digital or instrument control of the injury site (eg, SVC) is accomplished and is followed by definitive repair once the hemodynamics and vital signs are restored. An algorithm of this pathway is illustrated in the Figure.



Algorithm for the management of cardiovascular complications following electrophysiology procedures. RV indicates right ventricle; SVC, superior vena cava; ABCs, airway, breathing, and circulation.

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