Circulation
JOURNAL OF THE AMERICAN HEART ASSOCIATION

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Circulation. 2011;123:e378-e380
doi: 10.1161/CIRCULATIONAHA.110.987354
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0009-7322. Online ISSN: 1524-4539

CARDIOLOGY PATIENT PAGE

Pacemaker and Defibrillator Lead Extraction

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Surgically implanted cardiac devices play an important role in the treatment of heart disease. In the 50 years since the first pacemaker was implanted, technology has improved dramatically, and these devices have saved or improved the quality of countless lives. Pacemakers treat slow heart rhythms by increasing the heart rate or by coordinating the heart's contraction for some heart failure patients.[1] Implantable cardioverter defibrillators stop dangerous rapid heart rhythms by delivering an electric shock.[2] As the range of applications widens, the number of patients with cardiac devices continues to increase. Approximately 400 000 devices are implanted each year in the United States, and there >3 million patients with implanted cardiac devices currently.

Occasionally, pacemaker and implantable cardioverter defibrillator systems must be removed. The removal of such systems is potentially a high-risk procedure. With the increasing number of implanted devices, removal is required more frequently. To ensure patient safety, the Heart Rhythm Society has published guidelines for safe lead removal or extraction. These guidelines outline the indications for lead extraction, physician qualifications and training, and the tools and techniques used in the procedure.[3]

One part of the system is the pulse generator, a metal can that contains electric circuits and a battery, usually placed under the skin on the chest wall beneath the collarbone. To replace the battery, the pulse generator must be changed by a simple surgical procedure every 5 to 10 years. The other parts are the wires, or leads, which run between the pulse generator and the heart. In a pacemaker, these leads allow the device to increase the heart rate by delivering small bursts of electric energy to make it beat faster. In a defibrillator, the lead has special coils to allow the device to deliver a high-energy shock and convert dangerous rapid rhythms (ventricular tachycardia or fibrillation) back to a normal rhythm. For both of these functions, leads must be in contact with heart tissue. Most leads pass through a vein under the collarbone that connects to the right side of the heart (right atrium and right ventricle). To remain attached to the heart muscle, most leads have either a small screw or hooks at the end. Within a few months, the body's natural healing process forms scar tissue along the lead and at its tip, which fastens it even more securely in the patient's body. Leads usually last longer than device batteries, so leads are simply reconnected to each new pulse generator (battery) at the time of replacement.

When Is Lead Extraction Recommended?

Although they are designed to be implanted permanently in the body, occasionally these leads must be removed, or extracted. The most common reason for lead extraction is device infection. If any part of the system becomes infected, it is usually impossible to cure the infection without completely removing all hardware from the body. This requires removal of the pulse generator from the chest wall, as well as removal of all leads from the veins and heart. Another reason for lead extraction is when a lead fails to work properly (for example, due to a break in the metal wire or surrounding insulation). Sometimes, the broken lead can be abandoned in

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(*Circulation*. 2011;123:e378-e380.)

***Circulation* is available at http://circ.ahajournals.org** **DOI: 10.1161/CIRCULATIONAHA.110.987354**

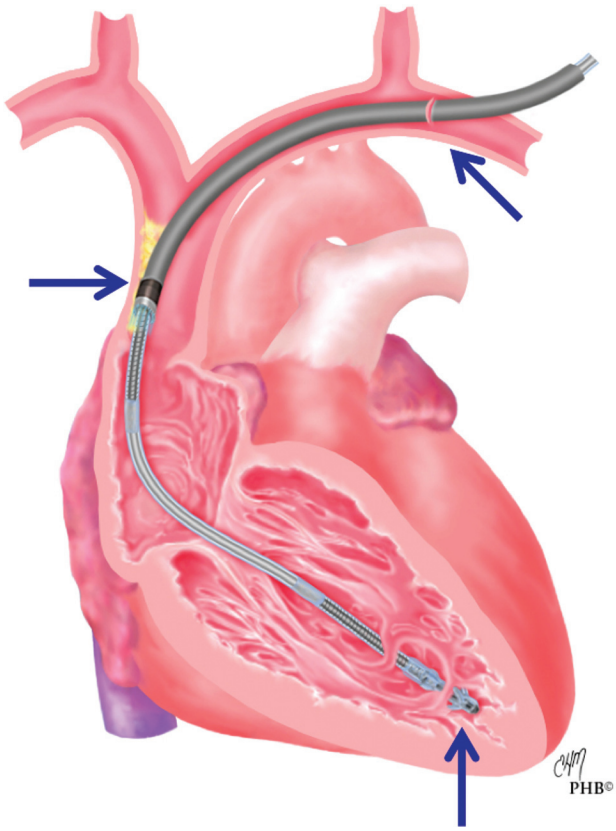

Figure 1. Pacemaker and implantable cardioverter defibrillator leads are removed from the inside of the heart by use of specialized tools, such as the laser sheath shown above. The most common approach follows the course of the lead through the subclavian vein under the patient's shoulder. Arrows show areas where scar tissue is most likely to form.

the heart, with a new lead placed alongside. However, veins can only accommodate a limited number of leads due to space constraints, and sometimes, nonfunctioning leads must be extracted to make space for a new lead. Occasionally, younger patients opt for removal of broken leads even if there are no space limitations because they will probably need more leads in the future, and leads are more difficult to extract after more time in the body. An uncommon reason for lead extraction is a mechanical lead failure that could be dangerous to the patient, such as a protruding wire.

How Is Lead Extraction Performed, and What Should I Expect From the Procedure?

The pulse generator can be removed relatively easily because it is contained in the chest wall pocket and can be reached through a surgical incision. The leads, however, run a long course through the veins into the heart (Figure 1). The body's natural healing process forms scar tissue at multiple sites along the lead that can create strong attachments to the wall of a blood vessel or a heart chamber. Freeing a lead from these attachments requires considerable skill and experience and is more difficult and risky than implanting the leads in the first place. Leads can be extracted from the shoulder area or the leg and shoulder area.

Historically, doctors did not have specialized tools for lead extraction. They used pulling force, or traction, to slowly break the lead free of its attachments. Sometimes they applied force gradually with weights and a pulley system. However, these techniques often failed, which resulted in broken leads with fragments left behind or damage to vital body structures and serious complications. A variety of tools have been developed to make lead extraction safer and more successful. One of these is a wire that passes down the length of the lead, locking into place and allowing force to be applied to the tip of the lead. Another tool is a flexible tube called a sheath that passes over the lead, surrounding it and freeing it from the body by disrupting scar tissue as it is advanced toward the heart (Figure 1). Sheaths can be made of stainless steel or plastic. Some work mechanically, relying on force to free the lead. These are much more effective than simple traction.

The latest technologies for lead extraction deliver various forms of energy to the tip of the sheath. These are called power sheaths. As the sheath is pushed over the lead and comes to an area of attachment, the operator can turn on the sheath's energy source to heat or vaporize scar tissue. This has the effect of cutting the lead from its attachments, allowing the lead to be removed with much less force. Once the entire lead is freed from scar tissue, it can be pulled out of the body safely. One of these specialized sheaths uses electrocautery, similar to what is used to cut through tissue in surgery. Another commonly used sheath has a ring of tiny lasers at its tip. When activated, the lasers vaporize water molecules in scar tissue within 1 mm, which allows the sheath to be passed slowly over the entire lead until it can be removed (Figure 2). Occasionally, leads cannot be extracted from the chest and are instead removed through the femoral vein in the groin by use of specialized tools. There is also a mechanical cutting tool for breaking through dense or calcified scar.

Usually, the lead-extraction procedure is performed with patients under general anesthesia, but sometimes, sedating medications may be used instead. A team of medical professionals, including a cardiologist or cardiac surgeon, anesthesiologist,

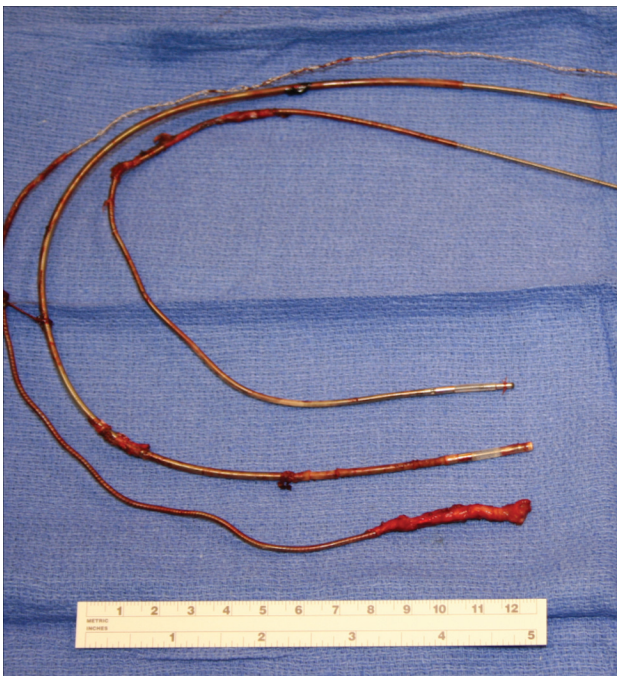

Figure 2. These 3 leads were removed from a single patient. Scar tissue is seen attached to each lead. Specialized sheaths can separate the lead from the blood vessel and heart wall to allow safe extraction.

nurses, and technicians, is required to perform the operation safely. Facility and equipment requirements include a wide array of lead-extraction tools, high-quality x-ray and ultrasound, and a well-equipped operating room. Because of these complex technical requirements, lead extraction is usually performed in specialized centers. Studies have shown that the procedure is more likely to be successful when performed by operators and medical centers with more experience. The overall success rate in a large series of procedures at 89 hospitals in the United States was >90%, but this depends on many factors, such as the specifications of the leads and the amount of time the leads have been implanted. Lead extractions usually take between 2 and 6 hours, and patients are usually admitted to the hospital for a minimum of 1 night. Certain medications, such as blood thinners, might be stopped before the procedure. If the patient needs a new cardiac device and leads, these may be implanted at the same time as the lead extraction or on a different day.

What Are the Risks and Complications of Lead Extraction?

Lead extraction is a complex surgical procedure with some unavoidable risks. Each time the lead is separated from scar tissue, there is a small chance of tearing the surrounding blood vessel or perforating the heart, which can result in major bleeding in the chest or around the heart. In some cases, this requires blood transfusion or even immediate open heart surgery to save the patient's life. Other major complications of lead extraction include a blood clot lodging in the lung, stroke, or various problems related to anesthesia. Less severe problems that have been reported include fluid accumulation around the heart or lung (not requiring drainage), bleeding under the skin, swelling of the arm, and a small amount of air entry into the vein. In the large published studies on lead extraction, the rate of major complications was 1.6% to 2.0%, or approximately 1 in 50 patients.

Summary and Conclusions

When an implanted cardiac device must be removed, experts can use specialized tools and techniques according to the Heart Rhythm Society guidelines to extract the device and leads safely and effectively. Patients should discuss the risks and benefits with their physicians before the procedure. As lead extraction becomes more common and more research in the area is performed, this procedure will continue to evolve and improve.

Disclosures

Dr Belott has served as a consultant to Spectranetics Inc. The remaining authors report no conflicts.

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