A Review Paper

Management of Elderly Patients With Hip Fractures and Cardiac Rhythm Devices

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Abstract

The annual incidence of hip fractures in the United States is expected to double by the year 2050. An additional challenge is that comorbidities are common in elderly patients. As indications for implantation of cardiac rhythm devices continue to broaden, the number of elderly patients with a pacemaker or an implantable cardioverter-defibrillator seen in the orthopedic surgeon's practice is likely to increase. We review the unique properties and functions of the most commonly implanted cardiac rhythm devices, provide an algorithm to assist the surgeon in gathering important patient information and developing perioperative approaches to treatment, and detail potential intraoperative complications and their prevention.

Treatment of hip fractures in the elderly population will continue to challenge orthopedic surgeons. The estimated annual incidence of 350,000 hip fractures in the United States is expected to double by the year 2050.[1-3] In addition, elderly patients at risk for hip fracture usually have multiple medical comorbidities, including hypertension, diabetes mellitus, dementia, chronic lung disease, and coronary artery disease (CAD).[4,5]

In elderly patients with hip fracture, presence of cardiovascular disease causes the most controversy and delay before surgery.[6] The orthopedic surgeon may need the assistance of a medical or geriatric physician to optimize the patient's medical condition before surgery. A coordinated approach to surgery has been shown to decrease time to surgery, and this decrease in time is thought to lead to improved outcomes, including decreased mortality and shorter hospital stay.[7-11] Of particular importance and concern is the presence of a cardiac rhythm device, such as a pacemaker or an implantable cardioverter-defibrillator (ICD). These devices are effective in managing cardiac arrhythmias and preventing sudden cardiac death in several clinical settings, and they have changed the management of patients with myocardial infarction and heart failure. Between 1990 and 2002 in the United States, 2.25 million pacemakers were implanted; over the past several years, the number has risen to more than 250,000 per year.[12] ICD implantation also has increased as indications have expanded. Approximately 415,000 ICDs were implanted between 1990 and 2002, and it is estimated that 100,000 ICDs are implanted annually.[12]

As use of these cardiac rhythm devices increases among the elderly, orthopedic surgeons encounter them more often

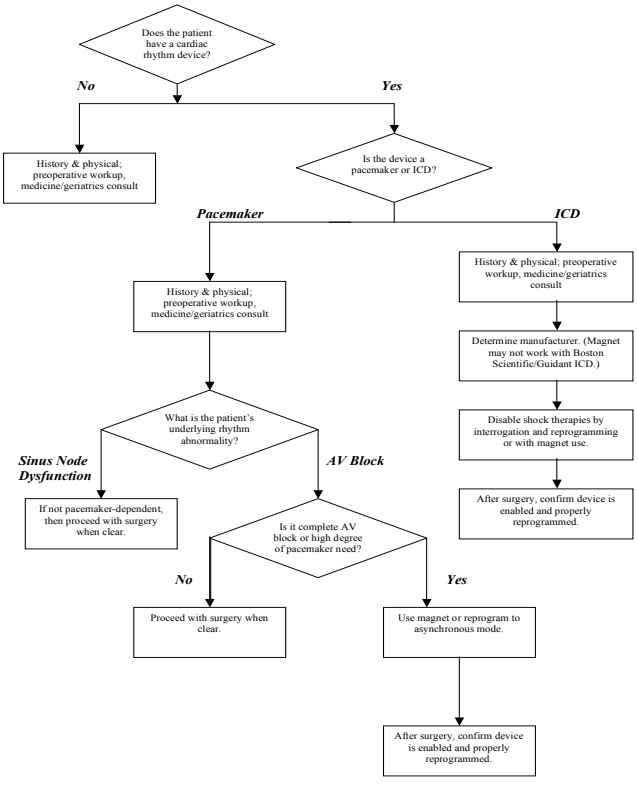

Figure. Algorithm of perioperative management of pacemakers/implantable cardioverter-defibrillators for hip fracture repair. Abbreviations: AV, atrioventricular; ICD, implantable cardioverter-defibrillator.

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in both trauma and elective surgery settings. In this article, we review selected types of cardiac rhythm devices and address their implications for perioperative management.

Types of Cardiac Rhythm Devices

Pacemakers

The introduction of cardiac pacemakers in the 1950s has significantly improved the treatment of patients with bradyarrhythmias and conduction abnormalities. The primary indications are sinus node dysfunction (or "sick sinus syndrome," which includes sinus bradycardia, sinus arrest, and sinoatrial block) and atrioventricular (AV) block. Other indications are advanced fascicular block, neurocardiogenic syncope, and cardiomyopathy.[13] Through the years, many different pacemaker models have been developed, of increasing complexity and decreasing size, including single-chamber, dual-chamber, and biventricular models.[14-17]

The pacemaker has 2 basic components—the pulse generator and the leads. The generator consists of a battery, capacitor, circuitry, and semiconductor chips. The generator is predicted to last 6 to 10 years.[14] It is usually implanted prepectorally and inferior to the clavicle. Usually, venous access is obtained through the cephalic, axillary, and/or subclavian veins. In a single-chamber model, the lead system passes through the heart's venous return to the apex of the right ventricle; in a dual-chamber model, the first lead is supplemented by a second lead inserted into the right atrium. The leads may last more than 20 years.

Pacemakers work by analyzing cardiac rhythm, computing when pacing is necessary, and delivering the appropriate pulse, which travels through myocardial tissue and causes muscle contraction.[18] In a unipolar pacing system, electrons flow from the tip of the lead (cathode), through cardiac and chest tissues, and back to the device (anode), producing a characteristic large "spike" on an electrocardiogram. Bipolar devices have a slightly larger lead because both the cathode and the anode are inside the lead. These modern devices are at lower risk for electromagnetic interference (EMI) because the current passes through much less tissue.[18]

Pacemaker modes and timing cycles have improved considerably since they were introduced. Whereas first-generation pacemakers triggered pacing regardless of heart status (asynchronous pacing), current models can sense depolarization of native cardiac tissue and react to this event. Most pacemakers implanted in patients in the United States are dual-chamber devices that sense and pace, thus preserving AV coordination.[13]

Implantable Cardioverter-Defibrillators

Devised in the 1970s and now implanted with the same technique used with the pacemaker, the ICD is designed to protect patients from sudden cardiac death.[14] The device detects arrhythmia with an intracardiac lead and then delivers a high-voltage current between generator and intracardiac coils to terminate ventricular tachycardia (VT) or ventricular fibrillation (VF). Weighing between 50 g and 100 g, the ICD consists of a battery, capacitor, voltage converter, and circuitry; it has the pacing capabilities of a pacemaker. The ICD detects the arrhythmia, charges itself, and delivers therapy, which may consist of antitachycardia pacing; synchronized, low-energy shocks (often less than 5 to 10 J); or high-energy, unsynchronized shocks up to 36 J.[14] These shocks "reset" the heart rhythm and break the arrhythmia. ICDs have proved effective in preventing sudden cardiac death in patients previously resuscitated from ventricular arrhythmias,[19] patients with CAD and inducible VT,[20] patients with CAD and history of infarct,[21] and patients with congestive heart failure without previous myocardial infarction or arrythmia.[22] As the efficacy of these devices in preventing sudden cardiac death increases, and indications for their use expand, the number of patients with ICDs also increases.

Patient Care in the Perioperative Setting

Presence of a pacemaker or an ICD in an elderly patient who presents with a hip fracture has numerous implications for the orthopedic surgeon. Most important, presence of a pacemaker or an ICD indicates a clinically significant cardiac history that the surgeon and anesthesiologist need to address in preparation for surgery. Patient history, physical examination, and laboratory studies should be used to determine if the patient's fracture resulted from a cardiac event (eg, arrhythmic syncope, pacemaker/ICD malfunction), in which case, additional cardiac workup may be necessary. A 12-lead electrocardiogram should always be obtained and analyzed. A chest radiograph may be helpful in establishing the integrity of the cardiac device hardware.

For patients with cardiac devices, a simple algorithm will assist the orthopedic surgeon in determining type of device implanted, reason for implantation, and perioperative goals (Figure). For example, was a pacemaker implanted for sinus node dysfunction or AV block? The answer has direct implications for surgery, as a patient with third-degree AV block is usually pacemaker dependent, whereas most patients with sinus node dysfunction are not. Was an ICD implanted for a history of VT or VF, or for prevention? Other important information includes history of ventricular arrhythmias/ICD firings, degree of pacemaker dependence, and general cardiac stability.

The orthopedic surgeon can contact the patient's primary physician or cardiologist to obtain the relevant cardiac history, including date of the device's most recent function check, or "interrogation," and to coordinate perioperative care. Proper functioning of pacemakers is ensured by interrogating them every 6 months; ICDs are checked every 3 months. This routine maintenance is performed in the cardiologist's office or in specialty cardiac device clinics. Having the most recent record of interrogation assists in preoperative preparation and expedites inpatient cardiology consultation, if required.

Table. Major Companies and Contact Information

Medtronic	1-800-505-4636	Available 24 hours a day
Boston Scientific	1-651-582-4000	Available 24 hours a day
St. Jude Medical/Pacesetter	1-800-722-3774	Available 24 hours a day
Biotronik	1-800-547-0394	Available 24 hours a day

Determining the manufacturer and model of the device is necessary because each device has unique traits (eg, programmable features, response to magnet application) and a unique programmer for interrogation. Manufacturers of the cardiac devices most commonly used in the United States are Medtronic (Minneapolis, Minnesota), Boston Scientific (formerly Guidant; Natick, Massachusetts), St. Jude Medical (St. Paul, Minnesota), and Biotronik (Berlin, Germany). The patient may know which device he or she has implanted. All patients with a cardiac device should carry a wallet card with this information printed on it. When a patient does not have this information, the manufacturers can be contacted to determine which one has a record of the patient's device and to arrange for a technician to interrogate the device (Table). If the information cannot be found, an experienced cardiologist usually can determine the device model on the basis of chest radiographic appearance.

A key issue in procedure planning is whether electrocautery will be used. Although the EMI produced by electrocautery has been reported to cause complications in patients with ICDs or pacemakers,[23-27] there are few reports in the orthopedic literature. In a report of a pacemaker-dependent pediatric patient with complete heart block undergoing scoliosis surgery, electrocautery interfered with the pacemaker and caused transient asystole.[23] Electrocautery was stopped, rhythm normalized, and surgery continued with use of a harmonic scalpel. Electrocautery also can inadvertently switch a pacemaker to a "power-on" or reset mode, which is often asynchronous pacing at a basal rate. In the event a pacemaker is reset, the patient may develop hemodynamic changes or discomfort, and the pacemaker must be externally reprogrammed by a technician.[18,28,29] The main concern for ICDs is the potential for EMI from electrocautery to be inappropriately detected by the device as ventricular fibrillation, triggering an unnecessary device shock to the heart.

There is a theoretical risk for myocardial tissue damage at the electrode–tissue interface and permanent damage to pacemaker circuitry when a large amount of energy is applied from the electrocautery device directly to the pacemaker or the ICD.[28,29] This risk can be countered by placing the electrocautery grounding pad in an area that allows the current to travel a path that does not involve the heart.[30] For example, during lower extremity surgery, when the grounding pad is placed caudal to the level of the umbilicus, current is less likely to interact with the cardiac rhythm device in the chest. Bipolar cautery has a theoretical advantage over monopolar cautery in patients with a cardiac rhythm device because the current pathway is limited to the immediate area of the electrocautery pen.[29,31]

An alternative to electrocautery is the harmonic scalpel, which uses high-energy ultrasound to cut and coagulate tissue. Case reports on its use in patients with cardiac rhythm devices who are having abdominal[32] or cardiac[33] surgery noted no clinically significant interaction with the devices.

For prevention of complications caused by EMI, pacemaker and ICD function can be altered before or during surgery. Immediately before surgery, an appropriately trained technician, nurse, or physician can externally modify the device program. During surgery, the anesthesiologist can use a magnet to alter the pace or disable the device. Reprogramming is preferred, especially for an ICD, because this option offers more control than use of a magnet does, but clinical circumstances, resources, and personnel availability may make application of a magnet the better choice.

Usually, a pacemaker responds to magnet use by pacing in an asynchronous mode (asynchronous ventricular pacing, asynchronous atrial and ventricular pacing), during which intrinsic cardiac activity is not sensed by the device. This response continues only while the magnet is applied, and the pacemaker returns to programmed settings when the magnet is removed. The rate at which the pacemaker operates in "magnet mode," usually 65 to 100 bpm, depends on the manufacturer and battery strength. As the battery reaches the end of its life, the magnet rate typically slows.

In contrast, when a magnet is applied to an ICD, the pacing function does not change. With the magnet in place, however, the device cannot detect tachycardias and, therefore, cannot trigger any needed ICD shock(s). Usually, programmed settings are restored when the magnet is removed from the ICD. In many Boston Scientific/Guidant ICDs, tachycardia therapy response to the magnet is programmable, and, therefore, different models may respond by temporarily suspending therapies, permanently suspending therapies, or leaving therapies unchanged.[28]

Use of a magnet for intraoperative management of cardiac rhythm devices has advantages and disadvantages. Advantages are ease of use and control of the device (by the anesthesiologist). For instance, when a VF/VT event occurs during surgery, the magnet can simply be removed to restore ICD function. Magnet use also maximizes how long the patient is protected by the ICD in the perioperative period; the magnet is applied immediately before and removed immediately after the procedure, and there is no delay waiting for a technician from an outside location to arrive. Disadvantages of magnet use are the risks for slippage or improper placement secondary to obstructed view because of draping or patient positioning, both of which could potentially lead to loss of ICD inhibition and device firing.

Altering ICD function by preoperative external programming also has advantages and disadvantages. The advantages are that it ensures the device is disabled, facilitates discovery of any incidental problems with the device, and provides the opportunity for device reprogramming. Disadvantages are more time and effort in getting the technician to arrive, longer time (compared with magnet use) the device is disabled, and, therefore, not protecting the patient from VT/VF, and the risk that the patient may leave the hospital with the device disabled. The circumstances of surgery also may affect treatment options. For example, emergency, lifesaving surgery should not be delayed by concerns about the device. For urgent or elective surgery in patients who have a pacemaker but are not pacemaker dependent, surgery can usually proceed without additional interrogation of the device.

Summary

The number of elderly patients continues to increase as the population ages and as medical management of previously fatal conditions improves with use of devices such as pacemakers and ICDs. Therefore, the orthopedic surgeon can expect to treat an increasing number of patients with hip fractures who also have implanted cardiac rhythm devices. Management of such patients is best approached with an understanding of the properties and functions of the devices and how they affect perioperative treatment choices.

For urgent or elective surgery in patients who have a pacemaker but are not pacemaker dependent, surgery can usually proceed without further interrogation of the device. For the pacemaker-dependent patient, usually a patient with complete AV block, the pacemaker should be programmed to an asynchronous mode, or the anesthesiologist should be prepared to apply a magnet over the pacemaker during electrocautery use. For patients with ICDs, tachycardia therapies should be disabled either by reprogramming or magnet application. In general, reprogramming is the preferred option, but clinical circumstances, resources, and personnel availability may make magnet use feasible in many instances. In all situations, the patient's cardiologist or device clinic should be consulted if there is uncertainty about intraoperative management.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

References

1. Macaulay W, Pagnotto MR, Iorio R, Mont MA, Saleh KJ. Displaced femoral neck fractures in the elderly: hemiarthroplasty versus total hip arthroplasty. *J Am Acad Orthop Surg.* 2006;14(5):287-293.
2. Morris AH, Zuckerman JD. National Consensus Conference on Improving the Continuum of Care for Patients With Hip Fracture. *J Bone Joint Surg Am.* 2002;84(4):670-674.
3. Lindskog DM, Baumgaertner MR. Unstable intertrochanteric hip fractures in the elderly. *J Am Acad Orthop Surg.* 2004;12(3):179-190.
4. Brainsky A, Glick H, Lydick E, et al. The economic cost of hip fractures in community-dwelling older adults: a prospective study. *J Am Geriatr Soc.* 1997;45(3):281-287.
5. Haentjens P, Autier P, Barette M, Boonen S, Belgian Hip Fracture Study Group. The economic cost of hip fractures among elderly women. A one-year, prospective, observational cohort study with matched-pair analysis. *J Bone Joint Surg Am.* 2001;83(4):493-500.
6. Cluett J, Caplan J, Yu W. Preoperative cardiac evaluation of patients with acute hip fracture. *Am J Orthop.* 2008;37(1):32-36.
7. Fox HJ, Pooler J, Prothero D, Bannister GC. Factors affecting the outcome after proximal femoral fractures. *Injury.* 1994;25(5):297-300.
8. Guryel E, Redfern DJ, Ricketts DM. Balancing priorities in the management of hip fractures: guidelines versus resources. *Ann R Coll Surg Engl.* 2004;86(3):171-173.
9. McGuire KJ, Bernstein J, Polsky D, Silber JH. The 2004 Marshall Urist award. Delays until surgery after hip fracture increases mortality. *Clin Orthop.* 2004;(428):294-301.
10. Weller I, Wai EK, Jaglal S, Kreder HJ. The effect of hospital type and surgical delay on mortality after surgery for hip fracture. *J Bone Joint Surg Br.* 2005;87(3):361-366.
11. Von Meibom N, Gilson N, Dhapre A, Davis B. Operative delay for fracture of the hip. A two-centre prospective study. *J Bone Joint Surg Br.* 2007;89(1):77-79.
12. Maisel WH, Moynahan M, Zuckerman BD, et al. Pacemaker and ICD generator malfunctions. Analysis of Food and Drug Administration annual reports. *JAMA.* 2006;295(16):1901-1906.
13. Kusumoto FM, Goldschlager N. Cardiac pacing. *N Engl J Med.* 1996;334(2):89-98.
14. DiMarco JP. Implantable cardioverter-defibrillators. *N Engl J Med.* 2003;349(19):1836-1847.
15. Ellenbogen KA, Wood MA. Pacemaker selection—the changing definition of physiologic pacing. *N Engl J Med.* 2005;353(2):202-204.
16. Jarcho JA. Biventricular pacing. *N Engl J Med.* 2006;355(3):288-294.
17. Toff WD, Camm AJ, Skehan JD, United Kingdom Pacing and Cardiovascular Events (UKPACE) Trial Investigators. Single-chamber versus dual-chamber pacing for high-grade atrioventricular block. *N Engl J Med.* 2005;353(2):145-155.
18. Stone KR, McPherson CA. Assessment and management of patients with pacemakers and implantable cardioverter defibrillators. *Crit Care Med.* 2004;32(suppl 4):S155-S165.
19. Antiarrhythmics Versus Implantable Defibrillators (AVID) Investigators. A comparison of antiarrhythmic-drug therapy with implantable defibrillators in patients resuscitated from near-fatal ventricular arrhythmias. *N Engl J Med.* 1997;337(22):1576-1583.
20. Buxton AE, Lee KL, Fisher JD, et al. A randomized study of the prevention of sudden death in patients with coronary artery disease. *N Engl J Med.* 1999;341(25):1882-1890.
21. Moss AJ, Zareba W, Hall WJ, et al. Prophylactic implantation of a defibrillator in patients with myocardial infarction and reduced ejection fraction. *N Engl J Med.* 2002;346(12):877-883.
22. Bardy GH, Lee KL, Mark DB, et al. Amiodarone or an implantable cardioverter-defibrillator for congestive heart failure. *N Engl J Med.* 2005;352(3):225-237.
23. Bales JG, Colon J, Ramadhyani U, LeDoux E, Bennett JT. Electrocautery-induced asystole in a scoliosis patient with a pacemaker. *J Pediatr Orthop B.* 2007;16(1):19-22.
24. Mangar D, Atlas GM, Kane PB. Electrocautery-induced pacemaker malfunction during surgery. *Can J Anaesth.* 1991;38(5):616-618.
25. Nercessian OA, Wu H, Nazarian D, Mahmud F. Intraoperative pacemaker dysfunction caused by the use of electrocautery during a total hip arthroplasty. *J Arthroplasty.* 1998;13(5):599-602.
26. Peters RW, Gold MR. Reversible prolonged pacemaker failure due to electrocautery. *J Interv Card Electrophysiol.* 1998;2(4):343-344.
27. Wilson S, Neustein SN, Camunas J. Rapid ventricular pacing due to electrocautery: a case report and review. *Mt Sinai J Med.* 2006;73(6):880-883.
28. Petersen BT, Hussain N, Marine JE, et al. Endoscopy in patients with implanted electronic devices. *Gastrointest Endosc.* 2007;65(4):561-568.
29. Yerra L, Reddy PC. Effects of electromagnetic interference on implanted cardiac devices and their management. *Cardiol Rev.* 2007;15(6):304-309.
30. American Society of Anesthesiologists Task Force on Perioperative Management of Patients With Cardiac Rhythm Management Devices. Practice advisory for the perioperative management of patients with cardiac rhythm management devices: pacemakers and implantable cardioverter-defibrillators. A report by the American Society of Anesthesiologists Task Force on Perioperative Management of Patients With Cardiac Rhythm Management Devices. *Anesthesiology.* 2005;103(1):186-198.
31. Dawes JC, Mahabir RC, Hillier K, Cassidy M, de Haas W, Gillis AM. Electrosurgery in patients with pacemakers/implanted cardioverter defibrillators. *Ann Plast Surg.* 2006;57(1):33-36.
32. Nandalan SP, Vanner RG. Use of the harmonic scalpel in a patient with a permanent pacemaker. *Anaesthesia.* 2004;59(6):621.
33. Epstein MR, Mayer JE Jr, Duncan BW. Use of an ultrasonic scalpel as an alternative to electrocautery in patients with pacemakers. *Ann Thorac Surg.* 1998;65(6):1802-1804.

This paper will be judged for the Resident Writer's Award.