

Pre-, intra- and postoperative issues and management of pacemaker and defibrillator carriers in the setting of electrocautery

# Recommendations for the perioperative management of patients with cardiac implantable electronic devices

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## Summary

Many patients undergoing elective or emergency surgery have a cardiac implantable electronic device (CIED), and their number continues to grow. This joint position paper of the Swiss Working Group on Cardiac Pacing and Electrophysiology of the Swiss Society of Cardiology and the Cardiovascular and Thoracic Anaesthesia Group of the Swiss Society of Anaesthesiology and Resuscitation gives a concise overview of the pre-, intra- and postoperative issues and management of pacemaker and defibrillator carriers in the setting of electrocautery used for surgery and strives to give practical and readily applicable guidance stressing the simple use of a magnet placed over the CIED.

Key words: pacemaker; defibrillator; electrocautery; magnet; reed switch; surgery

## Introduction

In Switzerland approximately 45 000 patients live with a cardiac implantable electronic device (CIED). CIEDs comprise cardiac pacemakers, implantable cardioverter defibrillators (ICDs) and devices for cardiac resynchronisation therapy (CRT). Their number continues to grow and these patients are already undergoing elective or emergency surgery in great numbers. The Swiss Working Group on Cardiac Pacing and Electrophysiology published a checklist for the perioperative management of CIED patients in 2009 ([www.pacemaker.ch/download/Checklist\\_Literature.pdf](http://www.pacemaker.ch/download/Checklist_Literature.pdf)). The current recommendations update the previous ones and represent a joint position paper of the Swiss

Working Group on Cardiac Pacing and Electrophysiology of the Swiss Society of Cardiology (SSC) and the Cardiovascular and Thoracic Anaesthesia Group of the Swiss Society of Anaesthesiology and Resuscitation (SGAR). It has been approved by the boards of the SSC and the SGAR.

In clinical practice, many patients undergo surgery at hospitals where reprogramming of the device is not possible. The main objective of these recommendations is to allow surgery at local centres as often as possible and to avoid unnecessary delays or referrals to centres with a cardiology service. There is also the real risk that the patient's device is left programmed in an asynchronous pacing mode or that life-saving ICD therapy remains inactivated. In fact, the vast majority of patients can be operated on with the simple use of a magnet [1]. Following the modified recommendations of the Canadian Heart Rhythm and Anesthesiologists' Society this position paper gives a pragmatic approach to elective and emergency surgery on CIED patients, stresses the importance of understanding the simple use of a magnet and explains in which conditions reprogramming really is necessary [1].

## Abbreviations

ATP: antitachycardia pacing  
CIED: cardiac implantable electronic device  
CRT: cardiac resynchronisation therapy  
EMI: electromagnetic interference  
ICD: implantable cardioverter defibrillator

## Potential perioperative risks

The main concerns when using cautery in a patient with a CIED is that it may inhibit pacing in a pacemaker-dependent patient or cause inappropriate anti-tachycardia pacing (ATP) or shock therapy in an ICD patient (table 1). Furthermore, though less threatening, inappropriate rapid pacing may occur if the rate response remains activated. The likelihood of occurrence of these events and the severity of their consequences depends on four factors:

1. Site of surgery  
Sensing electromagnetic interference (EMI) is more likely if surgery is performed <15 cm away from the device, i.e., above the umbilicus.
2. Underlying cardiac rhythm  
Only a minority of pacemaker patients are completely pacemaker-dependent and at risk for prolonged asystole. For the remainder, short periods of EMI (<5 seconds) during cautery will not result in asystole even if they temporarily inhibit pacing.
3. Type and programming of the device  
EMI is more likely in patients with unipolar leads (which have become very rare) and those with a very high programmed sensitivity.  
Inappropriately rapid pacing can be caused by manipulation in the vicinity of the generator (“activity sensors”) or by mechanical ventilation or monitoring of respiratory rate in patients with rate-modulation technology (minute ventilation sensors) [2]. These minute ventilation sensors are used in Boston Scientific and Sorin devices, and measure trans-thoracic impedance. Mechanical ventilation or the current delivered by external respiratory rate monitors may lead to rapid ventricular pacing which must not be misinterpreted as ventricular tachy-

cardia. Hence suspension of rate response during the procedure should be considered; this can be accomplished with a magnet in pacemaker patients, but requires reprogramming with ICDs.

### 4. Type of cautery utilised

EMI is more likely to occur with unipolar cautery. The grounding pad of the coagulation system should therefore be positioned away from the device (e.g., upper thigh). Bipolar cautery should be preferred over unipolar cautery, with bursts lasting <5 seconds with 5-second pauses between bursts. When using an argon beam coagulation system, reprogramming of the pacemaker in a dependent patient should be considered, since experience is still limited [1].

Of course, other consequences during surgery can impair the functionality of the device (e.g., physical damage to the leads, increase of pacing thresholds with loss of capture, increase of ICD defibrillation threshold owing to a perioperative pneumothorax, etc.).

## Principle of magnet use

CIEDs possess a reed switch which is activated when a magnetic field is applied. In short, the reed switch consists of two magnetic metal strips, that are usually separated, in a glass capsule. The magnetic field will bring these two strips together, which results in a sudden voltage change sensed by the sensing amplifier that will trigger programmed functions such as asynchronous pacing [3]. Newer devices that are designed to be magnetic resonance imaging-safe are equipped with Hall-effect sensor switches, which trigger an electronic switch when activated by a magnetic field.

**Table 1:** Patient- and procedure-related risk factors.

		Pacemaker		Implantable cardioverter defibrillator	
		Device always accessible and outside operation field		Bradycardia function	Tachyarrhythmia function
No or minimal cautery			No reprogramming Have magnet available	No reprogramming	Apply magnet
Significant cautery	<b>Not pacemaker-dependent</b>	Yes	No reprogramming Have magnet available	No reprogramming	Apply magnet
		No	No reprogramming	No reprogramming	Reprogramme
	<b>Pacemaker-dependent</b>	Yes	Apply magnet	Consider reprogramming	Apply magnet
		No	Reprogram	Reprogram	Reprogram

### Pacemakers (table 2)

Applying magnets to pacemakers serves both diagnostic and therapeutic purposes. The magnets should have a field strength >10 Gauss aligned with the reed switch in order to activate the switch (magnets provided by the industry have field strengths >90 Gauss). In very obese persons two magnets may be required to activate the reed switch.

The application of a magnet switches the programmed mode to an asynchronous mode and inactivates the rate response feature. Biotronik pacemakers are an exception in that in the default “auto” setting they will pace asynchronously for 10 beats only and then revert to the programmed synchronised mode.

### Implantable cardioverter defibrillators (table 3)

Generally, magnet application suspends antitachycardia therapy without any effect on the pacing mode. Sorin ICDs are an exception and will pace with the magnet rate. This means that the pacemaker part continues to function in the programmed synchronous mode, including rate responsiveness. Approximately 25% of ICD patients also require some kind of anti-bradycardia pacing.

Boston Scientific ICD can respond in a complex fashion. Older devices (PRIZM and VITALITY 1 families)

have the “change the mode with magnet” feature that can be programmed on. In that case magnet placement can permanently switch antitachycardia detection and therapy off. In order to reactivate it, the magnet has to be reapplied for >30 seconds. In the more recent Boston Scientific models, the “change the mode with magnet” feature is absent and these ICDs behave like the others. If in doubt, interrogating the Boston Scientific defibrillators postoperatively is strongly recommended.

### Minimal preoperative care

Before surgery one must ascertain whether the patient carries a CIED and if so which type. Usually, the patient presents with a pacemaker/ICD identification card that contains all important information. In the case of an emergency or other circumstances preventing the patient from providing this information, a scar in the left or right pectoral region should be sought. In most instances, the device can be palpated. The minimal information that has to be obtained before surgery is whether the patient carries a pacemaker or an ICD. This is important since the response to magnet application differs and may become an issue in a pacemaker-dependent patient. This information can easily be

**Table 2:** Specific responses of different pacemakers on magnet application.

Manufacturer	Response*	Remarks
<b>Biotronik</b>	Auto: DOO/VOO/VDO, 90 bpm for 10 beats, then back to synchronous	Can be programmed to Async or Sync response
<b>Boston Scientific</b>	DOO/VOO/VDO, 100 bpm	Can be programmed OFF
<b>Medtronic</b>	DOO/VOO/VDO, 85 bpm	
<b>St. Jude Medical</b>	DOO/VOO/VDO, 100 bpm	Can be programmed OFF
<b>Sorin/Ela</b>	DOO/VOO/VDO, 96 bpm	

\* Depicted are the default settings of the device. Initial response is pacing in an asynchronous mode (DOO/VOO/VDO). Rates refer to devices at beginning of life (BOL).

**Table 3:** Manufacturer-specific implantable cardioverter defibrillator responses to magnet application.

Manufacturer	Response to Brady function	Response to Tachy function	Remarks
<b>Biotronik</b>	None	Detection/therapy: OFF	Since Lumax: during maximum of 8 hours
<b>Boston Scientific</b>	None	*	
<b>Medtronic</b>	None	Detection: OFF	Patient alert “ON”: continuous tone: OK, alternating tone: alarm
<b>St. Jude Medical</b>	None	Detection/therapy: OFF	Can be programmed to “Ignore magnet” Atlas and Epic: vibratory alert
<b>Sorin/Ela</b>	Pace in programmed mode at magnet rate (96 bpm)	Detection/therapy: OFF	

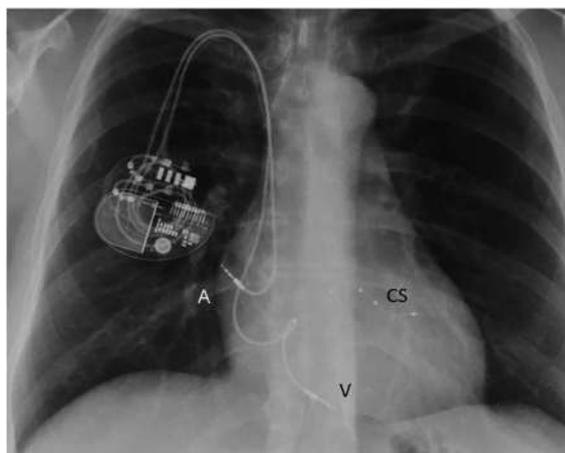
\* If the function “Enable magnet use” is “ON” (nominal): 30” beep synchronous to R wave, then: i) continuous beep (some old models): Tachy mode OFF, magnet can be removed; to activate therapy magnet must be reapplied, ii) intermittent beep (new models): magnet must be left to inhibit antitachycardia therapy. If the function “Enable magnet use” is “OFF”: no effect.

obtained from a simple chest X-ray (figs 1 and 2). An ICD can easily be recognised from the shock coils that are identified as a “thickening” of the lead in the right ventricle. Many (“dual-coil”) ICD leads carry a second coil in the superior vena cava. If these are discerned, the patient should be treated like an ICD carrier. The presence of a third pacemaker lead pointing posteriorly indicates that this patient is a CRT-carrier in whom perioperative fluid challenges should be avoided since he or she had or has heart failure. Often, however, additional leads are simply abandoned leads (without contact to the generator on the chest X-ray).

It is important to know if the patient is pacemaker-dependent or not. A conservative assumption of pacemaker dependency is an intrinsic ventricular rate <40 bpm (measured by temporarily modifying the baseline rate to 40 bpm with a programmer) or if only paced QRS complexes are visible on the ECG. In CRT-patients this cannot be applied since 100% biventricular pacing is desired.

If possible, one should try to identify the manufacturer and model of the CIED. This is pertinent in pacemaker-dependent patients since the pacemakers of one manufacturer (Biotronik) revert after positioning of the magnet from an asynchronous to the programmed mode after ten asynchronous beats and may require reprogramming.

In ICD patients, the magnet will deactivate only the antitachycardia therapies of the device and leaves the antibradycardia mode unaffected. Sorin ICDs set the pacing rate to 96 bpm without any change in pacing mode. One manufacturer (Boston Scientific) has a feature in some of their older models (Boston Scientific PRIZM and VITALITY 1) that permanently deactivates the defibrillator after 30 seconds.



**Figure 1:** Chest X ray (postero-anterior) of a CRT pacemaker: note the pacemaker leads in the right atrium (A), the right ventricle (V) and the quadripolar lead in the coronary sinus (CS) over the left ventricle.

## Intraoperative care

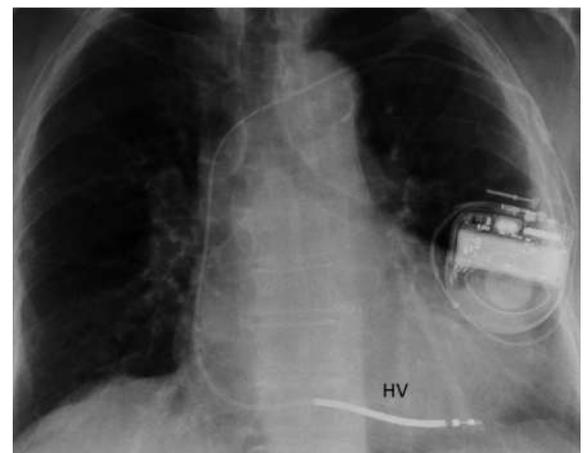
In all patients with an implanted CIED, the anaesthetic workplace must be equipped with a defibrillator with pacing capability. In cases where the patient is completely pacer dependent, or where the ICD functionality will be switched off and where there is no unrestricted access to the patient’s torso, defibrillation/pacing pad must be installed and connected to the external defibrillator device preoperatively.

## Pacemakers

The CIED should be accessible for magnet application. If this is not possible, transcutaneous pads for external pacing, defibrillation and cardioversion should be positioned (at least 5 cm from the generator) or a magnet applied and fixed to the CIED prior to scrubbing-up the patient.

If the patient is not pacemaker dependent and a rate-responsive mode (“R” function) is not programmed in a device using a minute-ventilation sensor (Boston Scientific and Sorin devices), the operation may be performed without magnet application or reprogramming. If a device equipped with a minute-ventilation sensor is left programmed in a rate-responsive mode for the intervention, the healthcare personnel must be aware of the risk of rapid pacing, which may be diagnosed and interrupted by magnet application to pacemakers.

In suspected or known pacemaker dependency, a magnet should be positioned over the generator, which results in asynchronous pacing in a VOO, VDO or DOO mode at a manufacturer-specific rate (table 1). Alternatively, the magnet may be applied only if inhibition by cautery is really observed (provided the device is read-



**Figure 2:** Chest X ray (postero-anterior) of a single-chamber ICD: note the presence of a high-voltage defibrillation coil (HV) in the right ventricle.

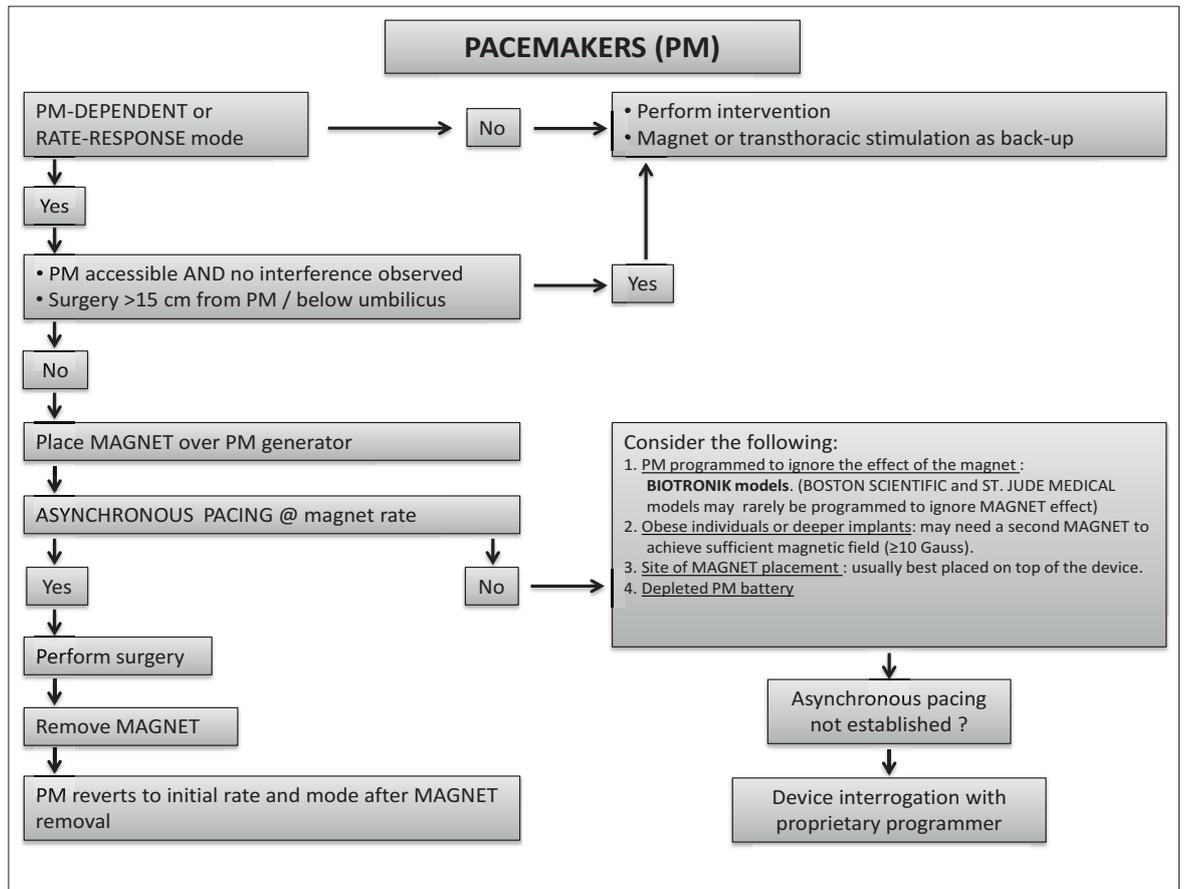


Figure 3: Perioperative management of patients with a pacemaker.

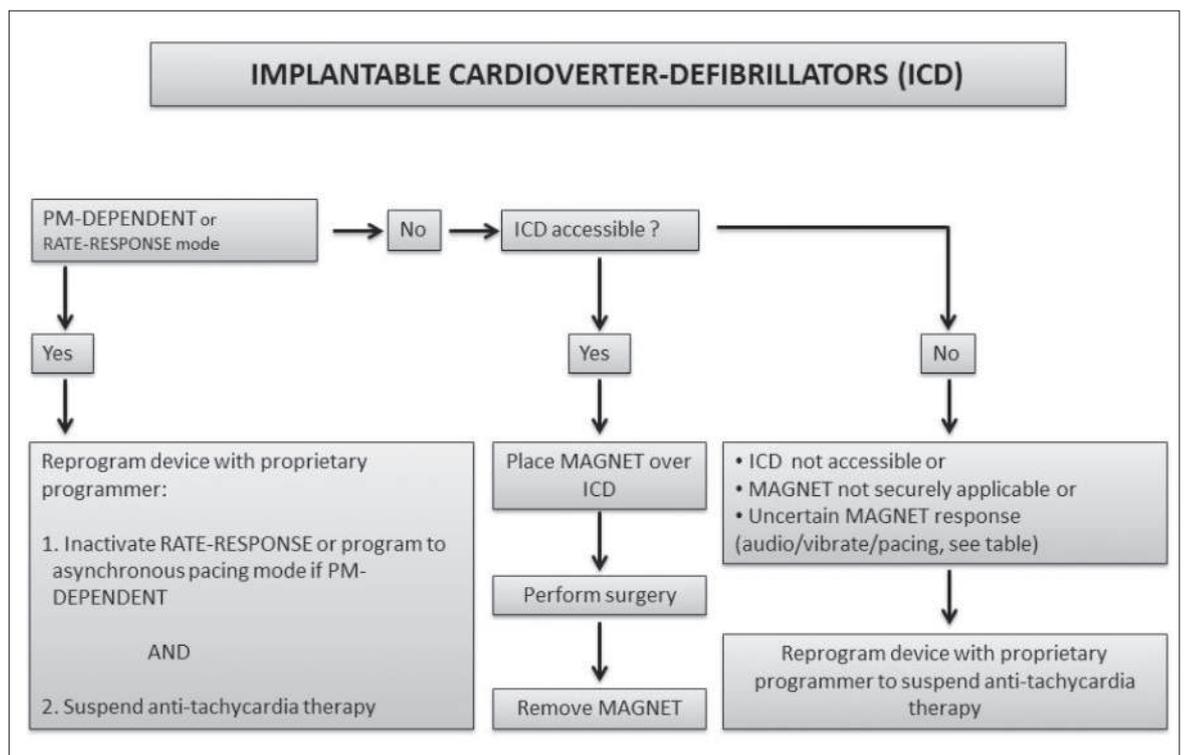


Figure 4: Perioperative management of patients with an implantable cardioverter-defibrillator.

ily accessible), particularly in operations below the umbilicus or a distance of >15 cm to the device [4]. In the default setting, which will be encountered in the overwhelming majority of CIED carriers, Biotronik pacemakers will revert to a synchronous mode after 10 beats. Should the need arise, the magnet may be removed and reapplied, which will render the device asynchronous for the following 10 beats.

In very rare cases, asynchronous pacing can induce ventricular fibrillation by pacing in the vulnerable period of the T-wave. Therefore, patients need to be monitored and an external defibrillator must be present. In clinical practice, this rarely causes problems when some principles regarding cautery are kept in mind (see above).

### Implantable cardioverter defibrillators

Regarding ICD carriers a magnet should always be securely applied in order to disable the antitachycardia functions. In fact, we recommend magnet positioning over reprogramming since the device will always immediately function as programmed after magnet removal. There is an abundance of clinical anecdotes of fatal and near-fatal events linked to failure to restore appropriate device settings [5].

In a pacemaker-dependent ICD patient, however, the device has to be reprogrammed to an asynchronous pacing mode and the tachycardia therapies have to be disabled, because the pacing mode is not affected by magnet application. Other scenarios where reprogramming is recommended are if the patient has to be placed in an abdominal position (since the magnet may dislocate without notice), a secure magnet position during surgery cannot be guaranteed for other reasons, or where a rate-responsive pacing mode is programmed with a minute-ventilation sensor (Boston Scientific devices).

Some ICDs will transiently emit an audible tone (e.g., Boston Scientific, Medtronic devices) or vibrate (St. Jude Medical) when coming into contact with the magnet, which is normal device behaviour. In cases of device reprogramming, institutions should have a standard operating procedure to ensure that the device functions will be correctly restored in a timely manner postoperatively.

### Postoperative care

After the removal of the magnet, the programmed settings are usually restored. If the device programming has been changed, it is critical to continuously monitor the patient and his/her ECG in an adequately equipped

environment with the possibility of immediate advanced life support until the device is reprogrammed. After thoracotomy, the lead position should be analysed on a postoperative X ray and the leads checked if applicable. It is important to recognise, that pacemaker-dependent patients have different physiological responses to shock and that minute-ventilation sensors may have to be switched off in patients ventilated for a prolonged period postoperatively [6] or if the respiratory rate is being monitored externally.

### Conclusion

The vast majority of patients with a CIED who undergo surgery will not experience any untoward effects and can be handled with the simple use of a magnet. The real challenge is to identify those few patients who are at higher risk and whose device should be reprogrammed before and after surgery. These comprise pacemaker-dependent patients with a CIED that is not accessible during surgery and ICD patients whose pacemaker function works in a rate-responsive mode using minute-ventilation sensors. The use of a magnet should be the preferred management since problems arising from forgotten, incomplete or faulty reprogramming cannot arise.

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### Disclosure statement

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### References

- 1 Healey JS, Merchant R, Simpson C, Tang T, Beardsall M, et al. Canadian Cardiovascular Society/Canadian Anesthesiologists' Society/Canadian Heart Rhythm Society joint position statement on the perioperative management of patients with implanted pacemakers, defibrillators, and neurostimulating devices. *Can J Cardiol.* 2012;28(2):141–51.
- 2 Mukerji S, Khunnawat C, Sankaran S, Thakur RK. Wide QRS complex tachycardia in a patient with a minute ventilation rate-responsive pacemaker. *Pacing Clin Electrophysiol.* 2006;29(3):296–7.
- 3 Jacob S, Panaich SS, Maheshwari R, Haddad JW, Padanilam BJ, John SK. Clinical applications of magnets on cardiac rhythm management devices. *Europace.* 2011;13(9):1222–30.
- 4 Cheng A, Nazarian S, Spragg DD, Bilchick K, Tandri H, et al. Effects of surgical and endoscopic electrocautery on modern-day permanent pacemaker and implantable cardioverter-defibrillator systems. *Pacing Clin Electrophysiol.* 2008;31(3):344–50.
- 5 Filipovic M, Michaux I, Seeberger MD. Harm associated with reprogramming pacemakers for surgery. *Anesthesiology.* 2002;97(4):1033–4; author reply 1034–5.
- 6 Anand NK, Maguire DP. Anesthetic implications for patients with rate-responsive pacemakers. *Semin Cardiothorac Vasc Anesth.* 2005;9(3):251–9.

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