

Preporuke za perioperacijski postupak kod bolesnika koji imaju ugrađene kardiovaskularne implantabilne elektroničke uređaje

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RECOMMENDATIONS FOR PERIOPERATIVE MANAGEMENT OF PATIENTS WITH CARDIAC IMPLANTABLE ELECTRONIC DEVICES

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SUMMARY – Four thousand cardiac implantable electronic devices (CIED) are implanted yearly in Croatia with constant increase. General anesthesia and surgery carry some specific risk for the patients with implanted CIEDs. Since most of the surgical procedures are performed in institutions without reprogramming devices available, or in the periods when they are unavailable, these guidelines aim to standardize the protocol for perioperative management of these patients. With this protocol, most of the procedures can be performed easily and, more importantly, safely in the majority of surgical patients.

Key words: *Croatia; Anesthesia, General; Cardiac Resynchronization Therapy Devices; Guideline; Perioperative Care*

Introduction

Four thousand cardiac implantable electronic devices (CIED) are implanted yearly in Croatia¹. CIEDs include pacemakers, implantable cardioverter-defibrillators (ICD), cardiac resynchronization therapy devices (CRT) and implantable loop recorders (ILR). Considering aging of the population and increase of implanted CIEDs in Croatia, an increasing number of patients undergo elective or urgent surgery. In a high

number of cases, surgeries are carried out in hospitals, which lack both the staff and devices for reprogramming of CIEDs, or in the periods (urgency, night duties) when reprogramming is not available. It is important to note that most procedures can be done safely for patients by using standardized protocols and algorithms, as well as easy use of magnets^{2,3}.

The aim of this document is to standardize care for these patients and their management, and to allow for safe performance of surgical procedures in most institutions in Croatia even when reprogramming is not available or is unnecessary according to the guidelines and this review.

This document is a result of modifications to the guidelines made by the Swiss Working Group on Arrhythmias and Working Group on Cardiovascular

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Anesthesiology, and the guidelines made by the Canadian Society of Cardiology^{2,3}. The document has been made in cooperation with the Working Group on Arrhythmias and Electrostimulation of the Croatian Cardiac Society and anesthesiologists from the Sestre milosrdnice University Hospital Centre.

Potential Perioperative Risks

The risks for CIEDs relate primarily to the use of electrocautery and electromagnetic interference with the device. The use of electrocautery can cause:

- a) inhibition of pacing in patients who are vitally dependent on cardiac pacing*;
- b) inappropriate anti-tachycardia pacing (ATP) or ICD shock delivery in patients with an ICD*;
- c) inappropriate fast pacing in patients with the activated rate response function; and
- d) direct mechanical damage of the device and/or electrodes*;

(a) and (b) may be life-threatening. Risks primarily depend on the following 4 factors:

1. Site of surgery

The probability of electromagnetic interference is much higher for the procedures carried out less than 15 cm away from the CIED. The more away the procedure is carried out, the interference is less likely. For example, procedures beneath the umbilical line have almost no risk of interference.

2. Basic cardiac rhythm

Only a few patients with pacemakers are completely, vitally dependent on anti-bradycardia pacing (patients with ventricular asystole). Others have some degree of their own rhythm and therefore the risks/consequences of the possible pacing inhibition are smaller.

3. Type and way of programming CIEDs

The CIEDs with unipolar electrodes or unipolar programmed pacing have a higher possibility of interference in comparison with the bipolar ones. Inappropriately fast pacing may be caused by CIED manipulation or in CIEDs that have activity sensors. CIEDs which have minute ventilation sensors (some pacemakers and ICDs produced by Sorin and Boston Scientific) have the possibility to increase heart rate by monitoring the increase of minute volume. During mechanical ventilation, there is a risk of a significant increase of pacing frequency, which can be misinterpreted as ventricular tachycardia (VT) or even cause

VT. The magnet application excludes this option in the case of pacemakers, whereas ICDs (produced by Sorin and Boston Scientific) need to be reprogrammed.

4. Type of cautery used in surgery

Electromagnetic interference is more frequent when using unipolar electrocautery, so the use of bipolar electrocutters is preferred for these patients. When using unipolar electrocautery, the indifferent electrode should be placed as far as possible from the CIED (upper part of the leg). It is recommended to use short (<5 seconds) applications with 5-second breaks between the use⁴.

Basic Functions of Magnet Applied to CIEDs

The CIED response to the use of magnets (and locating CIED in the magnetic field) is specific to the type of CIED and depends on the manufacturer and the model of the CIED⁵. Response to the magnet application is active as long as the magnet is placed above the device. It is important to note that the magnet should be available in all Emergency Departments, as well as in operating rooms/units where surgical or invasive procedures are performed. Also, all staff members in these units should know the location of the magnet and the situations in which it should be used and how to use it.

In the case of overweight patients, one should sometimes use two magnets to achieve the expected magnet response. The magnet can be fixated (glued) to the CIED subclavicular location in surgeries during which the patient is lying down in prone position. Although most requests for perioperative CIED testing are related to battery voltage, battery depletion is very rare in patients having undergone regular follow-ups, which is supported or proven by reviewing patient history. Additionally, if there is an expected response to the magnet application, it can be concluded that battery voltage is sufficient for the normal CIED function.

Pacemakers

Applying magnet over the pacemaker can be used for the purposes of diagnosis and treatment. By applying the magnet, the pacemaker (PM) is being reprogrammed automatically in asynchronous mode of pacing (AOO, VOO, DOO), which means that the PM is 'neglecting' impulses that are being sensed and paced

Table 1. Pacemakers – responses to applying magnet

Manufacturer	Response to applying magnet
Biotronik	Asynchronous mode (AOO, VOO, DOO) for 10 contractions, than return to synchronous mode
Boston Scientific [#]	Asynchronous mode (AOO, VOO, DOO), frequency 100/min*
Medtronic	Asynchronous mode (AOO, VOO, DOO), frequency 85/min*
St. Jude Medical	Asynchronous mode (AOO, VOO, DOO), frequency 100/min*
Sorin [#]	Asynchronous mode (AOO, VOO, DOO), frequency 96/min*

[#]nowadays very rare in Croatia; *response can be switched off by pacemaker programming

at the default frequency (which is manufacturer-specific). There are manufacturers for which it is possible to deactivate the specific response to the use of magnet when testing/programming the PM (St. Jude Medical, Boston Scientific). The PM responses to the magnet usage are shown in Table 1.

Implantable Cardioverter-Defibrillators

The magnet usage with implantable cardioverter-defibrillators (ICD) excludes detection and therapy of ventricular arrhythmias (anti-tachycardia pacing and shocks), whereas the use of magnet does not affect anti-bradycardia pacing. However, most patients do not need anti-bradycardia pacing, although up to 25% of patients with ICD periodically need stimulation. An exception to this rule are ICDs produced by Sorin (currently very rare in Croatia), which in addition to turning off detection and ventricular arrhythmias (VT/VF), stimulate in the asynchronous mode of pacing (as in pacemakers) (Table 2).

If during the magnet usage patient develops malignant ventricular arrhythmia (VT or VF), there are two options to act: the magnet which activates ICD detection and therapy (if not previously deactivated by reprogramming) can be removed, or the magnet usage is continued with external defibrillation. All the men-

Table 2. Implantable cardioverter-defibrillators – responses to applying magnet

Manufacturer	Anti-bradycardia function	Anti-tachycardia function
Biotronik	None	Detection/therapy - OFF ⁺
Boston Scientific [#]	None	Multiple answers are possible. With some devices, the magnet is applied only once, with others it must be applied continuously, and with some the response to magnet can be turned off
Medtronic	None	Detection/therapy - OFF
St. Jude Medical	None	Detection/therapy - OFF*
Sorin [#]	Asynchronous mode (AOO, VOO, DOO), frequency 96/min	Detection/therapy - OFF

[#]nowadays very rare in Croatia; *response can be switched-off with programming the pacemaker; ⁺in new ICD generation during 8 hours

tioned magnet responses are expected in CIEDs with normal function and appropriate battery voltage. If there is no response to the use of magnet, there are a few options:

- the magnet is used at a wrong site or it does not reach the device (for example, in overweight patients);
- the battery is depleted; and
- the magnet response is deactivated (option in ICDs produced by St. Jude Medical, Boston Scientific and some Biotronik devices).

Preoperative Care

Before surgery, it is necessary to determine that the patient has an implanted CIED, then the CIED type, its manufacturer and programming mode.

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CARTE EUROPEENNE D'IDENTIFICATION D'UN PORTEUR DE DEFIBRILLATEUR/CARDIOVERTEUR IMPLANTABLE

EUROFÄHSCHER SCHRITTMACHERAUSWEIS IMPLANTIERBARER KARDIOVERTER/DEFIBRILLATOR

TARJETA EUROPEA DE IDENTIFICACION DE PACIENTE CARDIOVERSOR/DESFIBRILADOR IMPLANTABLE

SCHEDA EUROPEA DI IDENTIFICAZIONE PAZIENTE CARDIOVERSORE/DEFIBRILLATORE IMPLANTABILE

Warning - Attention - Warnung - Aviso - Avvertenza

- Patient has an implanted Cardioverter/Defibrillator. In case of emergency please phone cardiologist below or nearest hospital.
- Ce patient est porteur d'un Défibrillateur/Cardioverteur implantable. En cas d'urgence, veuillez contacter le médecin mentionné ci-dessous ou l'hôpital le plus proche.
- Diesem Patienten wurde ein Kardioverter/Defibrillator implantiert. In Notfällen wenden Sie sich bitte an den unten genannten Kardiologen oder die nächstgelegene Klinik.
- El paciente lleva implantado un cardioversor/defibrilador. En caso de emergencia, por favor llame a un cardiólogo de los que se citan a continuación, o al hospital más próximo.
- Il paziente ha un Cardioversore/Defibrillatore implantato. In caso di emergenza si prega di telefonare al cardiologo sottocitato o al più vicino ospedale.

Cardiologist at Implanting Centre:
Name _____
Address _____
Tel. _____ Fax nr. _____
Follow-up Doctor if different from address above
Name _____
Address _____
Tel. _____ Fax nr. _____

Contact in case of emergency:

Prior to any surgery, MRI or use of therapeutic ionizing radiation, please contact the above mentioned implanting or follow-up center.

**PATIENT IDENTIFICATION CARD
IMPLANTABLE CARDIOVERTER/DEFIBRILLATOR**

1 Patient ID Nr.: _____ Sex: M F

Patient Name: _____
Patient Address: _____
Tel. Nr. _____

Date of Birth: Year ____ Month ____ Day ____ First Impl. Year ____ Month ____ Day ____

Symptom ____¹ ECG ____² Aetiology ____³

NYHA 1 2 3 4 Unassessed

Estimated EF > 50 30-50 < 30 ?

Previous Drug Rx: _____⁴
Prior Intervention: _____⁵

2 Implant Center Code Nr.: _____
Cardiologist _____
Hospital _____
Address _____
City/Postal Code _____
Country _____
Tel. Nr. _____ Fax Nr. _____

3 ICD Device/Implant Data: Mfr: _____
Model _____ Serial Nr. _____
Date of implantation: Year ____ Month ____ Day ____

Generator site * ____
Other surgery * ____
Unsuccessful approach for lead implant: No Prev Op This Op

4 Leads

(1) Type(s) _____ * Mfr: _____
Model _____ Serial Nr. _____
Connector Types ____¹ ____² ____³ ____⁴ ____⁵ ____⁶ ____⁷ ____⁸ ____⁹ ____¹⁰ ____¹¹ ____¹² ____¹³ ____¹⁴ ____¹⁵ ____¹⁶ ____¹⁷ ____¹⁸ ____¹⁹ ____²⁰ ____²¹ ____²² ____²³ ____²⁴ ____²⁵ ____²⁶ ____²⁷ ____²⁸ ____²⁹ ____³⁰ ____³¹ ____³² ____³³ ____³⁴ ____³⁵ ____³⁶ ____³⁷ ____³⁸ ____³⁹ ____⁴⁰ ____⁴¹ ____⁴² ____⁴³ ____⁴⁴ ____⁴⁵ ____⁴⁶ ____⁴⁷ ____⁴⁸ ____⁴⁹ ____⁵⁰ ____⁵¹ ____⁵² ____⁵³ ____⁵⁴ ____⁵⁵ ____⁵⁶ ____⁵⁷ ____⁵⁸ ____⁵⁹ ____⁶⁰ ____⁶¹ ____⁶² ____⁶³ ____⁶⁴ ____⁶⁵ ____⁶⁶ ____⁶⁷ ____⁶⁸ ____⁶⁹ ____⁷⁰ ____⁷¹ ____⁷² ____⁷³ ____⁷⁴ ____⁷⁵ ____⁷⁶ ____⁷⁷ ____⁷⁸ ____⁷⁹ ____⁸⁰ ____⁸¹ ____⁸² ____⁸³ ____⁸⁴ ____⁸⁵ ____⁸⁶ ____⁸⁷ ____⁸⁸ ____⁸⁹ ____⁹⁰ ____⁹¹ ____⁹² ____⁹³ ____⁹⁴ ____⁹⁵ ____⁹⁶ ____⁹⁷ ____⁹⁸ ____⁹⁹ ____¹⁰⁰ ____¹⁰¹ ____¹⁰² ____¹⁰³ ____¹⁰⁴ ____¹⁰⁵ ____¹⁰⁶ ____¹⁰⁷ ____¹⁰⁸ ____¹⁰⁹ ____¹¹⁰ ____¹¹¹ ____¹¹² ____¹¹³ ____¹¹⁴ ____¹¹⁵ ____¹¹⁶ ____¹¹⁷ ____¹¹⁸ ____¹¹⁹ ____¹²⁰ ____¹²¹ ____¹²² ____¹²³ ____¹²⁴ ____¹²⁵ ____¹²⁶ ____¹²⁷ ____¹²⁸ ____¹²⁹ ____¹³⁰ ____¹³¹ ____¹³² ____¹³³ ____¹³⁴ ____¹³⁵ ____¹³⁶ 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5 Adaptors
- Adaptors have been used Yes No
- Lead number Adapted ____ 1 ____ 2 ____ 3 ____ 4

6 "Defibrillation" Threshold:
Most severe Rhythm Tested VT VF O
Lowest Successful Shock ____ J &/or ____ V
Lowest Shock Tested ____ J &/or ____ V
Drug Rx at implant: ____⁴

7 Programmed Therapy at Time of Implant
Defibrillation Therapy On Off VF Trigger Rate ____ Min⁻¹
Shock in VT Zone Yes No NA
Tachy Term. Pacing On Off NA
Brady Pacing Yes No NA
If Yes, Pacing Mode: _____

European Pacemaker Patient Identification Card

1. PATIENT-DATA - Soc. Sec. No. _____
Identification No. _____
Name _____
Address _____
City _____ Postcode _____
Country _____
Tel. No. _____
Date of Birth Year ____ Month ____ Day ____ M F

Date of 1st implantation Year ____ Month ____ Day ____

Symptom primary ____¹ ECG ____² Aetiology ____³
Symptom secondary ____¹ ECG ____² Aetiology ____³

2. PACEMAKER CENTRE
Doctor / Department _____
Hospital _____
Address _____
City _____ Postcode _____
Country _____
Tel. No. _____

3. IPG Basic rate ____ min⁻¹ MODE ____¹ ____² ____³ ____⁴ ____⁵ ____⁶ ____⁷ ____⁸ ____⁹ ____¹⁰ ____¹¹ ____¹² ____¹³ ____¹⁴ ____¹⁵ ____¹⁶ ____¹⁷ ____¹⁸ ____¹⁹ ____²⁰ ____²¹ ____²² ____²³ ____²⁴ ____²⁵ ____²⁶ ____²⁷ ____²⁸ ____²⁹ ____³⁰ ____³¹ ____³² ____³³ ____³⁴ ____³⁵ ____³⁶ ____³⁷ ____³⁸ ____³⁹ ____⁴⁰ ____⁴¹ ____⁴² ____⁴³ ____⁴⁴ ____⁴⁵ ____⁴⁶ ____⁴⁷ ____⁴⁸ ____⁴⁹ ____⁵⁰ ____⁵¹ ____⁵² ____⁵³ ____⁵⁴ ____⁵⁵ ____⁵⁶ ____⁵⁷ ____⁵⁸

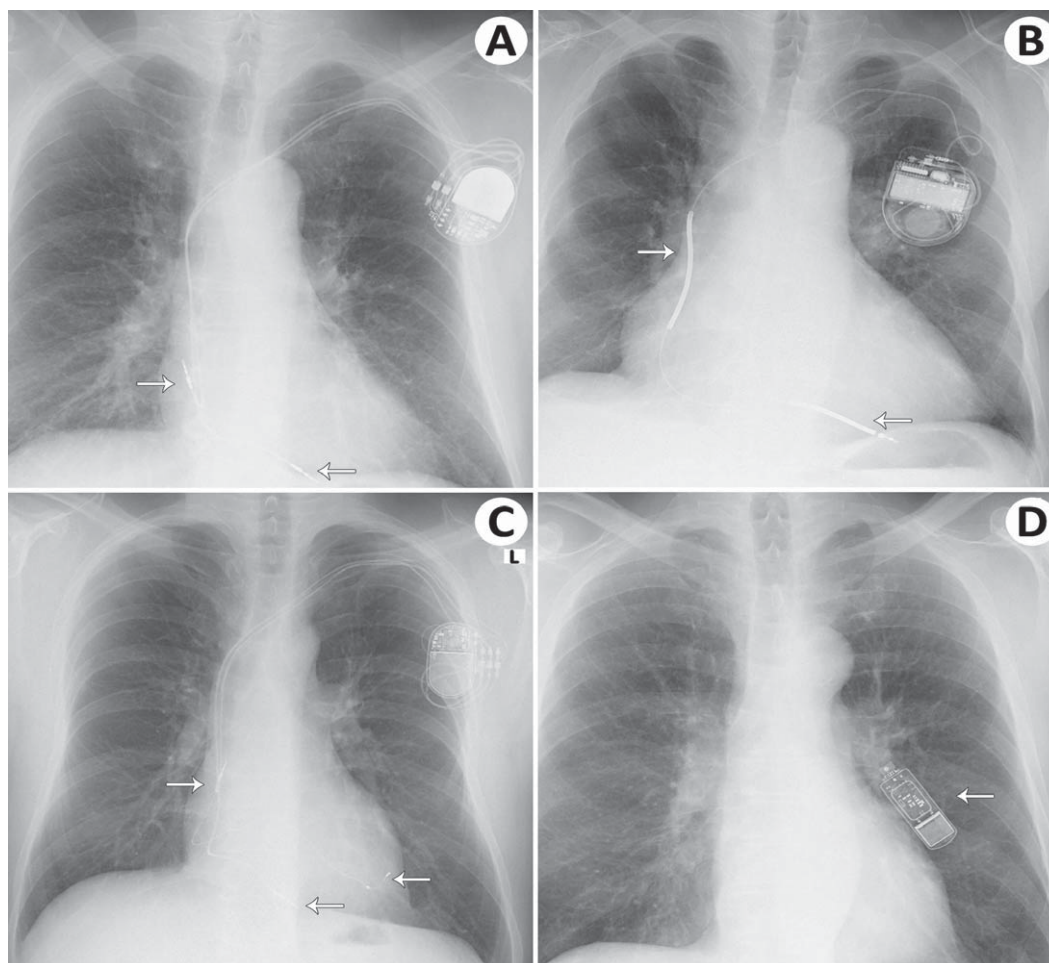


Fig. 2. Postero-anterior chest x-ray: (A) pacemaker can be recognized by the generator in the left pectoral region and two 'thin' electrodes in the right atrial appendage and right ventricular apex (arrows). In this case, double-chamber (DDD) pacemaker is shown (options with one lead in the ventricle or very rarely only in the atrium are possible); (B) cardioverter defibrillator can be recognized by coils on the leads, which deliver high-energy shocks (arrows). Options with one, two or three leads are possible (three leads if it is a CRT-D device); (C) cardiac resynchronization therapy (CRT-P) device. This device can be recognized by the presence of additional lead in the coronary sinus – left ventricle (arrow). Options without atrial lead or with ICD leads are possible; (D) implantable loop recorder (ILR), which is implanted left parasternally and has no leads in or outside the heart.

CIED and that these patients have a relatively high risk of developing acute heart failure and volume overload.

Patients with an implantable loop-recorder (ILR) (Fig. 2D) do not need reprogramming and do not develop perioperative risk related to the CIED except for direct mechanical damage during surgeries in the same anatomical position. In this case, it is necessary to stress to the patients to mention this at the next follow-up because some arrhythmias could be detected,

which in fact could be interference rather than true arrhythmias.

The device manufacturer can also be determined by chest x-ray with large battery enlargement (this is rarely needed).

After determining the type of the CIED, while planning further management, it should be determined whether the patient is vitally dependent on anti-bradycardia pacing. This is known on the basis of medical records or 12-lead electrocardiography

Table 3. Indications for cardiac implantable electronic device (CIED) reprogramming

Operation	Patient vitally dependable on CIED	Pacemaker	ICD	
			Anti-bradycardia function	Anti-tachycardia function
No electrocutter usage	Yes/no	No reprogramming needed	No reprogramming needed	No reprogramming needed
With usage of electrocutter	Yes	Apply magnet	Reprogramming	Apply magnet
	No	Magnet available	Apply magnet	Apply magnet

Note: For surgical procedures using electrocutters, recommendations relate to the situation when the application of a magnet is available (depending on the surgery location, as well as the patient position) and when the CIED is not within the operating field. In this case, reprogramming of the CIED is required. Also, when there is no appropriate response to the application of magnet, reprogramming is required.

(ECG). If ECG shows the patient's own rhythm or change of the patient's rhythm and pacing, it can be assumed that the patient is not vitally dependent. If there are no medical data, and there is only pacing rhythm on ECG, in urgent situations it can be assumed that the patient is vitally dependent on anti-bradycardia pacing. Most patients with an ICD are not vitally dependent on anti-bradycardia pacing (because the primary function is anti-tachycardia pacing and defibrillation), although pacing is needed in up to 25% of patients.

Indications for reprogramming or use of magnet are shown in Table 3.

Absolute indications for CIED testing/reprogramming before the surgery are the following:

- 1) suspicion of device malfunction/inadequate response to magnet use;
- 2) use of electrocautery during surgery in patients dependent on anti-bradycardia pacing and surgery is performed in the area of or close to the CIED, or the CIED is not available for magnet application during surgery;
- 3) use of electrocautery in patients dependent on anti-bradycardia pacing who have an ICD; and
- 4) use of electrocautery in patients with ICD and surgery is performed in the area of ICD or the ICD is not available for magnet application during surgery.

Intraoperative Care

In addition to the usual care during surgery, there are a few specific rules for patients with CIED:

- continuous monitoring of heart rhythm;
- during surgery, external defibrillator with the possibility of transcutaneous pacing and with self-adhesive electrodes must be available (because in patients with ICD, detection and treatment function are deactivated, and in all patients with CIED, especially those vitally dependent on anti-bradycardia pacing, complications and asystole occurrence are possible); and
- magnet should be available (see above).

Pacemakers

If the patient is not dependent on anti-bradycardia pacing, the surgery can be performed without the use of magnet (however, magnet must be available). In patients vitally dependent on anti-bradycardia pacing, magnet application during surgery switches the pacemaker in asynchronous mode of pacing (AOO, VOO, DOO). In patients with pacemakers produced by Biotronik, after the magnet application the pacemaker stimulates 10 heart contractions in asynchronous mode of pacing, after which it goes back into the programmed mode of pacing. The magnet has to be used again afterwards. As already stated, external defibrillator should be available since ventricular arrhythmias can occur in asynchronous mode of pacing ('R on T phenomenon'), although extremely rare.

Implantable cardioverter-defibrillators

For all patients with ICD, we recommend magnet application for turning off the detection and consequently treatment of ventricular arrhythmias. In case of ventricular arrhythmias (VT/VF), one should simply remove the magnet, which turns on the arrhythmia

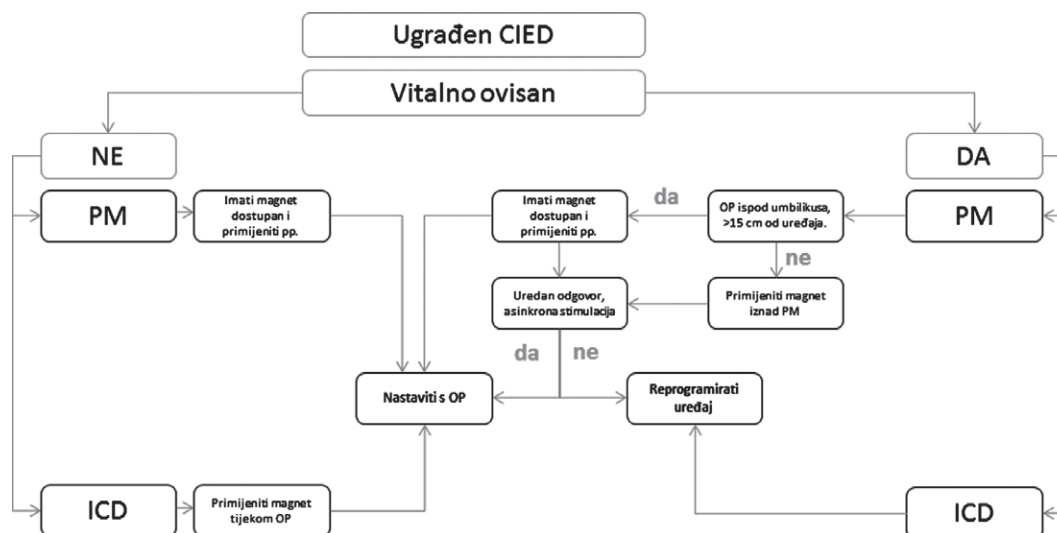


Fig. 3. Algorithm for perioperative management of patients with pacemakers and ICDs.

detection and restores the programmed ICD function. On the other hand, if ICD was reprogrammed (detection switched off) before the surgery, the usage of external defibrillation is an imperative, since the arrhythmia detection is turned off. In patients with ICD who are vitally dependent on anti-bradycardia pacing, it is necessary to reprogram the ICD before the procedure since the magnet does not affect the anti-bradycardia function (only ICD produced by Sorin is an exception; however, in patients with ICD who are vitally dependent on anti-bradycardia pacing the need for reprogramming can be taken as a rule).

Implantable Loop Recorders

In the case of ILR, one should pay attention to the risk of directly damaging the device. There is no risk for the patient since the device is intended only to monitor the heart rhythm.

Postoperative Care

After the surgery, it is necessary to monitor patients until the function of CIED is recovered to its pre-surgery function/mode of pacing. In patients for whom the magnet was used, it occurs after removal of the magnet. If the CIED has been reprogrammed preoperatively, monitoring is mandatory until new CIED testing and reprogramming to the previous mode is performed. This is extremely important for patients

with ICD in which the detection and treatment of arrhythmias function is turned off before surgery. Besides monitoring, for these patients external defibrillator should be available (in the case of VT/VF occurrence, the ICD will not deliver therapy until the detection mode is turned on).

In patients undergoing thoracotomy during surgery, it is necessary to do chest x-ray to verify the position of the electrodes and also routine postoperative CIED testing/programming⁶. Additional attention should be paid to and a cardiologist consulted, e.g., CIED reprogramming, in patients that develop postoperative shock due to different hemodynamics, as well as limited compensation by increasing heart frequency^{2,3,7}.

If the CIED function fails during the surgery, the device or electrodes are directly damaged or the CIED signals some kind of dysfunction by alarm (characteristic for ICD), the patient should be monitored and the device has to be urgently tested and programmed if needed.

Conclusion

In most patients, most surgical procedures can be done without reprogramming CIED with a simple use of magnet. The basis is to understand the function and response to magnet application for certain CIEDs. It is extremely important to identify patients in whom

reprogramming is required, and these are primarily patients who are dependent on anti-bradycardia pacing in whom the CIED is not available for magnet application and patients with ICDs who are also dependent on anti-bradycardia pacing.

Magnet application, apart from being simple and for most patients safe, is also a preferred way of perioperative care, which means avoiding repeated, incorrect or incomplete reprogramming.

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Sažetak

PREPORUKE ZA PERIOPERACIJSKI POSTUPAK KOD BOLESNIKA KOJI IMAJU UGRAĐENE KARDIOVASKULARNE IMPLANTABILNE ELEKTRONIČKE UREĐAJE

N. Pavlović, Š. Manola, H. Vražić, M. Vučić, S. Brusich, V. Radeljić, I. Zeljković, R. Matasić, A. Anić, I. Benko, Ž. Gavranović i M. Zlatić Glogoški; Radna skupina za aritmije i elektrostimulaciju Hrvatskoga kardiološkog društva

U Republici Hrvatskoj na godinu se implantira oko 4000 kardiiovaskularnih implantabilnih uređaja i taj broj je u stalnom porastu. Anestezija i kirurški zahvati kod bolesnika s ugrađenim implantabilnim uređajima nose određene rizike. Ove smjernice su nastale zato što se većina zahvata izvodi u ustanovama bez mogućnosti testiranja i reprogramiranja navedenih uređaja ili u vrijeme kada to nije dostupno. Cilj je standardizirati perioperacijsku skrb ovih bolesnika te učiniti kirurške zahvate dostupnima i sigurnima za veliku većinu ovih kirurških bolesnika u svim ustanovama u Hrvatskoj.

Ključne riječi: *Hrvatska; anestezija, opća; srčana resinkronizacijska terapija, uređaji; smjernice; perioperativna skrb*