Percentage of Patients with Cardiac Electronic Devices Requiring Magnetic Resonance Imaging

Magnetic resonance imaging (MRI) is a very useful imaging procedure for the diagnosis of several conditions, and it is estimated that 50-75% patients with pacemakers will have an MRI indication over their lifetime. (1) Magnetic resonance imaging is contraindicated in non-compatible cardiac stimulation devices as established by their manufacturers and by the Food and Drug Administration (FDA). While there are MRI-compatible pacemakers, the vast majority of the devices are not currently certified as compatible. The purpose of our research work was to determine the percentage of patients with devices who required or underwent an MRI as part of the diagnosis or treatment of certain cardiac or extracardiac conditions.

An observational and retrospective study was carried out on patients with cardiac stimulation devices who underwent the corresponding clinical monitoring between January and October 2019. Information was collected since the implantation of the cardiac stimulation device and during follow-up until the last consultation.

Data about gender, age, type of device (pacemaker, cardioverter defibrillator or resynchronization device) and also whether or not it was compatible or conditional for MRI, were collected from the electronic medical records. The evaluated endpoint was MRI request between device implantation and the last control, or the presence of a condition that would have required MRI for its management, arbitrarily defined by researchers as neurological disorders (stroke, seizures, tumors, metastasis), trauma injuries (spinal cord, knee, ankle or shoulder involving tendons), cardiac diseases (suspected myocarditis, hypertrophic or infiltrative cardiomyopathy) or oncological conditions (suspected metastasis).

Estimated sample size was approximately 310 patients, considering that the proportion of patients with MRI in international registries is about 28%, with an alpha error of 95% and an accuracy of 5%. Categorical variables were expressed as percentage and continuous variables as median and interquartile range. SPSS 17 statistical package (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis.

The study was approved by the Institutional Research Committee and ethical considerations were in compliance with the Declaration of Helsinki.

A total of 374 patients underwent device clinical monitoring at the Department of Electrophysiology and Arrhythmia of Hospital Privado Universitario de Córdoba during the period analyzed. Seventy-four patients were excluded from the study either because they were duplicates or were not followed up at our institution.

Finally, 300 patients (80.2%) were analyzed. Median age was 74 years (interquartile range 64-82 years) and 38.7% were women. A total of 71.9% of patients had pacemakers, and the rest other devices. In 68% of cases patients had 2 implanted leads and 3.7% had some abandoned lead; 47% had pacemaker-dependent heart rhythm (complete AV block), and 23.4% had an implanted cardioverter defibrillator with or without a resynchronization device. The percentage of MRI-compatible devices was 14.3%.

Follow-up was 941 days (interquartile range 281-2,252 days). During that period, 5 MRIs were performed (1.7%) and there were 50 patients (16.6%) with conditions that could have required an MRI for diagnosis or treatment (Figure 1). The 5 patients in whom MRI was performed had an MRI-compatible pacemaker in 80% of cases and 40% of these patients had pacemaker-dependent heart rhythm. Among the patients with conditions that could have required MRI, 16% had an MRI-compatible device (Table 1).

The main finding of this study has been the low use of MRI in our population with electronic cardiac

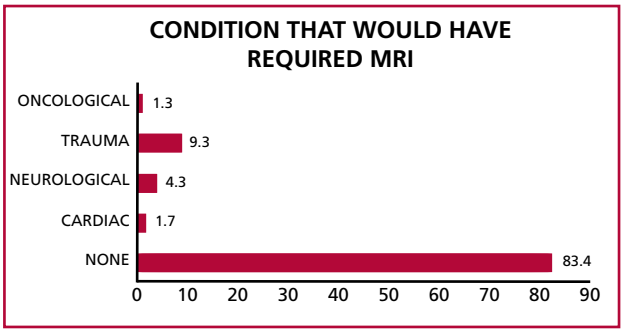

Fig. 1. Proportion of patients with MRI request or conditions requiring MRI

Table 1. MRI in Population

Performed MRI	MRI-compatible device (80%). MRI-non-compatible device (20%). In patients with PM (100%) PM-dependent heart rhythm (40%). Non-dependent (60%)
Potential MRI	MRI-compatible device (14.3%). MRI-non-compatible device (85.7%). PM (71.9%) ICD (23.4%) RC (4.6%) PM-dependent heart rhythm (47%). Non-dependent (53%)

PM: Pacemaker. ICD: Implantable cardioverter-defibrillator. RC: Resynchronization device. MRI: Magnetic resonance imaging.

stimulation devices. Current experience reports that the use of MRI in this population is approximately 20-30% (2), very similar to the potential need for MRI in our cohort. Magnetic resonance imaging is the primary tool for the evaluation of patients with neurological and muscular diseases, tumors, and some cardiovascular disorders, and it is estimated that the probability of a patient being indicated an MRI after the implantation of an electronic device may reach 75%. (1)

The first pacemakers were devices with a large surface area and presented alterations when an MRI was performed, so the FDA and device manufacturers did not recommend its use in patients with implanted pacemakers. Further studies have demonstrated that MRI could be performed with no significant clinical effects and no differences in the type and number of complications in patients who had a pacemaker that was non-MRI-compatible compared with patients with MRI-compatible devices, taking the necessary precautions and applying a safety protocol. (3, 4)

This protocol consists in programming the pacemaker to an asynchronous pacing mode in pacing-dependent patients, or inhibiting it (turning it off) in non-pacing-dependent cases, and in the inhibition of tachycardia monitoring and deactivation of therapies in patients with defibrillators. (4)

The theoretical risks of MRI in non-compatible device carriers are lead heating, reprogramming with loss of capture, and sensing or developing arrhythmias. (5) However, two recently published studies that included more than 2,500 patients who received MRI with 1.5 T scanner showed no significant complications applying the safety protocol. (3, 4) It should be pointed out that devices implanted before certain dates (pacemakers prior to 1998 or defibrillators prior to 2000) were taken as contraindication in these studies.

In our experience, only 3 devices predated the year 2000. Fractured, epicardial, and abandoned leads seem to be very susceptible to heating. (6) In our experience, a patient with abandoned lead received an MRI with no adverse events.

The study limitations include its retrospective and single-center nature. There may be a selection bias, since a large proportion of the patients included had their device implanted in recent years; therefore, their follow-up period was shorter and the likelihood to require an MRI was lower. On the other hand, a possible explanation for the low utilization of MRI in this study could be that the Imaging Service in our center does not perform cardiac MRI, so there is little experience in managing cardiovascular conditions and having an implanted cardiac stimulation device is still considered a contraindication.

In conclusion, MRI utilization in a population with cardiac-stimulation devices is low. Knowing and disseminating safety protocols is important, since more MRIs could be performed without significant clinical effects.

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Conflicts of interest

None declared.

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Transesophageal Echocardiography in the Era of COVID-19. Use of the Aerosol Box as an Additional Barrier

Coronavirus infection (COVID-19) is an acute -sometimes severe- respiratory disease caused by a new SARS-CoV-2 coronavirus. The rapid progression of this virus has collapsed first-world health systems. This leads us to act responsibly and swiftly in designing organization and action strategies to address this pandemic with as many resources as possible. (1)

Protecting healthcare personnel and preventing SARS-CoV-2 transmission should be a priority during this COVID-19 pandemic. Given the high infec-

tiousness of COVID-19 and the increasing lack of personal protective equipment (PPE) due to the collapse of health systems, healthcare professionals are more exposed to COVID-19 infection, with alarming rates of contagion and morbidity and mortality. (2, 3) The severe shortage of PPE has greatly increased the risk of infection for healthcare personnel, with disturbing rates of doctors and nurses infected in China, Italy, and Spain. (1-3)

Infected patients produce respiratory secretions and potentially transmit the disease when speaking, coughing, and sneezing, or when undergoing medical procedures that generate aerosols, such as orotracheal intubation or transesophageal echocardiography (TEE). (4)

The Aerosol Box device consists of an acrylic box that provides an additional barrier protection when performing procedures in the airway at risk of aerosolization (infected respiratory droplets). It was created by Lai Hsien-yung, an anesthesiologist from Taiwan, to provide additional protection to healthcare professionals in intensive care units.

With a low manufacturing cost, it consists of a transparent acrylic or polycarbonate box that covers the patient's head during endotracheal intubation, a necessary procedure for patients severely infected with COVID-19 who suffer from respiratory failure. The box has two holes on one side, through which doctors can insert their hands when performing the procedure, while shielding themselves from any aerosol particles that could be released from the patient's airway. (5) A third hole may be opened to develop negative pressure.

Fig. 1. Transesophageal echocardiography with Aerosol Box as an additional barrier to reduce the operator risk of COVID-19 infection. The operator should be at the patient's bedside. Right atrial-closure of the probe hole (adhesive film) –once positioned– can be added to reduce the risk of contact with secretion

The Aerosol Box design is registered under a Creative Commons license; it is free of charge to the public on condition that it is not used for commercial purposes and is properly attributed to the inventor. Recently, the Boston Medical Center group has published a simulation experience in which the use of the Aerosol Box was associated with less contamination from secretions produced by a simulated cough; this was restricted to the inner surface of the box, leading this group to suggest the use of the box as a complement to standard PPE. (6, 7)

In the context of the COVID-19 pandemic, the use of transesophageal echocardiography (TEE) has been reduced to a limited number of indications (mainly, infective endocarditis with valvular and perivalvular involvement, Stanford type-A aortic dissection, initiation of mechanical circulatory support, and prosthetic valve assessment due to suspected complications). (4)

Since TEE is a diagnostic study with possible direct transmission of respiratory droplets or viral aerosolization and inhalation during intubation, tube removal and coughing, our group analyzed the feasibility of performing TEE –only if it is essential– using the Aerosol Box. In this case, the operator should be at the patient's bedside, similar to the usual position during heart surgery. The hand holes in the Aerosol Box allow the operator to comfortably insert his hands and the probe. The probe is then placed in one of the holes and can be easily manipulated with a comfortable bend for the operator (Figure 1).

We recommend that the working teams in centers where TEE is performed be trained in placing and removing PPE according to current indications, and in using the Aerosol Box to reduce the risk of infection during the study, limiting its performance to necessary indications, as explained.

While it is not currently a validated method, some groups have reported that they have successfully used it in orotracheal intubation and, given the magnitude of the emergency and the infectiousness of the disease, we consider it is convenient to add this protective barrier, without complications for the patient, to airway management.

Conflicts of interest

None declared.

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Cardiac Reintervention and Hemi-Commando Procedure in Double-Valve Endocarditis

Aortic and mitral double-valve infective endocarditis affecting the fibrous skeleton of the heart is a complex condition that requires a challenging surgical management. Extensive debridement of necrotic and infective tissue with removal of all the prosthetic material must be performed to achieve healing results.

A difficult reconstruction is usually required, particularly in cases of aortic root abscess also involving the fibrous skeleton and the mitral valve. The "commando procedure" is the reconstruction of the aortomitral fibrous body for invasive double-valve endocarditis. It is a technically challenging procedure that includes root and aortic valve replacement and mitral valve replacement, along with reconstruction of the aortomitral fibrous body.

The hemi-commando procedure is a suitable and less complex treatment option than the "commando surgery" for invasive double-valve endocarditis not involving the mitral valve anterior leaflet free edge. Its advantage is that most of the mitral valve and subvalvular apparatus are preserved.

We present the case of an asymptomatic 38-year-old male patient, with history of severe aortic regurgitation and bicuspid valve, requiring mechanical aortic valve replacement. Two months after the procedure, the patient progressed to an early prosthetic aortic valve endocarditis, requiring a second valve replacement (both procedures were performed at another center).

The patient was admitted to our center with persistent fever. The admission transesophageal echocardiography showed images consistent with prosthetic aortic valve endocarditis with 15 mm vegetation. Protrusion of a periannular abscess through the vegetation with mitral-aortic membrane and anterior leaflet of the mitral valve involvement were observed (Figure 1 A, B), and blood cultures of samples isolated from the center of origin revealed non-fermenting Gram-negative bacilli. An empirical therapy was initiated with piperacillin-tazobactam, levofloxacin and trimethoprim-sulfamethoxazole.

A brain CT scan showed no evidence of anatomical alterations (Figure 1 C), as opposed to the abdominal CT scan, which exhibited images consistent with splenic embolic foci (Figure 1 D).

Sepsis progressed, non-responsive to antibiotics; consequently, surgical treatment was decided. Considering anatomical involvement in the images, cardiac reoperation using the hemi-commando procedure was proposed, which consists of the extensive resection of the infected tissue (Figure 2. B), homograft implantation with mitral valve repair, preservation of first- and second-order cords, and reconstruction of the mitral-aortic membrane (Figure 2 C, D). Also, the roof of the left atrium was reconstructed using a bovine pericardial patch, with 120 minutes of cross-clamping time and 150 minutes of total cardiopulmonary bypass time.

The course was favorable, without complications in the postoperative period. Only low doses of vasoconstrictor and inotropic drugs were necessary due to

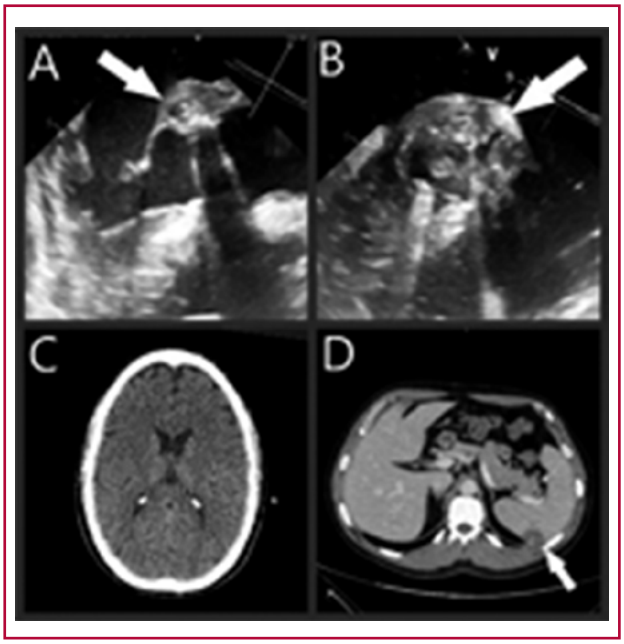

Fig. 1. Preoperative images. **A, B:** Transesophageal echocardiography with prosthetic, periannular, and mitral valve involvement. **C:** Normal brain CT scan. **D:** Splenic embolism.

mild vasoplegia and the patient remained in the Coronary Care Unit for 48 hours. A semi-permanent catheter was placed in advance for long-term outpatient antibiotic infusion, and the patient was discharged on the 7th postoperative day.

After one-year follow-up, the patient continues without clinical signs or images of reinfection, and has returned to his daily routine.

Technically, the hemi-commando procedure for double valve endocarditis represents a suitable and relatively less complex option than the "commando surgery", with the advantage of preserving most of the mitral valve and its subvalvular apparatus. This is beneficial in certain scenarios, such as young patients and patients with poor ventricular function. (1, 2, 3) The integrity of the posterior leaflet and the mitral valve anterior leaflet free edge is required when choosing this procedure. (2)

As a result of intraoperative findings, this procedure should be considered in the following cases:

- Invasive double-valve infective endocarditis.
- Involvement of the aortomitral fibrous skeleton or the anterior leaflet of the mitral valve.

Performing the procedure in a reoperation would increase the surgical risk.

Mid- and long-term outcomes in different series, such as those of David and Navia, support this procedure for endocarditis involving the aortic valve and part of the mitral valve, without need for a double prosthetic replacement. (4, 5)

In previous complicated replacements with extensive destruction, choosing homograft in combination with a bovine pericardial patch to reconstruct the cardiac anatomy is an excellent strategy. (4, 5) We believe that the hemi-commando procedure is a valid option, even in very complex scenarios such as cardiac reinterventions. In certain cases, this type of procedure is the only surgical option to restore the integrity of the heart. More importantly, preserving the mitral subvalvular apparatus and the left ventricular function provides an additional advantage in these high-risk patients.

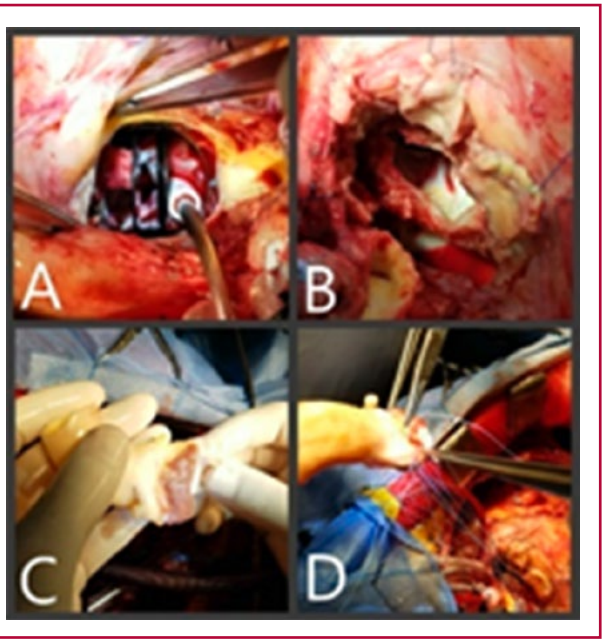

Fig. 2. Intraoperative images. **A:** Prosthetic valve endocarditis. **B:** Extension of necrotic tissue. **C, D:** Homograft implantation

Conflicts of interest

None declared.

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Subcutaneous Implantable Cardioverter Defibrillator in a Patient with Pacemaker

The implantation of a cardioverter defibrillator has shown to reduce mortality in primary and secondary prevention, in patients at high risk of sudden death. In the last 10 years, a new generation of totally subcutaneous implantable devices has been developed, i.e. extravascular devices that have provided a solution when vascular access must be avoided or is not possible. (1)

Current indications for subcutaneous implantable cardioverter defibrillator (S-ICD) focus on patients with inadequate vascular access, history of infection, or situations where it is preferable to avoid the use

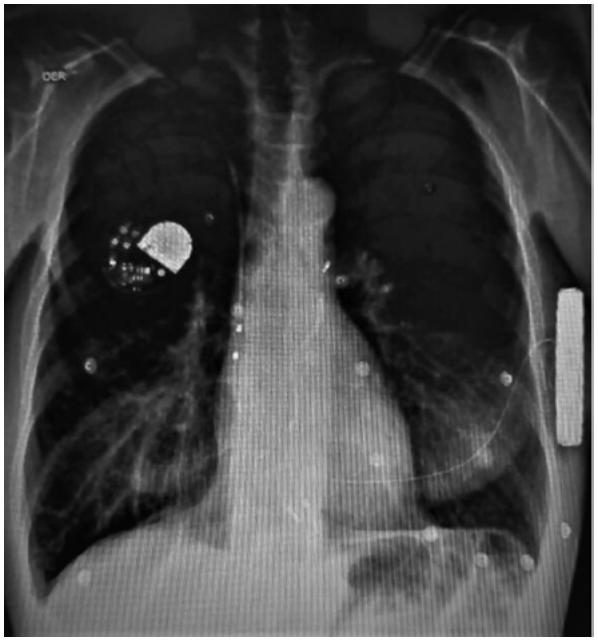

Fig. 1. Anterior chest X-ray. The image shows S-ICD generator in the mid-axillary line with the tunneled subcutaneous lead in the left parasternal area. The endovascular VDD pacing generator with its corresponding lead can also be observed.

of endovascular devices. (2) Moreover, indications should be applied to patients who do not require antitachycardia stimulation or resynchronization therapy, since as they do not have an endocavitary lead they cannot be stimulated, except for subcutaneous post-shock stimulation (30 sec).

The first S-ICD implantation in Argentina was performed in 2017. (3) However, no reports of implantation in a patient with previous endovascular pacemaker have been published to date.

We report the interesting case of a 61-year-old female patient with a permanent pacemaker who required a S-ICD due to progressive deterioration of ventricular function associated with complex ventricular arrhythmia, suspected noncompacted myocardium, and a family history of sudden death.

The patient came to our center with a long-standing medical history. She referred that she had been implanted with a permanent pacemaker due to complete AV block 20 years ago, and had suffered from infectious complications during follow-up. After generator replacement, the patient presented with pocket infection (left prepectoral area) with its subsequent exposure to the armpit, requiring endovascular removal of the leads and contralateral reimplantation (right prepectoral area).

The patient showed progressive deterioration of ventricular function during follow-up. A new echocardiogram validated noncompacted myocardium as the most likely diagnosis since an MRI could not be performed due to MRI-non-compatible pacemaker. During the directed interrogation, the patient referred the sudden death of her son due to unknown reasons.

Taking into account the presence of noncompacted myocardium, the history of previous endovascular infections, and the patient's reluctance to undergo another endovascular intervention, it was decided to implant a S-ICD as primary prevention of sudden death and to reduce the risks of infectious and mechanical complications in that clinical context.

The patient was permanently stimulated by the pacemaker. The usual screening for the correct detection of signals with three different vectors was successfully performed.

Finally, the device was implanted with the usual technique in a subcutaneous position, in the mid-axillary line between the serratus major and the wide dorsal muscles. The lead was tunneled and placed in the left parasternal area and an induction test was performed. Induced ventricular fibrillation was properly sensed, effective defibrillation was achieved with the first shock, and rhythm stimulated by endocavitary pacing was resumed. The patient was discharged, and outpatient follow-up continues without complications.

Implantation of cardioverter defibrillators may present complications. However, with the advent of S-ICD, all potential complications associated with endovascular implantation (pneumothorax, catheter displacement, endovascular infections, cardiac tamponade, etc.) have been overcome. One of the main remaining concerns about S-CDI are inappropriate shocks. Adequate QRS sensing is necessary to reduce them. This is done using pre-screening to evaluate whether the patient is a candidate or not, i.e. whether the sensing vectors will be able to discriminate the QRS properly.

The recent addition of specific filters has shown

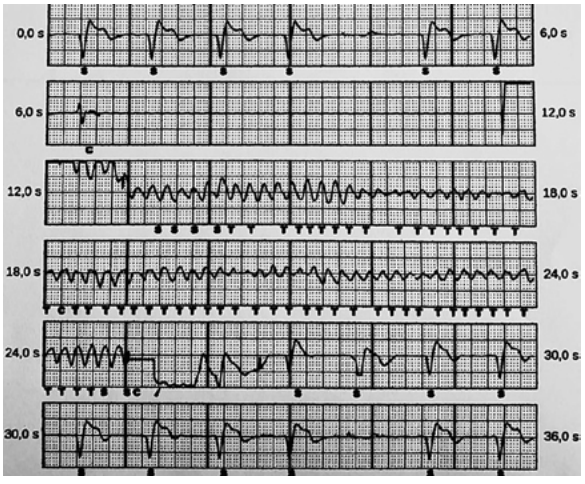

Fig. 2. Induction and defibrillation tests were successful. Stimulation-based pacing is followed by an induction period. Immediately, ventricular fibrillation is properly sensed and defibrillated

encouraging results in reducing inappropriate therapies. (4) Maintaining adequate sensing in pacemaker patients could be a challenge, given the potential presence of both native and stimulated QRS and, in turn, the resulting change in T-wave morphology.

International experience supports the use of S-ICD in patients with pacemakers or resynchronization devices. (5, 6) Recommendations to reduce the risk of sensing failure or oversensing include testing vectors with native and stimulated QRS, limiting the maximum pacemaker tracking rate, and performing a defibrillation test to confirm proper sensing of ventricular fibrillation.

Conflicts of interest

None declared.

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