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CARDIAC PACING
Original Paper

Proposal for a pacemaker implant technique with minimum radiation exposure

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ABSTRACT

Objective: To describe a standardized technique for implanting a pacemaker to reduce the time of surgery and radiation exposure and to demonstrate the results in a series of patients. **Methods:** Through descriptive and cross-sectional statistics, 109 patients undergoing dual-chamber (DDD) and single-chamber (VVI) pacemaker implantation were evaluated, using a standardized technical approach used in the cardiac surgery service of Santa Casa de Misericórdia of Ponta Grossa-PR, Brazil, from November 2016 to November 2019. Clinical aspects, implant indication, implant times, and radiation time were studied. The technique was described, and its most relevant aspects were discussed. **Results:** 68.81% of the pacemakers were DDD and the surgical time ranged from 11'22" to 34'43", with a median of 18'15". In these cases, the fluoroscopy time ranged from 34" to 5'10", with a mean of 1'42" and a 16.9 mGy median amount of radiation. The time to implant the VVI pacemaker ranged from 12' to 42', with a median of 17'12". The fluoroscopy time ranged from 26" to 6'25", with a mean of 1'41" and the median amount of radiation was 13.6 mGy. **Conclusion:** The technique proved to be agile, safe, with low fluoroscopy times and small amount of radiation. There were no postoperative complications. However, few studies were found for comparison.

KEYWORDS: Pacemaker, artificial; Surgical Procedures, Operative; Radiation Dosage; Fluoroscopy.

INTRODUCTION

The implantable pacemaker (PM), developed in the 1950s by Wilson Greatbatch, is a device that operates by means of a battery and aims to promote regular myocardial contraction through synchronized electrical stimuli[1,2]. The first implant was performed in Sweden by heart surgeon Ake Senning in 1958, marking the beginning of a new phase in the treatment of conduction axis disorders[1,3].

Initially, the use of the PM was indicated exclusively for the treatment of complete atrioventricular block (AVB). However, nowadays, due to technological advances and the physiological knowledge of the heart[3], artificial cardiac stimulation acts as one of the most promising therapeutic option for a range of cardiac rhythm disorders. This approach

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can be applied to address various forms of bradyarrhythmias, including those resulting from complete AVB, second degree AVB - Mobitz II and advanced AVB; as well as sinus node diseases (SND) and other cardiac electrical axis anomalies[4].

Associated with the technological advancement of the device, there was also an evolution in the implant technique. Initially, major surgical procedures were conducted, with thoracotomy and general anesthesia for the implantation of epimyocardial leads[5]. Currently, this technique is only recommended in specific situations, including the presence of tricuspid valve disease, tricuspid prosthesis, endocarditis, venous anomalies, infants, or young children, and when the pacemaker is implanted during another cardiac surgery[6]. The most used procedure for the introduction of the leads is the transvenous procedure, in which necessitates only local anesthesia and puncture of the subclavian or internal jugular veins are required, or alternatively, dissection of the cephalic vein to facilitate access to the cardiac chambers[5].

In 2001, Costa and Mond[7], surveyed the number of PM implants performed worldwide. The United States led the ranking with 223,226 implants, followed by Germany with 69,823. In Brazil, there were 15,167 implants. In these countries, most patients were over 60 years old, and the main etiologies were advanced AVB and SND. In the period between June 2005 and May 2006, an epidemiological survey was conducted by Pachón M et al.[8] to analyze the 12th year of Brazilian pacemaker registration. The study verified the implementation of 12,172 devices in the country. with a mean age of patients of 68.1 years and fibrosis of the cardiac conduction system was the main cause of implantation.

The fluoroscope, equipment used as an artificial source of ionizing radiation, is of fundamental importance in the implantation of the endocardial PM. This equipment allows the visualization of the leads, facilitating their implantation in the cardiac chambers[5,9]. However, fluoroscopy is considered one of the radiological procedures that most exposes health professionals and patients to ionizing radiation10. When accumulated over time, radiation causes irreversible genetic changes, even when the intermittent doses are of low intensity. For this reason, it is necessary to minimise exposure to these rays as much as possible[9].

The literature is poor in articles that address the implantation time and amount of radiation to which the patient and the team are exposed. Seeking to fill this gap, the objective of this article is to describe a standardized technique for PM implantation aiming to reduce the time of surgery and radiation exposure and demonstrate the results in a series of patients.

METHODS

Type of study

This is a descriptive cross-sectional study, approved by the Ethics Committee in Research on Human Beings of the Universidade Estadual de Ponta Grossa (UEPG) under protocol number 2,072,250.

Statistical analysis

The statistical analysis was descriptive as there were no variables to be compared. All data were tested for normality using the Kolmogorov - Smirnov test. Qualitative variables were presented as absolute numbers and percentages, and quantitative variables as mean, standard deviation (SD) and amplitude. For variables outside the normal range, the median and the interquartile range (IQR) were used as measures of central tendency and deviation, respectively. The software used for the calculations was EpiInfo 7.2.2.16®.

Study place

All patients who underwent pacemaker (PM) implantation by the study author between November 2016 and November 2019 at the Cardiac Surgery Service of Hospital Santa Casa de Misericórdia of Ponta Grossa, Paraná, Brazil, were selected for inclusion in the study.

Inclusion and exclusion criteria

All patients who consented to participate in the research and signed the Free and Informed Consent Term were included in the study. Non-acceptance was the only exclusion criterion.

Type of intervention

The selected patients underwent implantation of a dual-chamber (DDD) or single-chamber (VVI) pacemaker, performed by a single surgeon and following the standardized sequential technique indicated below.

Pacemaker Implant Technique

The complete surgical technique is outlined in Table 1. The steps of the technique that are useful in preventing complications and, therefore, in reducing surgical time are as follows: (I) The use of anesthetic diluted in saline, as it increases the volume inoculated into the subcutaneous tissue, helping to compress the vessels and reducing the occurrence of bleeding, which could make the procedure difficult; (II) The puncture procedure should be performance without vessel dissection and before the skin incision. The dissection of the cephalic vein requires a longer execution time, and puncture before the skin incision allows, in cases of difficult puncture, to change the side without the patient having two incisions; (III) Having two punctures, as it prevents the atrial (AL) and ventricular (VL) leads from being passed in a single, narrow space, which can lead to displacement of one when handling the other; (IV) Introduction of both leads after passing the sheaths, before being positioned. When placing the first sheath and positioning the first lead, there is a risk of the second sheath, when introduced, displacing the already in position; (V) Only with a static x-ray to confirm the position of the guides and when both leads are introduced, the use of the fluoroscope is initiated, also minimizing the time of exposure to X-rays; (VI) Positioning the AL before the VL, because when the VL is positioned, the patient may develop dependence on the stimulus and as the atrial guide has a "J" shape, it can displace the VL when manipulated, causing an emergency situation; (VII) Another feature that also helps to reduce time is the simultaneous work between the surgeon and the technician who performs the measurements. While the latter takes the measurements of the AL, the former performs the implantation of the VL. Then, while the technician performs the VL measurements, the surgeon makes the subfascial pocket for the generator implant.

Table 1. Surgical technique

Steps	Description
Material and patient preparation	1. Availability of the necessary material is checked. 2. Patient is admitted to the surgical environment. 3. Patient is informed about all the steps of the implant and what he will be able to feel during the procedure. The need to remain still and cooperative during surgery is also explained. Special attention is given to the guidance that the patient can refer pain or any discomfort during the procedure only verbally, without moving and that all measures will be promptly taken to offer the greatest possible comfort to the patient. 4. Patient is positioned in dorsal decubitus and peripheral venous access is obtained, monitoring is carried out with pulse oximetry, cardioscope and non-invasive pressure with cuff on the right arm, except in case of arterial obstruction of this limb. 5. Cefazolin is used, considering 1g for patients with up to 70kg of body weight and 2g for heavier patients. 6. Saline or slow glucose are used to maintain venous access. It is important to warn the team to avoid infusion of large amounts of volume, especially in patients with heart failure to prevent pulmonary congestion. 7. The skin of the neck and chest is washed with chlorhexidine degerming and dried with a sterile compress, carrying out antisepsis with 0.2% chlorhexidine. 8. Surgical fields are positioned, delimiting the area of access to the bilateral infraclavicular and supraclavicular regions for deep venous puncture of the subclavian veins, or possibly of the internal jugular veins. 9. The fluoroscope is positioned with a "C" arc on the right for access to the left subclavian vein. In cases where the patient had temporary PM or venous access in the left subclavian vein, the implant was performed on the right.

Continue...

Table 1. Continuation...

Steps	Description
Local anesthesia	10. An anesthetic button at the puncture site is performed by administering 2% lidocaine (20mg/ml), without vasoconstrictor, diluted 1:1 in saline. Dilution in saline improves the osmolarity of the solution and reduces the infiltration pain. The skin is firstly anesthetized, followed by the deeper tissues along the subclavian vein puncture with about 2 ml of the solution. Patients must be warned about the pain and discomfort they may feel during this action. The health team must remember that the maximum individual total dose of lidocaine should not exceed 4.5 mg/kg of body weight and in general it is recommended that the maximum total dose should not exceed 300 mg[11].
Venous puncture	11. Palpation of the crossing space between the clavicle and the first rib is carried out. Then, deep venous puncture occurs with a specific needle and syringe, at an angle of 45 degrees in relation to the skin. The needle tip should be directed towards the sternal notch. During this process, the needle should be inserted slowly, always maintaining the plunger aspiration to keep a negative pressure inside the syringe. Interruption of movement occurs when there is aspiration of venous blood. At this point, it is removed to pass the guide wire. Patients must be warned that they may feel profound discomfort due to the passage of the guide and later of the dilator and sheath. 12. X-ray is taken to make sure the guide is in place. The image is used to correct the position of the image intensifier screen which must be vertical for the surgeon. 13. If the puncture is easy, a mini-incision of about 5mm is made and a second puncture is performed inside this incision to pass the second guide wire. After this process, a new quick X-ray must be taken to ensure the proper position of the second wire. The mini-incision is intended to facilitate the passage of the sheaths and facilitate the subsequent enlargement of the incision without damage. Note: In case of difficult puncture and due to the risk of accident in a second puncture, it was deemed prudent to proceed with the dilator, followed by sheath with dilator in the first guide wire, then, the dilator was removed, and passed the second guide wire through the sheath. After that, the sheath was removed leaving the two guide wires to be used to pass two sheaths. Although this procedure avoids a second puncture, it makes it difficult to manipulate the leads because they are very close in the same puncture. The manipulation of one can displace the other, so an assistant is often necessary to keep one lead in a fixed position while the surgeon manipulates the other. 14. After the two guide wires have been introduced, one of the guide wires is fixed to the field with hemostatic forceps and the other one is used to pass the dilator followed by the dilator sheath. After removing the guide wire and the dilator, the sheath is occluded with a finger for some seconds before placing the lead to prevent air entry or bleeding.
Leads	15. The atrial lead with straight guide is introduced. At this moment, an image is taken with progression of the lead to the lower portion of the atrium. After that, the sheath is removed. The second dilator passes through the guide wire, followed by the sheath with the dilator and, finally, the ventricular lead following the same sequence described above*. 16. After passing the two leads, they are positioned, starting with the atrial lead. The straight guide wire is replaced by a J-shaped guide wire. After that, traction is applied to the lead until the tip is secured within a trabecula. At this moment, an opening of the J-shaped guide wire is observable, followed by the fixation of the lead. After that, the fixation is tested with light traction and introduction of the lead with the guide wire to make sure it is firmly fixed. The initial approach involves positioning the lead with the tip directed medially. In the event of an unsuccessful attempt, the procedure is repeated with the tip directed towards the lateral wall of the atrium. 17. After fixing the atrial lead, the technician performs the electrical measurements: "P" wave amplitude, impedance, and stimulation threshold. The surgeon proceeds to the positioning of the ventricular lead: if the lead migrates to the inferior cava with the straight guide, the guide is removed and the guide is curved, which is adapted to the size of the cardiac area so that the curvature can be in the right atrium (RA) and the lead tip is placed at the tip of the right ventricle (RV). Bending should always be performed with a hand clear of blood and moist with saline. The presence of blood in the guide may make it difficult to move it inside the lead. Often, the lead does not enter in the first attempt, and, in this circumstance, if the tip is fixed at some point in the RA, the lead can be advanced by introducing it so that it curves into the RV. The lead must be advanced enough so that there is a large extension of it in the RV. After this process, the guide is carefully removed, then a straight guide not used yet is passed, pulling the lead, so that the tip of the straight guide stays within the curvature in the inner portion of the RV. It is necessary to extract the lead until the tip exhibits a whipping motion and enters the RV. Then, the lead is transported to the tip, where it is fixed, and the measurements are then taken. 18. While the technician takes the measurements, the surgeon performs anesthesia in the region of the pocket and proceeds to make the generator pocket. The incision starts at the puncture hole and goes laterally and slightly inferiorly. The procedures begin with a dissection of the soft tissues, followed by the opening of the pectoralis major fascia to create a subfascial pocket. Hemostasis is then assessed.

Continue...

Table 1. Continuation...

Steps	Description
Leads	19. If the measurements of both leads are within the optimal parameters for stimulation, the guides are removed under radioscopy and the curvatures are observed, which must be comfortable, preventing the leads from being stretched. Afterwards, the leads are fixed with 2-0 non-absorbable thread, the same thread is used to fix the generator. An important observation is that a first threshold measurement that is not adequate is often observed and a new measurement after a few minutes in general has better and more reliable results, so the authors suggest continuing other procedures in the sequence, such as hemostasis, for example, before quickly changing the position.
Generator	20. The leads are connected to the generator, passing the point of the same thread that fixed the leads through the generator fixing hole. The generator is then placed in storage, and the wires are wound under the device.
Finishing the procedure	21. The pectoral muscle fascia is sutured with Vicryl™ 2-0. The running suture is used to reach the end of the incision and back over the subcutaneous tissue until finding the other end, to finally make the knot. 22. The skin is sutured with colorless Vycril™ 3-0 in intradermal suture. 23. Finally, the bandage is completed, and a weight of 1 kg is left on it for a period of 6 hours after the operation.

* Single-chamber pacemaker (VVI) implantation follows the same steps as DDD; however, without the passage of a second guide wire and atrial lead.
Source: Elaborated by the authors.

RESULTS

A sample of 109 patients was studied. The PM DDD was implanted in 68.81% of the sample (n=75), while the PM VVI was implanted in 31.19% (n=34) of the patients. The equipment utilized was of the brands Biotronik™ and St Judes Medical™. The patients' ages ranged from 21 to 94 years, with a mean of 71.5 years and a standard deviation (SD) of 12.89. The age range for patients with DDD implantation was from 21 to 91 years, with a mean of 70.8 years and a 11.74 SD, while for patients undergoing VVI, the mean, SD and age range were 72.9 (15.19); 36-94, respectively. There was a balance between genders, with 56 women (51.4 %) and 53 men (48.6%). The same homogeneity was maintained when analyzing each of the types of PM implanted. In the DDD group, 38 (50.7%) were women and 37 (49.3%) were men. In the VVI group, 18 patients (52.9%) were female and 16 (47.1%) were male. The body mass index (BMI) ranged from 16.32 to 38.22; with a mean of 27.03 and SD of 5.51. For patients with DDD implants, the mean SD and BMI range were 27.35 (4.88); 16.32 – 37.13, respectively. As for those submitted to PM VVI, they were 26.27 (6.77); 17.67-38.22, respectively.

The main indications for implantation were complete AVB (26.86%) and low-response atrial fibrillation (AF) (21.31%). For patients with DDD implants, complete AVB (32%) and 2nd degree AVB (17.33%) were the most prevalent indications, while in individuals undergoing PM VVI, low-response AF (51.51%) and symptomatic sinus pauses (18.18%) were the most common. Other indications are described in Table 2. There were no complications during the procedures.

Regarding associated symptoms, dyspnea was the most prevalent, being observed in 77 patients (71.3%). The majority of these patients (n=44) were in NYHA II functional class (40.74%). It was followed by dizziness, reported by 64.22% of the sample. Furthermore, reports indicated the presence of syncope and pre-syncope, chest pain, and fatigue. As for comorbidities, the most frequent was systemic arterial hypertension (SAH), present in 66.97 % (n=73), followed by diabetes mellitus reported by 41.28% (n=13). Additionally, patients with coronary artery disease, previous acute myocardial infarction, tricuspid regurgitation, and mitral regurgitation were also found. The patients' symptoms and comorbidities are shown in Table 3.

The quantitative variables and their respective measures of central tendency and dispersion, as collected during the surgical procedure, are presented in Table 4. For DDD implantation, the median surgery time was 18'15" and the fluoroscopy time had average of 1'42". The median amount of radiation emitted was 16.9 mGy. In the VVI implants, the median surgical time was 17'12", with an average radiation exposure of 1'41". The total amount of radiation emitted during surgery had a median of 13.6 mGy.

Table 2. Indications for pacemaker implantation

Indications	Total		DDD		VVI	
	n	%	n	%	n	%
Symptomatic sinus bradycardia	15	13.9%	11	14.66%	4	12.12%
2nd Degree AVB	14	12.96%	13	17.33%	1	3.03%
tAVB	29	26.86%	24	32%	5	15.15%
Low response AF	23	21.31%	6	7.99%	17	51.51%
Trifascicular block	12	11.12%	9	11.99%	3	9.09%
Symptomatic sinus pauses	18	16.69%	12	15.98%	6	18.18%
Sinus Node Disease	6	5.55%	4	5.33%	Two	6.06%

AVB: Atrioventricular Block; AF: Atrial Fibrillation; tAVB: total atrioventricular block. Source: Elaborated by the authors.

Table 3. Symptoms and comorbidities of the total sample, verified in the pre-surgical anamnesis

Symptoms	Number of patients (n)	%
Dizziness	70	64.22%
Syncope	37	33.94%
Presyncope	42	39.25%
Precordial pain	38	34.86%
Tiredness	69	63.30%
Dyspnea	77	71.3%
NYHA Rating		
NYHA I	31	28.7%
NYHA II	44	40.74%
NYHA III	20	18.52%
NYHA IV	13	12.04%
Comorbidity		
SAH	73	66.97%
DM	45	41.28%
Low response AF	37	34.58%
CAD	38	34.86%
Previous AMI	30	27.52%
Tricuspid regurgitation	20	18.35%
Mitral regurgitation	23	21.10%

CAD: Coronary Artery Disease; SAH: Systemic Arterial Hypertension; AMI: Acute Myocardial Infarction. Source: Elaborated by the authors.

Table 4. Measures of central tendency and dispersion of quantitative variables in DDD and VVI pacemakers

Variables	DDD pacemaker			VVI pacemaker		
	Mean / Median*	Standard Deviation/IQR*	Amplitude	Mean / Median*	Standard Deviation/IQR*	Amplitude
Surgery time	18'15"*	16'26"- 21'37"*	11'22" – 34'43"	17'12"*	14' – 19'21"*	12' – 42'
Radiation time	1'42"	57"	34"- 5'10"	1'41"	1'15"	26" – 6'25"
Total radiation (mGy)	16.9*	10.5 - 26*	4.4- 137.2	13.6*	8.46- 25.3*	3.81 - 38.34
Atrial lead						
P wave	2.93	1.29	1.1-7	2.49	1.88	0.6- 6.8
Impedance	546*	487- 620*	330- 1932	448*	409- 585*	361- 760
Threshold	0.8*	0.7- 1.2*	0.4- 1.9	0.8*	0.6- 1.1*	0.6-2.2
Tested positions	1*	1*	0-4			
Ventricular Lead						
R wave	9.8	4.13	1.6-25	8.93	4.86	2.1-25
Impedance	741*	663-901*	36- 8388	702*	565-910*	7.02- 1217
Threshold	0.7*	0.5- 0.8*	0.4- 1.5	0.73*	0.5- 0.9*	0.4-8
Tested positions	1*	1*	1-7	1*	1*	1-3

Source: Elaborated by the authors.

During the implantation of the DDD devices, in 5 patients (6.67%) it was necessary to perform a contralateral puncture due to initial puncture difficulties. In the case of VVI pacemakers, this number was 2 (5.88%). The rest of the qualitative variables of the procedures are detailed in Table 5.

Table 5. Absolute number and percentage of qualitative variables obtained from DDD and VVI pacemaker implants

Variables	DDD pacemaker		VVI pacemaker	
	No. of patients	Percentage	No. of patients	Percentage
Right implant	17	22.97%	14	41.18%
Left implant	58	78.38%	20	58.82%
Contralateral puncture due to difficulty	5	6.67%	2	5.88%
IV Input in Straight Edge Progression	38	50.67%	13	38.24%
IV Input in Curved Lateral Progression	37	49.33%	21	61.76%
Use of straight guide only	27	36%	15	44.12%
Use of curved guide	48	64%	17	50%
PM implantation in subfascial store	60	80%	19	55.88%
PM implantation in a subcutaneous store	15	20%	15	45.45%

IV: ventricular; PM: pacemaker. Source: Elaborated by the authors.

DISCUSSION

Often, in the same service, different teams can adopt different techniques in PM implantation, making their own adaptations and thus bringing inconsistency in the clinical-surgical management, in addition to greater risks in performing the procedures[2]. Therefore, it is important to study the techniques used for PM insertion to ascertain the optimal intervention possibilities.

Since most of those who require the use of PM are in the elderly age group[7,8], the reduction in surgical time is of significant value. During the procedure, the patient must be conscious and remain in a fixed position on the operating table, with only local anesthesia. This brings some degree of discomfort, as in addition to the concerns about the procedure itself, the patient remains in an uncomfortable position. In addition, both patients and staff are exposed to radiation and its consequences. To enhance patient comfort and ensure the safety for both patients and staff, the authors developed a technical strategy to minimize surgery time and radiation exposure. Literature still does not offer much information about surgical times and times of exposure to radiation, which can guide comparisons. This study is pioneer, since it concerns itself with radiation and with the time of pacemaker implantation. The median duration of surgeries was encouraging, with a median time of less than 19 minutes for DDD and 18 minutes for VVI. However, it should be noted that data serving as a comparison parameter were not found in the literature.

Complications associated with pacemaker implatation include pneumothorax, hemothorax, gas embolism, suture dehiscence, bruise, displacement of electrode, skin erosion over the generator, atrial or ventricular perforation, pericarditis, failure in the generator connection, infection and venous thrombosis[5]. However, in this study, there were no such occurrences, which demonstrates, in addition to agility, the safety of the procedure.

The time and the total dose of radiation emitted during the procedure can be considered low, which is beneficial because, according to Iared and Shigueoka[12], the effects caused by radiation are dependent on the dose received throughout life, due to a cumulative effect. Therefore, the lower the dose of ionizing rays the individual receives, the lower the probability of developing significant genetic alterations that culminate in highly malignant diseases, such as thyroid neoplasms, strongly related to radiation exposure[13].

Medical examinations and procedures represent the most significant artificial source of radiation exposure, with levels increasing sixfold over the past two decades. Cardiology specialists are responsible for about 40% of the total effective dose accumulated in the North American population in all medical procedures, except for radiotherapy. The most active

and experienced cardiologists experience an annual exposure of 5 mGy, which is three times greater than radiologists and nuclear medicine specialists[14].

The measurement of radiation verified in the fluoroscope is given in Gray (Gy) (unit of dose absorbed by a specific organ or tissue in unit of mass), which is equivalent, when it comes to X-rays, to the Sievert (Sv) (effective dose), which expresses the biological injury per unit of radiation[13]. According to Bonato and Elnecave[13], a radiation dose of 0.1 mSv is equivalent to 10 days of exposure to ambient radiation, so, in patients undergoing DDD pacemaker implantation, an average radiation emitted was approximately 1,690 days (16.90 mGy) of ambient radiation, while those who received PM VVI implantation had a total of 1,360 days (13.60 mGy).

A comparison of the data from this study with the results of Tsalafoutas[14] et al., 2005 revealed that the surgical approach developed in this work presented a shorter mean fluoroscopy time. Their study demonstrated a mean fluoroscopy time of 9' (±4') for DDD implantation and a median (IQR) of 2'54" (2'06" – 6'36") for VVI. In contrast, our research indicated that the mean time of fluoroscopy was 1'42" during the placement of the MP DDD and 1'41" during the implantation of the VVI.

The reduction in fluoroscopy time was due to: (1) Placing the atrial electrode first, as this is usually easier and avoids the risk of the J-guide of the atrial electrode displacing the ventricular electrode; (2) Only start using X-rays when the electrodes are already in place, with the sole aim of positioning them, since there is no need for radiation to lower the electrode from the sheath to the heart; (3) Only use radioscopy when it is essential; (4) Not changing the electrode unnecessarily many times; if the threshold is high in the first measurement, move on to the next step and leave the technician waiting, as thresholds generally drop after about 2 minutes; (5) Often, the lead does not enter in the first attempt, and, in this circumstance, if the tip is fixed at some point in the RA, the lead can be advanced by introducing it so that it curves into the RV. The lead must be advanced enough so that there is a large extension of it in the RV. After this process, the guide is carefully removed, then a straight guide not used yet is passed, pulling the lead, so that the tip of the straight guide stays within the curvature in the inner portion of the RV; (6) Only have the technique performed by a professional with years of experience.

As there is not a radiation dose that is totally safe, the ideal would be a device that did not emit any type of ionizing wave; however, as there is no technology that fits such requirement, it is necessary to minimize exposure as much as possible. In this regard, devices such as the St. Jude Nav X are capable of performing a three-dimensional electromagnetic mapping of the cardiac area, which serves as the primary guide for the positioning of the leads. Consequently, there is a significant reduction in radiation received by the patient and professionals, so that the use of fluoroscopy is restricted to confirming the position of the leads[15,16].

It seems relevant to note that the degree of exposure to ionizing radiation during medical and cardiological procedures varies considerably between countries. In the United States, where nuclear cardiology is widely used, it is estimated that 10% of public radiation comes from cardiologic procedures, whereas in Japan it is estimated to be only 1%. This is exemplified by the fact that professionals are more concern with limiting patients exposure to radiation, and thus prefer non-fluoroscopic tests over cinecoronariography[17]. In Japan, Kawakami et al. (2021) reported some concern about patient exposure to ionizing radiation in electrophysiology and proposed a catheter ablation technique with zero fluoroscopy[18]. However, there is a paucity comparative studies addressing fluoroscopy time and the attempt to decrease radiation emission during DDD and VVI PM implantation is clearly noticed.

CONCLUSION

The median duration of surgery for DDD and VVI pacemaker implantation was 18'15" and 17'12", respectively. The average times of exposure to radiation was 1'42" for the implantation of the PM DDD and 1'41" for the VVI. These values are considered low and safe. There were no complications with the implants. However, further studies on the subject are still needed.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conceptualization: Costa MAC; **Investigation:** Costa MAC, Grczczak RCV, Machado LVM, Souza ACMF; **Writing:** Costa MAC, Grczczak RCV, Machado LVM, Souza ACMF; **Review and editing:** Costa MAC, Grczczak RCV, Machado LVM, Souza ACMF; **Final approval:** Souza ACMF.

DATA AVAILABILITY STATEMENT

All datasets were generated or analyzed in the current study.

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