

Impact of self-selected music on perceived pain intensity during cardiac implantable electronic device procedures: a single-centre experimental study

Abstract

Background: Cardiac implantable electronic devices (CIEDs), such as pacemakers and implantable cardioverter-defibrillators (ICDs), play a fundamental role in the treatment of arrhythmias. Their implantation and replacement procedures, generally performed under local anesthesia, require adequate analgesia to minimize patient pain. Music therapy, a nonpharmacological intervention free from adverse effects, has been shown to reduce pain perception, particularly when the music is selected by the patient. Therefore, investigating the impact of music during these procedures may contribute to the development of more effective pain management strategies.

Objectives: To evaluate the effect of self-selected music on pain perception in patients undergoing cardiac implantable electronic device implantation procedures.

Methods: A prospective, experimental, and analytical study was conducted at a hospital centre between March and August 2025. Sixty adult participants who met predefined inclusion and exclusion criteria were enrolled and subsequently randomized into a control group, with no music exposure, or an experimental group exposed to self-selected music throughout the entire procedure. Pain was assessed postoperatively using the Visual Analogue Scale (VAS).

Results: Statistical analysis demonstrated homogeneity between the control and experimental groups. The non-normal distribution of the data required the use of the Mann-Whitney U test, yielding a pvalue below 0.05. The mean VAS score was 4.40 in the control group and 1.44 in the experimental group, corresponding to a difference of 2.96 points. Thus, the experimental group reported significantly lower pain perception than the control group. The covariates assessed did not influence the results.

Conclusion: Exposure to self-selected music was associated with a statistically significant and clinically relevant reduction in pain during CIED procedures. Further evaluation across different device types and multicentre studies may establish this intervention as a valuable tool in healthcare practice associated with these procedures.

Keywords: self-selected music, pain, cardiac implantable electronic devices, pacemaker, implantable cardioverter-defibrillator, local anesthesia

Volume 10 Issue 4 - 2026

Ana Luísa da Cunha Rodrigues Santos de Almeida, Assunção Alves, Andreia Couto

Cardiopneumology Department, School of Health- Technical University of Porto, Portugal

Cardiovascular Diagnostic and Interventional Unit, Hospital Senhora da Oliveira- Health Local Unit of Alto Ave, Portugal
Cardiopneumology Department, Medtronic; School of Health- Technical University of Porto, Portugal

Correspondence: Ana Luísa da Cunha Rodrigues Santos de Almeida, Cardiopneumology Department, School of Health- Technical University of Porto, Portugal, Tel 937901958

Received: September 02, 2026 | **Published:** October 01, 2026

Introduction

Pacemakers and implantable cardioverter-defibrillators (ICDs) are essential cardiac implantable electronic devices for the prevention and treatment of severe consequences arising from cardiac arrhythmias. The implantation and replacement of these devices are frequently performed under local anesthesia, with the patient remaining conscious throughout the procedure.¹⁻⁴ The careful administration of local anesthetics must remain within established safety limits, which is crucial to preventing toxicity while ensuring maximum patient comfort and analgesia.² Pain is a complex and multidimensional phenomenon comprising physiological, sensory, affective, cognitive, behavioural, and sociocultural components. Its experience is subjective and unique to each individual, requiring a multidisciplinary and individualized approach to assessment and management.^{5,6} Non-pharmacological strategies may complement pharmacological treatment, including sensory stimulation interventions such as auditory stimulation.^{7,8}

Music has been investigated as a non-pharmacological intervention, and its effects on pain perception appear to depend on several factors, including musical style and the individual's familiarity with the music. Recent studies suggest that patient-selected music may provide greater reductions in acute pain perception compared with investigator-selected music. This effect has been associated with emotional responses and the induction of relaxation.⁹⁻¹³ Self-selection therefore introduces an element of personalization and active patient participation that distinguishes this intervention from standardized musical exposure. Despite growing interest in the use of music during invasive procedures, evidence specifically related to cardiac implantable electronic device procedures remains limited. Therefore, the present study aimed to evaluate the impact of self-selected music, according to patients' preferred musical genres, on perceived pain intensity during pacemaker or ICD implantation and generator replacement procedures.

Methods

Study design and participants

A prospective, experimental, and analytical study was conducted with random allocation of participants from *Hospital Senhora da Oliveira* – Health Local Unit of *Alto Ave*. Participants were not informed that the specific purpose of the study was to evaluate the effect of music on pain perception. Instead, they were informed that they would hear background sound during the procedure and that their perceived pain would subsequently be assessed. The study was therefore designed as a single-blind randomized trial. Participants were recruited between March and August 2025 from an initial population of 116 patients. Following the application of eligibility criteria, 60 participants comprised the final sample, with 30 allocated to the control group and 30 to the experimental group. Adults undergoing pacemaker implantation, ICD implantation, or elective generator replacement were eligible for inclusion. Exclusion criteria included cardiac resynchronization therapy (CRT), implantable cardiac monitors, leadless pacemakers, subcutaneous or extravascular ICDs, lead repositioning or extraction, upgrades to CRT systems, hearing or cognitive impairment, current psychiatric illness, chronic pain, sedation, general anesthesia, altered consciousness, refusal to participate, and participants allocated to the experimental group who were not exposed to their self-selected music during the procedure.

Intervention and pain assessment

Participants were randomly assigned to either the control or experimental group. In the control group, the usual procedural background noise was maintained. In the experimental group, each patient was asked to identify their preferred or most relaxing musical style, which was then played through a loudspeaker throughout the entire procedure. The intervention was therefore self-selected and individualized. Procedures were performed under local anesthesia. A 2% lidocaine solution was used, with an initial dose of 20 mL, except in some cases where the procedure began with 10 mL of 2% lidocaine combined with 10 mL of 0.5% ropivacaine. Whenever patients reported pain after the initial dose, additional local anesthetic was administered. During postoperative recovery, pain experienced during the procedure was assessed using the Visual Analogue Scale (VAS) after a standardized explanation of the scale by the investigator.

Results

Participant eligibility assessment

Total individuals assessed for eligibility: N=116

- I. Excluded: N=56
- II. CRT implantation: N=8
- III. MCI implantation: N=19
- IV. Leadless pacemaker implantation: N=2
- V. Subcutaneous ICD implantation: N=2
- VI. Lead replacement: N=3
- VII. Spatial and temporal disorientation: N=8
- VIII. Cognitive impairment: N=1
- IX. Chronic pain: N=3
- X. Hearing impairment: N=3

XI. No exposure to preferred music, despite being assigned to the experimental group: N=7 Final sample included in the study: N=60

Control Group: N=30 Experimental Group: N=30

Figure 1 – Study sample selection process

Sample characteristics and group comparability

The participant selection process is presented in Figure 1. Of the 116 individuals initially assessed for eligibility, 56 were excluded according to predefined criteria, resulting in a final sample of 60 participants. Thirty participants were allocated to the control group and 30 to the experimental group. The final sample consisted of 33 men and 27 women, with a mean age of 78 years (range: 33-97 years). Thirty-two participants reported no previous experience of pain during procedures performed under local anesthesia, whereas 28 reported having experienced pain in similar circumstances. The procedures included 27 dual-chamber pacemaker implantations, 15 pacemaker generator replacements, 9 single-chamber pacemaker implantations, 5 dual-chamber ICD implantations, and 4 single-chamber ICD implantations. The control and experimental groups were comparable with regard to the main covariates assessed. For sex, age, previous procedural experience, and type of device/procedure, the respective p-values were 0.606, 0.946, 1.000, and 0.344. For venous access, total dose of local anesthetic administered, and total procedure duration, p-values were 0.470, 0.374, and 0.685, respectively. Therefore, no statistically significant differences were identified between groups for any of these variables.

Primary outcome: perceived pain intensity

Levene's test yielded $F = 5.641$ ($p = 0.021$), indicating heterogeneity of variances between groups. The Shapiro-Wilk test demonstrated non-normal distribution of VAS scores in both groups, with $p = 0.003$ in the control group and $p < 0.01$ in the experimental group. Consequently, comparisons between groups were performed using the non-parametric Mann-Whitney U test. The mean VAS score was 4.40 in the control group and 1.44 in the experimental group, corresponding to a difference of 2.96 points. This difference was statistically significant ($U = 121.000$; $Z = -4.867$; $p < 0.001$). The consistency of the Monte Carlo significance estimates ([0.000; 0.000]) further supported the robustness of the findings. Correlation matrix analysis revealed a strong, negative, and statistically significant association between allocation to the experimental group and pain perception ($r = -0.605$). All remaining variables showed only very weak or negligible correlations with pain perception (r values ranging from -0.210 to +0.096).

Discussion

The principal finding of this study was the marked difference in pain perception between participants exposed to self-selected music and those allocated to the control group. Mean VAS pain scores were 4.40 and 1.44 for the control and experimental groups, respectively, representing a difference of 2.96 points. This difference exceeds the threshold of 2 points that Turk et al. identified as clinically meaningful on a 0-10 pain scale.^{14,15} Therefore, the observed effect should be interpreted not only in terms of its statistical significance but also its clinical relevance. Throughout data collection, participants' informal comments suggested that self-selected music exerted a considerable influence on perceived pain. Notably, participants frequently attributed this effect not merely to relaxation but rather to the emotional connection, enthusiasm, and memories associated with

their chosen music. Although these observations do not constitute formal qualitative findings, as no qualitative methodology was employed, they provide insight into potential underlying mechanisms, including distraction, emotional engagement, and enhanced feelings of personal control.

Campos et al. highlighted the influence of psychological factors such as self-confidence and catastrophizing on pain perception. Individuals with higher levels of catastrophizing tend to report greater pain intensity and interference in daily activities, whereas greater self-confidence is associated with improved emotional regulation and lower perceived pain intensity. The findings of the present study support the possibility that the musical intervention acted through similar mechanisms.¹⁶ Participants frequently described their attention being occupied by pleasant, comforting, and encouraging thoughts during the procedure, suggesting an important role for emotional modulation and cognitive distraction. These observations reinforce the relevance of interventions that encourage emotional expression and self-care. The recognition of pain as the “fifth vital sign” reflects the growing importance of addressing pain comprehensively in clinical practice.⁶

Conventionally, it is often suggested that one sex may tolerate pain better than the other. Although previous literature, including publications from the International Association for the Study of Pain, has reported significant differences between men and women regarding pain perception and expression, no statistically significant sex-related differences were detected in the present study.^{17,18} Pain remains an inherently subjective experience, even when assessed using standardized instruments. In this study, the investigator provided a standardized explanation of the VAS to all participants, and patients were unaware that the specific objective was to evaluate the effect of music on pain. These measures were implemented to minimize potential sources of assessment bias. Furthermore, the absence of significant differences between groups regarding the primary covariates supports the interpretation that the observed reduction in pain was associated with the intervention under investigation, although the contribution of unmeasured factors cannot be entirely excluded.

Nevertheless, the findings should be interpreted despite several limitations. The sample size was relatively small, and all participants were recruited from a single hospital center, limiting the generalizability of the results. In addition, all participants were Portuguese and Caucasian, preventing the evaluation of cultural and generational differences in perceived pain and expression. Procedures were performed by three different operators, potentially introducing technical variability. Although the initial local anesthetic dosage was standardized, it was not adjusted according to body weight; instead, total anesthetic dose was analyzed. Moreover, physiological indicators such as blood pressure, heart rate, and respiratory rate were not collected.

A particularly important limitation concerning the personalization hypothesis is that the study design compared only the absence of music with patient-selected music. Consequently, while the study demonstrates the effectiveness of the combined intervention of self-selected music, it does not allow the specific effect of patient choice to be isolated from the general effect of music itself. A future three-arm randomized trial comparing no music, investigator-selected music, and self-selected music would allow a more direct assessment of this hypothesis. The inclusion of anxiety measures, physiological parameters, and systematic evaluation of emotional responses could further clarify the mechanisms responsible for the observed benefits. The present findings therefore support a more person-centred approach

to care. Allowing patients to choose the music they wish to listen to during invasive procedures represents a simple, low-cost intervention that can be integrated into each individual’s healthcare experience without replacing conventional analgesic strategies.¹⁹

Conclusion

Exposure to self-selected music was associated with a substantial reduction in perceived pain intensity during cardiac implantable electronic device procedures. The principal contribution of this study lies in the individualized nature of the intervention. Although the study design does not allow definitive conclusions regarding whether the process of music selection itself is responsible for the observed effects, the findings support the potential value of self-selected music as an adjunctive strategy for pain management. Overall, the results contribute to a more holistic perspective on healthcare delivery, highlighting the potential integration of music into clinical care and its capacity to enhance patient well-being during invasive cardiovascular procedures.

Acknowledgements

None.

Conflicts of interest

The author declares there is no conflict of interest.

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