Trauma Surgery & Acute Care Open

Presence of Permanent Pacemakers: Implications for Elderly Patients Presenting with Traumatic Injuries

Tanzim Bhuiya ,[1] Demian Omeh,[2] Rezwan Munshi,[2] Brian Berookhim,[2] Ashley Roper,[2] Viliane Vilcant,[2] Elisa Syzdziak,[3] Ofek Hai,[2] Roman Zeltser,[1,2] Jody Digiacomo,[3] Amgad N Makaryus [1,2]

[1]Donald and Barbara Zucker School of Medicine at Hofstra/Northwell, Hempstead, New York, USA
[2]Cardiology, Nassau University Medical Center, East Meadow, New York, USA
[3]Surgery, Nassau University Medical Center, East Meadow, New York, USA

Correspondence to
Dr Amgad N Makaryus; amakaryu@numc.edu

Received 7 November 2022
Accepted 26 April 2023

To cite: Bhuiya T, Omeh D, Munshi R, *et al*. *Trauma Surg Acute Care Open* 2023;**8**:e001053.

ABSTRACT

Background The presence of permanent pacemakers (PPM) is common among the elderly population. Trauma literature has shown that the inability to augment cardiac output by at least 30% after injury portends a higher mortality. The presence of a PPM may be a surrogate marker to identify patients who are unable to increase cardiac output. We aimed to evaluate the association between the presence of PPM and clinical outcomes in elderly patients presenting with traumatic injuries.

Methods A total of 4505 patients aged ≥65 years admitted with acute trauma from 2009 to 2019 at our Level I Trauma center were evaluated and stratified into two groups using propensity matching on age, sex, injury severity score (ISS), and year of admission based on the presence of PPM. Logistic regression was performed to analyze the impact of the presence of PPM on mortality, surgical intensive care unit (SICU) admission, operative intervention, and length of stay. Prevalence of cardiovascular comorbidities was compared using χ^2 analysis.

Results Data from 208 patients with PPM and 208 propensity-matched controls were evaluated. Charlson Comorbidity Index, mechanism of injury, intensive care unit admission, and rate of operative intervention were comparable in the two groups. PPM patients had more coronary artery disease (p=0.04), heart failure with reduced ejection fraction (p=0.003), atrial fibrillation (AF, p<0.0001), and antithrombotic use (p<0.0001). We found no association between mortality amongst the groups after controlling for influencing variables (OR=2.1 (0.97 to 4.74), p=0.061). Patient characteristics associated with survival included female sex (p=0.009), lower ISS (p<0.0001), lower revised trauma score (p<0.0001), and lower SICU admission (p=0.001).

Conclusion Our study shows no association between mortality among patients with PPM admitted for treatment of trauma. Presence of a PPM may be an indicator of cardiovascular disease, but this does not translate into increased risk in the modern era of trauma management in our patient population.

Level of evidence Level III.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Increased age and a previous cardiac history are both independent risk factors for worse trauma outcomes.
⇒ There is a paucity of data on the outcomes of elderly patients with permanent pacemakers who suffer traumatic injuries.

WHAT THIS STUDY ADDS

⇒ Our study shows no association between mortality among patients with permanent pacemaker admitted for treatment of trauma compared with those without a permanent pacemaker after controlling for other risk factors.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study shows that in the modern era of trauma management, the presence of a pacemaker in the elderly population should not necessarily play a role in triaging critically ill patients with traumatic injuries as it does not portend an increased mortality in these patients.

INTRODUCTION

According to the 2019 estimates by the U.S. Census Bureau, the population of persons ≥65 years increased by 34.2% in the last decade.[1] Aging is a risk factor for cardiac conduction abnormalities and cardiovascular diseases in general.[2 3] Advanced age is also an independent risk factor for adverse outcomes in trauma patients.[4] Presence of permanent pacemakers (PPM) is common among the elderly population.

PPM were first developed to treat severe hemodynamic compromise due to bradycardia in patients with cardiac conduction abnormalities.[5] Advancements in cardiovascular care using PPM has created the opportunity for a more active lifestyle for elderly patients with cardiac diseases, and this has in turn increased their risk of traumatic injuries. Patients aged ≥65 years represent about 16.5% of the population, but this group accounts for 23% of all trauma admissions.[1 6] Augmentation of cardiac output is central among the physiological responses to traumatic injury. It has been shown that an inability to augment cardiac output by at least 30% after injury portends a higher mortality.[7] Cardiac pacemakers have a wide beneficial effect on hemodynamics. Pacing therapy can improve cardiac function by normalizing cardiac electrical activation. Cardiac pacing can improve hemodynamic measurements through multiple means such as using an average of a set number of heart beats, ensuring all beats are included and pacing the heart at faster rates.[5] AV synchrony achieved through pacemakers has a beneficial hemodynamic effect at rest in most patients. During exercise or cardiac stress such as trauma, heart rate increase is more important than AV synchrony. Thus, in patients with chronotropic incompetence due to sick sinus syndrome, rate adaptive pacing is important. Studies demonstrate that dual-chamber pacing provides a higher cardiac output without disturbing myocardial oxygen balance in patients with ischemic heart disease.[8] Although the indications for pacemakers have widened and the delivery of pacing therapy has become more intricate, the fundamental aim of the device therapy has remained the same: to improve cardiac function and hemodynamics by normalizing cardiac conduction. As a result, the presence of a PPM can act as a surrogate to identify patients who may be less able to increase cardiac output.

As the elderly population with significant cardiac comorbidities continues to grow, there is a notable paucity of data on the outcomes of elderly patients with PPM who suffer traumatic injuries. The objective of our study is to evaluate the association between the presence of PPM and clinical outcomes in elderly patients presenting with traumatic injuries.

METHODS

Our tertiary care institution is a public safety net hospital and serves a population of nearly 1.4 million people.[9] It is a Level 1 Trauma center verified by the American College of Surgeons. The emergency department has approximately 75 000 visits and the trauma center approximately 1700 admissions each year.

Our study obtained approval from the Institutional Review Board (IRB#19–214) and followed the STROBE guidelines for cohort studies.[10] The Trauma Registry was queried for all patients aged ≥65 years of age during a period of 11 years (from January 1, 2009 to December 31, 2019). Patients with a PPM at the time of admission were identified using ICD 9 and ICD 10 codes for PPM. Demographic information, comorbid conditions, preinjury medications, mechanism of injury (MOI), vital signs, injury severity score (ISS), revised trauma score (RTS), admission disposition, hospital course, intensive care unit length of stay (ICU-LOS), hospital length of stay, complications, disposition, and outcome were extracted from our trauma registry supplemented by direct review of the electronic medical record. Incomplete records were excluded from further analysis based on the nature and extent of missing data fields. The Charlson Comorbidity Index (CI) was calculated based on published criteria.[11]

All patients ≥65 years admitted to our trauma service during the study period were included in the study. Patients that were less than 65 years and those that left or were transferred out from our emergency department were not captured by our sampling method and were excluded from our study. Initially, patients with both PPMs and automatic implantable cardioverter defibrillators (AICD) were identified. However, our search yielded only 19 patients with AICD. As a result, these patients were excluded from further evaluation because the sample size was too small for meaningful analysis of that subgroup. Additionally, the patient population of those with an AICD varies greatly from those with a cardiac pacemaker. Those who require AICDs typically have very low ejection fractions or are prone to lethal arrhythmias in contrast to patients who receive pacemakers typically for bradyarrhythmias.

Patients were stratified into two groups based on the presence (PPM+) or absence (PPM-) of an implanted PPM. Propensity score matching was used to create comparable risk groups in the PPM+ and PPM- groups. Patients were matched based on age, sex, ISS, and year of hospital admission.

Table 1 Patients' characteristics

Variables	PPM+ (N=208)	PPM– (N=208)	P value
Mean age (matched)	86.25 (±7.0)	86.37 (±7.4)	0.79*
Sex=female (matched)	107 (51.4%)	107 (51.4%)	1.00
Mechanism of injury	0.12†		
Ground level fall	110 (52.9%)	128 (61.5%)	
Fall from height	57 (27.4%)	54 (26.0%)	
MVC/Pedestrian struck	32 (15.4%)	23 (11.1)	
Others	9 (4.3%)	3 (1.4%)	
Mean ISS (matched)	10.74 (±8.3)	10.42 (±7.2)	0.90*
Mean RTS	7.74 (±0.6)	7.60 (±0.7)	0.0028*
Hospital LOS	5.8 (±7.0)	4.8 (±4.5)	0.38*
ICU LOS	3.7 (±4.1)	3.3 (±2.9)	0.80*
Discharge disposition	0.23†		
Expired	20 (9.6%)	16 (7.7%)	
Home	82 (39.4%)	97 (46.6%)	
Rehab	96 (46.2%)	91 (43.8%)	
Transfer	10 (4.8%)	4 (1.9%)	
SICU admission	138 (66.4%)	141 (67.8%)	0.75
Operative intervention	63 (30.3%)	54 (26.0%)	0.33
In-hospital mortality	20 (9.6%)	16 (7.7%)	0.49
Mean Charlson CI	5.21 (±1.47)	5.39 (±1.74)	0.42*
HFrEF	33 (15.9%)	14 (6.7%)	0.003
Hypertension	157 (74.5%)	158 (76.0%)	0.91
CAD	91 (43.8%)	71 (34.1%)	0.04
Acute MI	20 (9.6%)	17 (8.2%)	0.61
Diabetes mellitus	42 (20.2%)	44 (21.2%)	0.81
CKD	18 (8.7%)	12 (5.8%)	0.26
CVA	29 (13.9%)	29 (13.9%)	1.00
Hyperlipidemia	88 (42.3%)	84 (40.4%)	0.69
Atrial fibrillation	125 (60.1%)	47 (22.6%)	<0.0001
Antithrombotics	88 (42.3%)	46 (22.1%)	<0.0001

*Wilcoxon rank sum test; means shown for illustrative purposes only.
†Fisher's exact test.
CAD, coronary artery disease; CI, Comorbidity Index; CKD, chronic kidney disease; CVA, cerebrovascular accident; HRrEF, Heart failure with reduced ejection fraction; ISS, Injury severity score; MI, myocardial infarction; MVC, motor vehicular crash; pRBC, packed red blood cell; RTS, revised trauma score; SICU, surgical intensive care unit.

Basic descriptive statistics were used to summarize the demographic and clinical variables. Continuous variables were summarized by presenting mean and SD. Categorical variables were summarized using frequency and percentages. Continuous variables were compared using Student t-test and Wilcoxon rank sum test. Fisher exact test or Pearson χ^2 test was used to examine the association of categorical variables. Logistic regression predicting mortality to ascertain if the presence of PPM was significant, controlling for SICU LOS, Charleston Index and RTS was performed. $P<0.05$ was considered statistically significant. Statistical analysis was performed using SAS 9.4 software (Cary, North Carolina). Our primary end-point was all-cause in-hospital mortality.

RESULTS

A total of 4505 acutely injured patients aged ≥65 years were admitted by the trauma service over the 11-year study period, of whom 208 had PPM as identified by ICD codes. Data from these 208 patients with PPM (PPM+) and 208 propensity-matched controls (PPM-) were included in the final analysis (table 1).

Table 2 Logistic regression model for risk factors for in-hospital mortality

Variable	OR	95% CI	P value
Cardiac device present	2.1	0.97 to 4.74	0.061
SICU admission	10.7	2.36 to 48.58	0.002
Charleston Index	1.38	1.12 to 1.70	0.003
RTS	0.383	0.26 to 0.57	<0.0001

RTS, Revised trauma score; SICU, surgical intensive care unit.

Table 3 Patient characteristics based on survival

Variables	Survived (N=380)	Did not survive (N=36)	P value
Mean age (matched)	86.2 (±7.2)	87.5 (±6.5)	0.29*
Sex=female (matched)	203 (53.4%)	11 (30.6)	0.009
Mechanism of injury	0.15		
Ground level fall	223 (58.7%)	15 (41.7%)	
Fall from height	100 (26.3%)	11 (30.6%)	
MVC/Pedestrian struck	47 (12.4%)	8 (22.2)	
Others	10 (2.6%)	2 (5.6%)	
Mean ISS (matched)	9.6 (±6.5)	20.8 (±12.1)	<0.0001*
Mean RTS	7.73 (±0.5)	7.0 (±1.5)	<0.0001*
Hospital LOS	5.0±5.1	8.3±10.7	0.30*
ICU LOS	3.3±3.0	5.3±5.6	0.42*
SICU admission	246 (64.7%)	33 (91.7%)	0.001
Operative intervention	105 (27.6%)	12 (33.3%)	0.50
Mean Charlson CI	5.23 (±1.6)	6.0 (±1.6)	0.002
HFrEF	40 (10.5%)	7 (19.4%)	0.11
HFpEF	37 (9.7%)	7 (19.4%)	0.07
Hypertension	293 (77.1%)	22 (61.1%)	0.03
CAD	145 (38.2%)	17 (47.2%)	0.29
Acute MI	32 (8.4%)	5 (13.9%)	0.27
Diabetes mellitus	79 (20.8%)	7 (19.4%)	0.85
CKD	24 (6.3%)	6 (16.7%)	0.02
CVA	51 (13.4%)	7 (19.4%)	0.32
Hyperlipidemia	165 (43.4%)	7 (19.4%)	0.005
Atrial fibrillation	153 (40.3%)	19 (52.8%)	0.15
Antithrombotics	121 (31.8%)	13 (36.1%)	0.60

*Wilcoxon rank sum test; means shown for illustrative purposes only.
CI, Comorbidity Index; CKD, chronic kidney disease; DNR/DNI, do not resuscitate/do not intubate; HRpEF, Heart failure with reduced ejection fraction ; pRBC, packed red blood cell; RTS, Revised trauma.

Mean age across all subjects was 86.3 years. Slightly more than half of the subjects were female (51.4%). The mean ISS was 10.6.

Charlson Comorbidity Index (CI), MOI, ICU admission, and rate of operative intervention were comparable in the two groups. Ground-level fall was the most common MOI in both study arms, accounting for more than half of all admissions. Roughly two-thirds of the patients in both groups were admitted to the ICU.

The CI was also similar, being 5.21 for the PPM+ group and 5.39 for the PPM- group (p=0.42). The RTS was 7.74 for the PPM+ group and 7.60 for the PPM- group (p=0.0028). PPM+ patients had more coronary artery disease (CAD) (43.8% vs 34.1%, p=0.04), heart failure with reduced ejection fraction (HFrEF) (15.9% vs 6.7%, p=0.003), atrial fibrillation (AF) (60.1% vs 22.6%, p<0.001), and higher use of antithrombotics (42.3% vs 22.1%, p<0.001). AF included all subtypes of the arrythmia. Use of antithrombotics included all anticoagulation and antiplatelet medication.

There was no statistically significant difference in the in-hospital mortality rates between the PPM+ group than the PPM- group (9.6% vs 7.7%, p=0.49). Even after logistic regression controlling for risk factors for in hospital mortality such as SICU admission, CI, and RTS, the presence of a PPM was not significant in predicting in-hospital mortality for patients aged ≥65 years admitted after acute injury (p=0.061) (table 2). Patient characteristics that were associated with survival after trauma included female sex (53.4% vs 30.6%, p=0.009), lower ISS (9.6±6.5) vs 20.8±12.1), p<0.0001), lower RTS (7.74±0.5) vs 7.00±1.5), p<0.0001), lower SICU admission (64.7% vs 91.7%, p<0.001), and lower mean Charlson CI (5.23±1.6) vs 6.00±1.6).95, p=0.002; table 3). Additionally, 64.7% of patients who survived were admitted to the SICU compared with 91.7% in the patient group that did not survive (p<0.001).

DISCUSSION

Elderly patients experience worse morbidity and mortality after traumatic injury. The cause of this increased morbidity and mortality is multifactorial. Elderly patients have more comorbidities and risk factors such as reduced physiologic compensatory reserve, frailty, and polypharmacy.[6 12] It has been shown that patients with comorbidities that compromised their ability to significantly increase their cardiac output after emergent surgical procedures due to trauma, performed poorly in the postoperative period.[7 13] Crude 30-day mortality after a traumatic injury was 3.5% among young adults compared with 8.2% among the geriatric population.[14] Patients younger than the age of 65 years with an AICD device have a survival rate greater than 10 years versus those age ≥75 years who have a survival rate of 5 years.[15] The extent to which the presence of cardiac rhythm devices affects the cardiovascular response to traumatic injury is poorly understood.

Our study compares the outcomes of traumatic injuries in elderly patients aged ≥65 with PPM to a propensity-matched control group with comparable comorbidity burden. Our study groups were matched for age, sex, injury severity, and admission year, differing only in the presence or absence of PPM. The exact prevalence of PPM implantation in the elderly population is not clearly documented, but over 80% of PPM are implanted in elderly patients with a mean age of 75±10 years[2 15] In our study, a total of 5.3% of patients aged ≥65 years admitted for traumatic injuries during the study period had a cardiac device. Other reports have shown a slightly higher proportion (~9%) of either PPM or AICD in patients aged ≥60 years admitted for traumatic injuries.[14 16]

In our population, patients with a PPM did not have an association with all-cause in-hospital mortality after trauma, after controlling for other variables that affect mortality, when compared with patients without PPM (OR=2.1 [0.97 to 4.74], p=0.061). There was a significant difference between presence of certain cardiac risk factors between the two groups including HFrEF, CAD, AF and use of antithrombotics, which is consistent with the need for a PPM in this study group. Although there was a statistically significant different mean RTS between the two study groups in our study, we do not think this is a clinically significant finding as evidenced by the insignificant difference in mortality rate between the two groups. The insignificant difference between the two groups is consistent with other studies which demonstrate risk factors for death in patients ≥85 years with a pacemaker are generally non-cardiac in nature.[17] Similar to our results, other reports have shown that after controlling for non-equivalence of their study groups, the presence of PPM ($p=0.81$) was not an independent predictor of mortality in elderly patients aged ≥60 years admitted for traumatic injuries.[14 16] This demonstrates that the overall worse trauma outcome that the elderly experience is multifactorial. A systemic review and meta-analysis of predictors of mortality in geriatric trauma patients aged ≥65 years of 17 studies published between 1994 and 2012, with a total of 65 897 patients, found an overall pooled mortality rate of 14.8% (95% CI 9.8 to 21.7%, $p<0.0001$).[4] The mortality rate of 9.6% in our study subjects was considerably lower than 14.8% and may be an indication of the improvement in trauma care and medical risk stratification in trauma patients over the last decade.[18 19]

LIMITATIONS

Our study was a single-center retrospective study; hence, it is prone to selection bias. The study groups were selected by propensity matching which holds the inherent limitation of unknown confounders that were not accounted for. Additionally, our study size was limited to 208 patients in each group leading to large confidence intervals in our results. There was also a paucity of patients with an AICD in our study time frame, so we could not assess the impact of trauma on mortality in that study population. Additionally, we did not subcategorize the pacemaker group by type of device such as single versus dual-chamber or rate-responsive versus non-responsive. Future studies from a larger database, such as a multi-institutional study, can further strengthen the results of our study and can pursue the relationship between AICD, pacemaker subtypes and trauma outcomes. Lastly, only a few patients had documentation of their cardiac device interrogation during hospitalization; hence, we could not identify whether device failure patients, if any, existed.

CONCLUSION

Our investigation did not show increased mortality rates in patients with PPM admitted for trauma compared to patients without a PPM after controlling for risk factors. Presence of PPM may be an indicator of cardiovascular disease, but this may not translate to increased risk in the modern era of trauma management. Finally, presence of a PPM, although important for evaluation, likely does not affect outcomes in these critically ill patients presenting with traumatic injuries. Instead, factors such as mean ISS, mean RTS, and SICU admission were associated with differences in survival outcome in our study.

Twitter Amgad N Makaryus @AmgadMakaryus

Contributors Authors TB, DO, RM, BB, AR and VV were responsible for data collection. ES was responsible for statistical analysis. TB, DO, RZ, JD and AM were responsible for writing of the manuscript. JD and AM led the project and are the guarantors on the quality of the study.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Study approved by Nassau Health Care Corporation Institutional Review Board underIRB# 19-214.

Provenance and peer review Not commissioned; internally peer reviewed.

Data availability statement Data are available on reasonable request.

ORCID iDs
Tanzim Bhuiya http://orcid.org/0000-0003-0685-9740
Amgad N Makaryus http://orcid.org/0000-0003-2104-7230

REFERENCES

1 Bureau UC. 65 and older population grows rapidly as baby boomers age. Available: https://www.census.gov/newsroom/press-releases/2020/65-older-population-grows.html [Accessed 3 Apr 2021].
2 Bradshaw PJ, Stobie P, Knuiman MW, Briffa TG, Hobbs MST. Trends in the incidence and prevalence of cardiac pacemaker insertions in an ageing population. *Open Heart* 2014;1:e000177.
3 Mirza M, Strunets A, Shen WK, Jahangir A. Mechanisms of arrhythmias and conduction disorders in older adults. *Clin Geriatr Med* 2012;28:555–73.
4 Hashmi A, Ibrahim-Zada I, Rhee P, Aziz H, Fain MJ, Friese RS, Joseph B. Predictors of mortality in geriatric trauma patients: a systematic review and meta-analysis. *J Trauma Acute Care Surg* 2014;76:894–901.
5 Miyazawa AA, Francis DP, Whinnett ZI. Basic principles of hemodynamics in pacing. *Card Electrophysiol Clin* 2022;14:133–40.
6 Fakhry SM, Morse JL, Garland JM, Wilson NY, Shen Y, Wyse RJ, Watts DD. Redefining geriatric trauma: 55 is the new 65. *J Trauma Acute Care Surg* 2021;90:738–43.
7 CLOWES GH Jr, DEL GUERCIO LR, BARWINSKY J. The cardiac output in response to surgical trauma: a comparison between patients who survived and those who died. *Arch Surg* 1960;81:212–22.
8 Buckingham TA, Janosik DL, Pearson AC. Pacemaker hemodynamics: clinical implications. *Progress in Cardiovascular Diseases* 1992;34:347–66.
9 U.S Census Bureau Quickfacts: Nassau County, New York. Available: https://www.census.gov/quickfacts/nassaucountynewyork [Accessed 11 Mar 2022].
10 von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP, STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Int J Surg* 2014;12:1495–9.
11 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40:373–83.
12 Ahmadinejad M, Mohammadzadeh S, Shirzadi A, Soltanian A, Ahmadinejad I, Pouryaghobi SM. Trauma factors among adult and geriatric blunt trauma patients. *International Journal of Surgery Open* 2021;28:17–21.
13 Kirkman E, Watts S. Haemodynamic changes in trauma. *Br J Anaesth* 2014;113:266–75.
14 Moore L, Turgeon AF, Sirois MJ, Lavoie A. Trauma centre outcome performance: a comparison of young adults and geriatric patients in an inclusive trauma system. *Injury* 2012;43:1580–5.
15 Bradshaw PJ, Stobie P, Briffa T, Hobbs MST. Use and long-term outcomes of Implantable cardioverter-defibrillators, 1990 to 2009. *Am Heart J* 2013;165:816–22.
16 Altieri MS, Almasry I, Jones T, McPhee C, McCormack JE, Huang EC, Eckardt P, Shapiro MJ, Eckardt S, Vosswinkel JA, *et al*. Implantable cardioverter defibrillators and permanent pacemakers: prevalence and patient outcomes after trauma. *Am J Surg* 2016;212:953–60.
17 Marini M, Martin M, Saltori M, Quintarelli S, Zilio F, Guarracini F, Coser A, Valsecchi S, Bonmassari R. Pacemaker therapy in very elderly patients: survival and prognostic parameters of single center experience. *J Geriatr Cardiol* 2019;16:880–4.
18 Choi J, Carlos G, Nassar AK, Knowlton LM, Spain DA. The impact of trauma systems on patient outcomes. *Curr Probl Surg* 2021;58:100840.
19 Holcomb JB. Major scientific lessons learned in the trauma field over the last two decades. *PLOS Med* 2017;14:e1002339.