Public Health and Epidemiology: Open Access

PRIME OPEN ACCESS

Volume 1, Issue 1

Research Article

Date of Submission: 28 March, 2025
Date of Acceptance: 21 April, 2025
Date of Publication: 30 April, 2025

Exploring Contra-lateral Pneumothorax Following Pacemaker Placement: A Comprehensive Systematic Review of Case Reports

Haseeb Khan Tareen*

Mayo Hospital, Punjab, Pakistan

***Corresponding Author:**
Haseeb Khan Tareen, Mayo Hospital, Punjab, Pakistan.

Citation: Tareen, H. K. (2025). Exploring Contra-lateral Pneumothorax Following Pacemaker Placement: A Comprehensive Systematic Review of Case Reports. *Public Health Epidemiol OA, 1*(1), 01-08.

Abstract

Objective: Contra-lateral pneumothorax following pacemaker placement is a rare but clinically significant complication, with sparse documentation in the existing literature. This review aims to comprehensively investigate this phenomenon, focusing on risk factors, diverse clinical presentations, diagnostic challenges, and effective management strategies.

Methods: We conducted a systematic literature search and data extraction from PubMed, Cochrane, Science Direct, and Google Scholar following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results: Our review identified 28 cases of contra-lateral pneumothorax (CPTX) following pacemaker or implantable cardioverter-defibrillator (ICD) placement. The mean age was 70.5 years, with a predominantly male demographic (71%). The interval between the procedure and the onset of CPTX ranged from as early as 2 hours to as late as 6 months post-procedure. The most common presentations were chest pain (52%) and shortness of breath (30%).

Risk factors were categorized into procedural and non-procedural factors. Procedural factors included active fixation of a helical screw-in lead 17/28 (60%), atrial appendage lead placement 9/28 (32%) followed by lateral atrial wall lead placement 4/28 (14%). In 18/28 cases (64.3%), the subclavian vein was used as the access site, dual-chamber pacemakers were used in 23/28 cases (82%). Non-procedural factors encompassed steroid use 7/28 (25%), the presence of a thin-walled or multilobed atrial appendage 4/28 (14%) and long-standing smoking and emphysema 2/28 (7%).

Chest X-rays 27/28 (96%) and CT imaging 23/28(82%) were performed in most of the cases. An echocardiogram was performed in 46% of cases. Chest tube placement was necessary in 18/28 (64.3%) cases, while the remaining 10 cases were managed conservatively without invasive intervention (35.7%).

Conclusion: Contra lateral Pneumothorax is a rare but significant complication of cardiac implantable electronic device (CIED) placement. Key risk factors include the access site, lead placement location, pacemaker type, and steroid use. Management should be individualized based on symptom severity, ranging from conservative approach to invasive interventions such as chest tube placement. Special cautions are advised during active fixation lead screwing and when placing leads in the trial appendage, as these techniques were associated with an increased incidence of pneumothorax in our study.

Introduction

Iatrogenic pneumothorax (PTX) is a significant complication that can occur during CIED procedures. Recent studies report that the incidence of PTX following CIED implantation ranges from 0.6% to 1.3% [1-4]. CPTX, however, is an extremely rare complication during pacemaker implantation, and very few cases have been reported in literature. The development of contra-lateral pneumothorax is uncommon and may be undetected on an initial chest radiograph [5-8]. It typically occurs acutely within 24 to 72 hours after implantation, referred to as acute CPTX (Acute CPTX)

[9,10]. Two potential mechanisms have been suggested for CPTX. The first involves the helix of an active fixation lead puncturing through the right atrial free wall, potentially damaging the nearby pericardium and right pleura [11].The second mechanism pertains to right pleural injury during the insertion of the Seldinger set, particularly when the guide wire or sheath dilator causes trauma to the extra pericardial segment of the superior vena cava [5,6].

Sub-acute CPTX (>72hours) due to atrial lead perforation can also occur. It can be overlooked because it occurs outside the immediate post-operative period (1,6,12–16) Most patients need to undergo atrial lead repositioning [15,16]. The risk factors for contra-lateral pneumothorax (CPTX) included Over screwing of the lead, active fixation lead positioning, location on the right free wall, corticosteroid therapy, lead repositioning, among others [7-10,17]. However, the underlying mechanism for subacute CPTX despite stable a trial lead positioning remains unclear [13]. Non-procedural factors, such as prolonged corticosteroid use and the presence of a thin-walled atrial appendage, have been suggested as potential contributors [18,19]. To consolidate published literature on the topic, we performed a systematic review that aims to summarize available case reports to provide a detailed overview of contralateral CPTXs post-pacemaker placement.

Methods

Search Strategy

A systematic literature search was conducted across PubMed, Cochrane Library, science direct, and Google Scholar using specific keywords including "contra lateral," "pneumothorax," and "pacemaker". From inception till July 2024 the search was restricted to articles published in English. A complete and comprehensive search strategy is provided in the supplementary file.

Inclusion and Exclusion Criteria

The inclusion criteria for this review were case reports or series showing contralateral pneumothorax post-pacemaker placement with comprehensive patient demographics, clinical presentation, risk factors, management strategies, and outcomes. Reviews, editorials, and articles lacking primary patient data or sufficient clinical details for thorough analysis were excluded from the review.

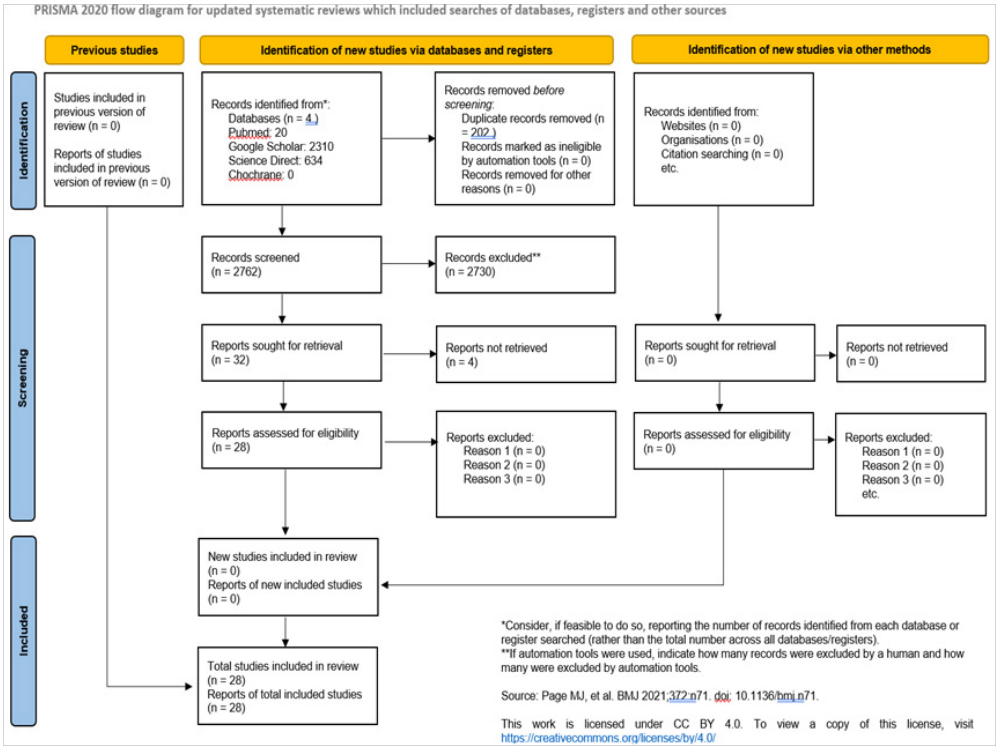

Figure 1: PRISMA Flowchart Outlining the Systematic Review Process, Including the Identification, Screening, Eligibility, and Inclusion Stages for the Studies Analyzed

Study Selection and Data Extraction

Search and Screening Process

The articles were searched and screened according to the PRISMA flowchart (20) (Figure 1). Records identified through the initial search were downloaded into Mendeley, and duplicates were removed. Two independent reviewers, HT and MAQ, conducted the screening process. The initial search yielded 2,964 articles. Following a thorough review of titles and abstracts, 38 articles were shortlisted for full-text evaluation. Of these, 28 articles met the inclusion criteria and were included in the final systematic review. Microsoft Excel was used for data extraction as well as the calculation of these variables. The references were added through Zotero.

Quality Assessment

The quality of the studies included was assessed using the Joanna Briggs Institute Critical Appraisal Tool [21]. Three

reviewers (HT, HA, and MAQ) independently scored each article and then reached a consensus score for each study. A detailed score report is provided in the Supplementary files.

Results

Patient Demographics

The patients had a mean age of 70.5 years (SD 17.1). Males were more commonly reported (71%, 20/28) compared to females (29%, 8/28).

Serial No	Study/ Author	Year/ Country	Gender/ Age	Pacemaker Indication	Pacemaker type	Access Point	Time from implantation to presentation	Imaging Performed	Chest tube insertion	Lead repositioning
1	Ishizue (6)	2017	M/67	2:1 Mobitz type II AV Block	Dual chamber pacemaker	Left subclavian vein	4 days	Chest-Xray and CT scan	No	No
2	Dilling boer (22)	2003	M/51	Dilated cardiomyopathy, ventricular tachycardia	Dual chamber ICD	Left subclavian vein	3 Days	Chest-Xray and CT scan	Yes	Yes
3	Srivathsan (17)	2003	F/77	Symptomatic Bradycardia	Dual chamber pacemaker	Left subclavian vein	8 hours	Chest Xray and CT scan	Yes	Yes
4	Ho WJ (23)	1999	F/79	Complete heart block	Dual chamber pacemaker	Left subclavian vein	4 hours	Chest Xray	Yes	Yes
5	Oginasawa (7)	2002	M/26	dyspnea on effort and a syncopal episode (indication?)	Implantable Cardioverter Defibrillator	Left subclavian vein	2 hours	Chest Xray	No	No
6	Shao-Wei Lo (24)	2022	M/76	sick sinus syndrome	Dual chamber pacemaker	Left subclavian vein	5 hours	Chest X-Ray and CT scan	Yes	No
7	Hegwood case 1 (11)	2023	M/81	Symptomatic Bradycardia	Dual chamber pacemaker	Left subclavian vein	1 day	Chest X-ray and CT scan	Yes	Yes
8	Hegwood case 2 (11)	2023	F/83	symptomatic irreversible bradycardia	Dual chamber pacemaker	Left subclavian vein	1 day	Chest X-Ray and CT scan	No	Yes
9	Parashar (25)	2019	M/62	recurrent episodes of presyncope	Dual chamber pacemaker	Left axillary vein	7 hours	Chest X-Ray and CT scan	Yes	No
10	Nantsupawat (26)	2018	M/83	tacy brady syndrome	Dual chamber pacemaker	Left axillary vein	1 day	Chest X-Ray and CT scan	Yes	No
11	Munguti (27)	2017	M/85	Type 2 Mobitz	Dual chamber pacemaker	N/A	1 day	CT Chest	Yes	Yes
12	Hardzina (18)	2015	M/73	Paraoxysmal 2nd deg AV block	Dual chamber pacemaker	Left cephalic vein and left subclavian v	1 day	Chest X-Ray	Yes	Yes
13	Dong chen case 1 (28)	2018	F/89	Sick sinus syndrome	Dual chamber pacemaker	Left subclavian vein	5 days after PPM	Chest X-ray and CT scan	Yes	No
14	Dong chen case 2 (28)	2018	F/93	Sick sinus syndrome	Dual chamber pacemaker	Left subclavian vein	7 days	Chest X-ray and CT scan	Yes	No
15	Yada (19)	2008	M/83	Sick sinus syndrome	Dual chamber pacemaker	Axillary vein	1 day	Chest X-ray and CT scan	No	No

16	Pettemerides (8)	2011	M/63		Dual chamber pacemaker	subclavian vein	1 day	Chest X-ray and CT scan	No	Yes
17	Irwin (29)	1987	F/80	weakness and documented bradycardia	Dual chamber pacemaker	N/A	7 months	Chest X-ray and CT scan	No	Yes
18	Rehman (30)	2022	F/79	complete third-degree heart block	Dual chamber pacemaker	Axillary vein	1 day	Chest X-Ray And CT scan	Yes	No
19	Diva (31)	2024	M/68	symptomatic long pauses	Dual chamber pacemaker	Left subclavian vein	2 days	Chest X-ray	Yes	No
20	Baird		M/75	Symptomatic bradycardia and AV block	Dual chamber pacemaker	N/A	6 months	Chest X-Ray And CT scan	No	No
21	Sebastian		M/73	Symptomatic Mobitz type 2 AV block	Dual chamber pacemaker	Left subclavian vein	2 days	Chest X-Ray And CT scan	Yes	No
22	Saradha		M/88	Mobitz type 2 AV block	Dual chamber pacemaker	N/A	12th day	Chest X-Ray And CT scan	No	Yes
23	Syakumar (32)	2011	M/78	Dilated cardiomyopathy and congestive cardiac failure	ICD	Left subclavian	2 hours	Chest X-Ray And CT scan	Yes	Yes
24	A Kocharian		M/69	bifascicular block, intermittent chronotropic incompetence.	Dual chamber pacemaker	Left subclavian	12 hours	Chest X-Ray And CT scan	Yes	Yes
25	Morales-Estrella J (15)	2019	F/27	severe ischemic cardiomyopathy	dual-chamber implantable cardioverter-defibrillator (ICD)	N/A	6 th day	Chest X-ray and CT scan	No	right atrial lead was repositioned
26	TAREK M. MOUSA (33)	2012	M/70	?? Not described	dual-chamber ICD	Left subclavian vein	3 days	Chest X-Ray and CT scan	No	repositioning of the right atrial lead during recurrent pneumothorax
27	Rosman (33)	2007	M/64	sarcoidosis and bifasicular block	left sided ICD implantation	N/A	2 days	Chest X-Ray and CT scan	Yes	Yes
28	Tran (16)	2001	M/33	hypertrophic cardiomyopathy	implantable cardioverter defibrillator (ICD)	Left subclavian vein	4th day	Chest-Xray	Yes	Yes

Table 1: Baseline Characteristics

Clinical Presentation

Table 2 below summarizes the timing of symptom onset, and the distribution of cases categorized as acute or sub-acute. Notably, the majority of cases occurred acutely, with most symptoms presenting within the first 24 hours. Similarly, Table 3 Highlights the most common presenting symptoms associated with pneumothorax in these patients.

Time from Pacemaker Insertion to Symptom Onset		Number of Cases	Total Cases
Acute <72 hours	<24hours	13	19
	24-72 hours	6	

Subacute >72 hours	72 hours -1wk	5	9
	<2wk	1	
	<4wk	1	
	>6 months	2	

Table 2: Timing of Symptom Onset Following Pacemaker Insertion

Symptom	Percentage
Chest Pain	52%
Shortness of Breath	30%
Upper Abdominal Pain	9%
New Oxygen requirement	9%
Severe Headache	4%
Neck and Jaw pain radiating to anterior chest	4%

Table 3: Common Presenting Symptoms in Patients with Pneumothorax Following Pacemaker Insertion

Risk Factors

27Serial No28.	Study	Procedural Risk Factors			Non-Procedural Risk Factors		
		Active Fixation Screw-in Lead	Lead Insertion Location	Over screwing of the lead	Steroid Use	Emphysema/ Smoking History	Presence of thin walled or multilobed atrial appendage
1	Ishizue	Y	RA anterolateral wall	Y	Y	N	N
2	Dilling boer	Y	RA appendage	Y	N	N	N
3	Srivathsan	Y	RA appendage	N	N	N	Y
4	Ho WJ	Y	N/A	Y	N	N	N
5	Oginasawa	Y	Lateral RA free wall	N	N	N	Y
6	Shao-Wei Lo	Y	RA appendage	N	Y	Y	N
7	Hegwood case 1	N/A	RA appendage	N	N	N	N
8	Hegwood case 2	N/A	RV apex and RA appendage	N	N	N	N
9	Parashar	Y	N/A	N	N	N	N
10	Nantsupawat	Y	Anterolateral RA free wall	N	N	N	N
11	Munguti	N/A	N/A	N	N	N	N
12	Hardzina	Y	RA appendage	N	N	N	N
13	Dong chen case 1	Y	anterior wall of the RA	N	N	N	N
14	Dong chen case 2	Y	RA appendage	N	Y	N	N
15	Yada	Y	N/A	N	N	N	N
16	Pettemerides	Y	RA appendage	N	N	N	N
17	Irwin	N/A	N/A	N	Y	N	N
18	Rehman	N/A	N/A	N	N	N	N
19	Diva	N/A	RA Apex	N	N	N	N
20	Baird	N/A	N/A	N	N	N	Y
21	Sebastian	N/A	N/A	N	N	N	N
22	Saradha	N/A	N/A	N	Y	N	N
23	Syakumar	Y	lateral right atrial free wall	N	N	Y	N
24	A Kocharian	Y	N/A	N	N	N	Y
25	Morales-Estrella J	N/A	N/A	N	N	N	N
26	TAREK M. MOUSA	Y	N/A	N	N	N	N
27	Rosman	Y	right atrial (RA) appendage.	N	Y	N	N
28	Tran	Y	N/A	N	N	N	N

Table 4: Risk Factors for Contra-lateral Pneumothorax

Radiological Findings

Diagnosis of CPTX primarily relied on radiological imaging. X-rays were conducted for all 28 cases. Of these, chest X-rays (CXR) clearly identified right-sided pneumothorax in 23 cases. In the remaining 5 cases, 3 did not reveal any pneumothorax, 1 case showed bilateral pleural effusions, and 1 case exhibited a right-sided pleural effusion. Additionally, displacement of the atrial lead was noted in 3 cases, and one case also displayed a left hemi-diaphragm. Computed tomography (CT) scans were done in 23 cases which further confirmed right pneumothorax in 13 cases, extrusion or displacement of the lead causing perforation in 15 cases, pneumopericardium with or without pneumomediastinum in 9 cases, pleural effusion in 1 case (4%), bilateral emphysema in 2 cases, and displacement of the lead without perforation in 2 cases. Echocardiography was done in 13 cases. Findings revealed pericardial effusion in 4 cases, pneumopericardium in 2 cases, and no evidence of pericardial effusion in the remaining 7 cases.

Management Strategies

Management of CPTX varied based on the severity of symptoms and the extent of the pneumothorax. Chest tube insertion was performed in 18 cases (64%), while 10 cases (36%) were managed without chest tube insertion. Repositioning of the leads was necessary in 16 cases (57%), whereas in 12 cases (43%), lead repositioning was not performed. These interventions generally led to clinical improvement and resolution of symptoms.

Discussion

CPTX is an exceptionally rare complication following pacemaker implantation, with only isolated case reports documented in the literature. While pneumothorax on the same side as the implant (ipsilateral pneumothorax) is a well-recognized complication of CIED) procedures, occurring in approximately 1% of cases, (18) CPTX remains far less understood. This systematic review provides the most comprehensive analysis to date, summarizing 28 reported cases of CPTX. By examining procedural and non-procedural factors, this review highlights potential risk factors, varied clinical presentations, and strategies for effective management and prevention of this uncommon but clinically significant condition.

Gender

Risk factors for ipsilateral pneumothorax after CIED placement can be categorized into procedural and non-procedural factors. Procedural factors include the use of the subclavian vein approach [1,2]. Active fixation lead placement, and the level of operator experience [1,4]. Non-procedural factors in a few large studies, included advanced age with median age of 77 years, female sex, and the presence of chronic obstructive pulmonary disease (COPD) [1,4]. In our study of contralateral pneumothorax, the risk factors were largely similar; however, contralateral pneumothorax was more commonly observed in the male population (71%). In addition to this, the mean age of patients was 70.5 years.

Choice of Device and Access Site

Dual-chamber devices are more commonly associated with pneumothorax following cardiac implantable electronic device (CIED) placement [1,4]. In our study, 24 out of 28 cases (86%) of contralateral pneumothorax (CPTX) were caused by dual-chamber pacemakers. To our knowledge, this is the first study to specifically report this association in the context of contralateral pneumothorax. Subclavian vein as the access site is strongly associated with the risk of pneumothorax irrespective of laterality (34,35). Another method to access the venous system is through the axillary vein, which has a low risk of pneumothorax. A large nonrandomized study of 1,264 patients found a 0% incidence of PTX when puncturing over the first rib vs 2.4% when the conventional proximal subclavian access was used (P = .0006) [2]. In our study, in 18/28 cases (64.2%), the access site was subclavian vein describing it as one of the biggest risk factors for CPTX.

Procedural and Non-Procedural Risk Factors

In our analysis, procedural factors are not very different from those described for ipsilateral pneumothorax after CIED placement. Active fixation of a helical screw-in lead was noted in 17 out of 28 cases (60%), highlighting its predominance as the fixation technique. Atrial appendage lead placement accounted for 9 out of 28 cases (32%) and lateral atrial wall placement identified in 4 out of 28 cases (14%). Location of lead positioning is very important, as proximity to vulnerable structures might predispose patients to adverse outcomes. Among the non-procedural factors, steroid use was observed in 7 out of 28 cases (25%), aligning with existing literature on the adverse effects of corticosteroids on tissue integrity and healing, which may predispose patients to complications [6,11,13]. The anatomical characteristics of the atrial appendage, particularly a thin-walled or multilobed structure, were documented in 4 out of 28 cases (14%), indicating a possible intrinsic susceptibility due to structural fragility. Additionally, long-standing smoking history and emphysema, reported in 2 out of 28 cases (7%), are well-established risk factors for pulmonary complications and may have contributed to the observed outcomes.

The incidence of pneumothorax requiring a chest tube was 0.66% in one study. In our study, chest tube was required in 18/28 cases (64.3%) cases, while the remaining 10 cases were managed conservatively without invasive intervention (35.7%). Key strategies for minimizing the risk of contralateral pneumothorax following pacemaker placement include optimizing the location of atrial lead placement to avoid excessive mechanical stress on the atrial wall, limiting the number of lead insertion attempts to reduce procedural trauma, ensuring precise and careful active lead fixation to minimize tissue injury, and maintaining meticulous procedural technique, especially in patients identified as high risk due to anatomical or clinical factors.

Conservative treatment, including observation and supplemental oxygen, is typically justified in cases of small, asymptomatic pneumothorax or when the patient demonstrates hemodynamic stability and adequate oxygenation. In contrast, chest tube placement is warranted for larger pneumothoraces, symptomatic cases with respiratory distress, or when there is a progression of the pneumothorax despite conservative measures. Early identification of high-risk patients and timely intervention can prevent complications and improve outcomes.

Study Limitations

This systematic review of case reports is subject to several potential biases and limitations. Reporting bias may arise from inconsistent documentation of outcomes, treatments, and patient characteristics, with important details like follow-up times, often missing. Variability in diagnostic methods and short follow-up durations can further affect consistency. Uncontrolled confounders, such as comorbidities complicate result interpretation. Publication bias may skew findings toward positive outcomes, as negative results are less likely to be published. Additionally, heterogeneity in patient population and observer bias due to subjective author interpretations can limit the generalizability of the findings.

Conclusion

Contralateral pneumothorax (CPTX) is a very rare but significant complication following cardiac implantable electronic device (CIED) placement. Early recognition is crucial, as presentations can range from asymptomatic to severe. Management should be tailored to the patient's clinical symptoms and the extent of pneumothorax, with conservative observation being appropriate for mild cases and invasive interventions, such as chest tube placement and lead repositioning, reserved for symptomatic or complicated cases.

References

1. Kirkfeldt, R. E., Johansen, J. B., Nohr, E. A., Moller, M., Arnsbo, P., & Nielsen, J. C. (2012). Pneumothorax in cardiac pacing: a population-based cohort study of 28 860 Danish patients. *Europace, 14*(8), 1132-1138.
2. Kotter, J., Lolay, G., Charnigo, R., Leung, S., Mckibbin, C., Sousa, M., ... & Elayi, C. S. (2016). Predictors, morbidity, and costs associated with pneumothorax during electronic cardiac device implantation. *Pacing and Clinical Electrophysiology, 39*(9), 985-991.
3. Liu, P., Zhou, Y. F., Yang, P., Gao, Y. S., Zhao, G. R., Ren, S. Y., & Li, X. L. (2016). Optimized axillary vein technique versus subclavian vein technique in cardiovascular implantable electronic device implantation: a randomized controlled study. *Chinese medical journal, 129*(22), 2647-2651.
4. Ogunbayo, G. O., Charnigo, R., Darrat, Y., Morales, G., Kotter, J., Olorunfemi, O., ... & Elayi, C. S. (2017). Incidence, predictors, and outcomes associated with pneumothorax during cardiac electronic device implantation: a 16-year review in over 3.7 million patients. *Heart Rhythm, 14*(12), 1764-1770.
5. Ho, W. J., Kuo, C. T., & Lin, K. H. (1999). Right pneumothorax resulting from an endocardial screw-in atrial lead. *Chest, 116*(4), 1133-1134.
6. Ishizue, N., Kishihara, J., Niwano, S., & Ako, J. (2017). Subacute pneumothorax contralateral to the venous access site associated with atrial lead perforation in a patient who was receiving corticosteroid therapy. *Journal of Arrhythmia, 33*(4), 335-337.
7. Oginosawa, Y., Abe, H., & Nakashima, Y. (2002). Right pneumothorax resulting from an endocardial screw-in atrial lead in an implantable cardioverter defibrillator system. Pacing and clinical electrophysiology, 25(8), 1278-1279.
8. Pettemerides, V., & Jenkins, N. (2012). Contralateral pneumothorax following repositioning of an atrial lead. *Europace, 14*(4), 606-606.
9. Schorlemmer, G. R., Khouri, R. K., Murray, G. F., & Johnson Jr, G. (1984). Bilateral Pneumothoraces Secondary to latrogenlc Buffalo Chest: An Unusual Complication of Median Sternotomy and Subclavian Vein Catheterization. *Annals of surgery, 199*(3), 49A.
10. DIVAKARA MENON, S. M., Ayati, M., & Healey, J. S. (2017). Harder Roads to Trek? Paradoxical Slowing of an Atrioventricular Reentrant Tachycardia With Contralateral Bundle Branch Block. *Journal of Cardiovascular Electrophysiology, 28*(4), 455-457.
11. Hegwood, E., Burkman, G., & Maheshwari, A. (2023). Risk for contralateral pneumothorax, pneumopericardium, and pneumomediastinum in the elderly patient receiving a dual-chamber pacemaker—a case report of 2 patients with acute and chronic atrial lead perforation. *HeartRhythm Case Reports, 9*(9), 680-684.
12. Van Herendael, H., & Willems, R. (2009). Contralateral pneumothorax after endocardial dual-chamber pacemaker implantation resulting from atrial lead perforation. *Acta cardiologica, 64*(2), 271-273.
13. Chen, X. D., Xu, X., Ji, J. W., Liu, H. L., & Shen, J. P. (2018). Contralateral pneumothorax in the subacute phase after pacemaker implantation: lead retention and follow-up. *Journal of Geriatric Cardiology: JGC, 15*(12), 744.
14. Irwin, J. M., Greer, G. S., Lowe, J. E., German, L. D., & Gilbert, M. R. (1987). Atrial lead perforation: a case report. *Pacing and Clinical Electrophysiology, 10*(6), 1378-1381.
15. Toader, D. M. (2024). Echocardiographic Evaluation of Patients with Implanted Devices. Springer.
16. Tran, N. T., Zivin, A., Mozaffarian, D., & Karmy-Jones, R. (2001). Right atrial perforation secondary to implantable cardioverter defibrillator insertion. *Canadian Respiratory Journal, 8*(4), 283-285.
17. Srivathsan, K., Byrne, R. A., Appleton, C. P., & Scott, L. R. (2003). Pneumopericardium and pneumothorax contralateral to venous access site after permanent pacemaker implantation. *EP Europace, 5*(4), 361-363.
18. Hardzina, M., Ząbek, A., Boczar, K., Matusik, P., Małecka, B., & Lelakowski, J. (2015). Contralateral pneumothorax after cardiac pacemaker implantation. *Advances in Interventional Cardiology/Postępy w Kardiologii*

Interwencyjnej, 11(4), 347-348.
19. Yada H, Sato T, Soejima K, Jo Y, Jinzaki M, Togashi I, et al. Images in cardiovascular medicine. Pseudonormal position of an atrial pacemaker lead associated with a contralateral pneumothorax: where is the atrial lead? Circulation. *2008 Apr 29;117*(17):2297–8.
20. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *bmj,* 372.
21. Jordan, Z., Lockwood, C., Munn, Z., & Aromataris, E. (2019). The updated Joanna Briggs Institute model of evidence-based healthcare. *JBI Evidence Implementation, 17*(1), 58-71.
22. Dilling-Boer, D., Ector, H., Willems, R., & Heidbüchel, H. (2003). Pericardial effusion and right-sided pneumothorax resulting from an atrial active-fixation lead. *EP Europace, 5*(4), 419-423.
23. Ho, W. J., Kuo, C. T., & Lin, K. H. (1999). Right pneumothorax resulting from an endocardial screw-in atrial lead. *Chest, 116*(4), 1133-1134.
24. Lo, S. W., & Chen, J. Y. (2022). Case report: A rare complication after the implantation of a cardiac implantable electronic device: Contralateral pneumothorax with pneumopericardium and pneumomediastinum. *Frontiers in Cardiovascular Medicine, 9,* 938735.
25. Parashar, N. K., Deepti, S., Yadav, R., Sinha, M., & Ramakumar, V. (2019). An unexpected complication of intracardiac device implantation: contralateral pneumothorax and pneumopericardium. *Indian Pacing and Electrophysiology Journal, 19*(4), 167-170.
26. Nantsupawat, T., Li, J. M., Benditt, D. G., & Adabag, S. (2018). Contralateral pneumothorax and pneumopericardium after dual-chamber pacemaker implantation: mechanism, diagnosis, and treatment. *HeartRhythm case reports, 4*(6), 256-259.
27. Munguti, C. M., Eliveha, J. M., & Eid, F. A. (2017). Contralateral Pneumothorax after the Implantation of a Dual Chamber Pacemaker. *Kansas Journal of Medicine, 10*(3), 74.
28. Chen, X. D., Xu, X., Ji, J. W., Liu, H. L., & Shen, J. P. (2018). Contralateral pneumothorax in the subacute phase after pacemaker implantation: lead retention and follow-up. *Journal of Geriatric Cardiology: JGC, 15*(12), 744.
29. Irwin, J. M., Greer, G. S., Lowe, J. E., German, L. D., & Gilbert, M. R. (1987). Atrial lead perforation: a case report. *Pacing and Clinical Electrophysiology, 10*(6), 1378-1381.
30. Rehman, W. U., Muneeb, A., Sakhawat, U., Ganesh, P., Braiteh, N., Skovira, V., ... & Rehman, A. U. (2022). A case of contralateral pneumothorax, pneumomediastinum, and pneumopericardium after dual-chamber pacemaker implantation. *Case Reports in Cardiology, 2022*(1), 4295247.
31. Maraj, D., Ahmed, O., Qureshi, M., & Othman, H. (2024). Traumatic Right Atrium Perforation Causing a Pneumothorax and Pneumopericardium, Treated Conservatively. *Cureus, 16*(2).
32. Menon, S. M. D., Sumner, G. L., Ribas, C. S., Healey, J. S., Nair, G. M., Connolly, S. J., & Morillo, C. A. (2011). Contralateral pneumothorax in left sided CRT device implantation. *Indian Pacing and Electrophysiology Journal, 11*(1), 16.
33. Rosman, J., Shapiro, M. D., & Hanon, S. (2006). Pneumomediastinum and right sided pneumothorax following dual chamber-ICD implantation. *Journal of Interventional Cardiac Electrophysiology, 17,* 157-158.
34. Eberhardt, F., Bode, F., Bonnemeier, H., Boguschewski, F., Schlei, M., Peters, W., & Wiegand, U. K. H. (2005). Long term complications in single and dual chamber pacing are influenced by surgical experience and patient morbidity. *Heart, 91*(4), 500-506.
35. Link, M. S., Estes, N. M., Griffin, J. J., Wang, P. J., Maloney, J. D., Kirchhoffer, J. B., ... & Lamas, G. A. (1998). Complications of dual chamber pacemaker implantation in the elderly. *Journal of interventional cardiac electrophysiology, 2,* 175-179.