Cardiac Complications Post Parathyroidectomy: A Systematic Review

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Abstract

Parathyroidectomy (PTX) treats hyperparathyroidism, but it can lead to significant cardiac complications. This systematic review analyses the incidence, types, risk factors, pathophysiological mechanisms, and management strategies of cardiac complications following PTX. Following PRISMA guidelines, a systematic search of PubMed and Europe PMC up to May 2024 included 62 studies. Cardiac complications identified included early and delayed reversible cardiac failure, tachyarrhythmias (such as atrial fibrillation and ventricular tachyarrhythmia), chest pain, myocardial infarction mimic, hypotension, and other two rare complications. Rapid calcium level changes and thyrotoxicosis post-surgery were the significant contributors to the complications. Vigilant monitoring and management are essential for favourable outcomes post-PTX. Comprehensive preoperative evaluation, meticulous intraoperative monitoring, and tailored postoperative care are crucial. Further research is needed to refine management protocols and improve patient safety.

Keywords: Atrial fibrillation, cardiac failure, parathyroidectomy, tachyarrhythmia, ventricular tachycardia

Introduction

Parathyroidectomy (PTX) is primarily performed to treat primary and secondary hyperparathyroidism (HPT) and has been shown to reduce cardiac risk factors, including ECG abnormalities, 2D-echo abnormalities, arrhythmias, and NT-proBNP levels.[1-6] At 10 years, PTX is associated with an absolute risk reduction for major adverse cardiovascular events, cardiovascular (CV) disease-related hospitalisations, and CV hospitalisation-associated mortality compared to conservative management.[7] Despite these benefits, PTX is not without potential complications, including adverse effects on the CV system.

Cardiac complications, though rare, can occur in patients undergoing thyroidectomy. In a US-based cohort of 3,575 patients, approximately 0.2%–0.3% developed congestive heart failure (CHF) during follow-up.[8] A study by Kravietz *et al*.[9] found that while readmission rates were lower in primary HPT (PHPT) patients (5.6%) compared to secondary HPT (SHPT) patients (19.4%), heart failure was more prevalent in PHPT patients (10.8%) compared to SHPT patients (3.9%).

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Additionally, patients with existing CHF undergoing PTX have a higher likelihood of readmission.[10] Although cardiac complications are rare, they can occasionally be fatal.[11]

While there are reviews on PTX, they focus on different areas, and none provide a comprehensive analysis of cardiac complications specifically.[12,13] This systematic review aims to fill this gap, enhancing early detection and management of these complications by adhering to PRISMA guidelines.[14] Due to word count constraints, details on Materials and Methods and rare complications are provided in the Supplementary Materials [Figure 1].

Systematic review

Cardiac complications, although rare, are important to consider post-PTX, as they can occasionally be fatal. The relationship

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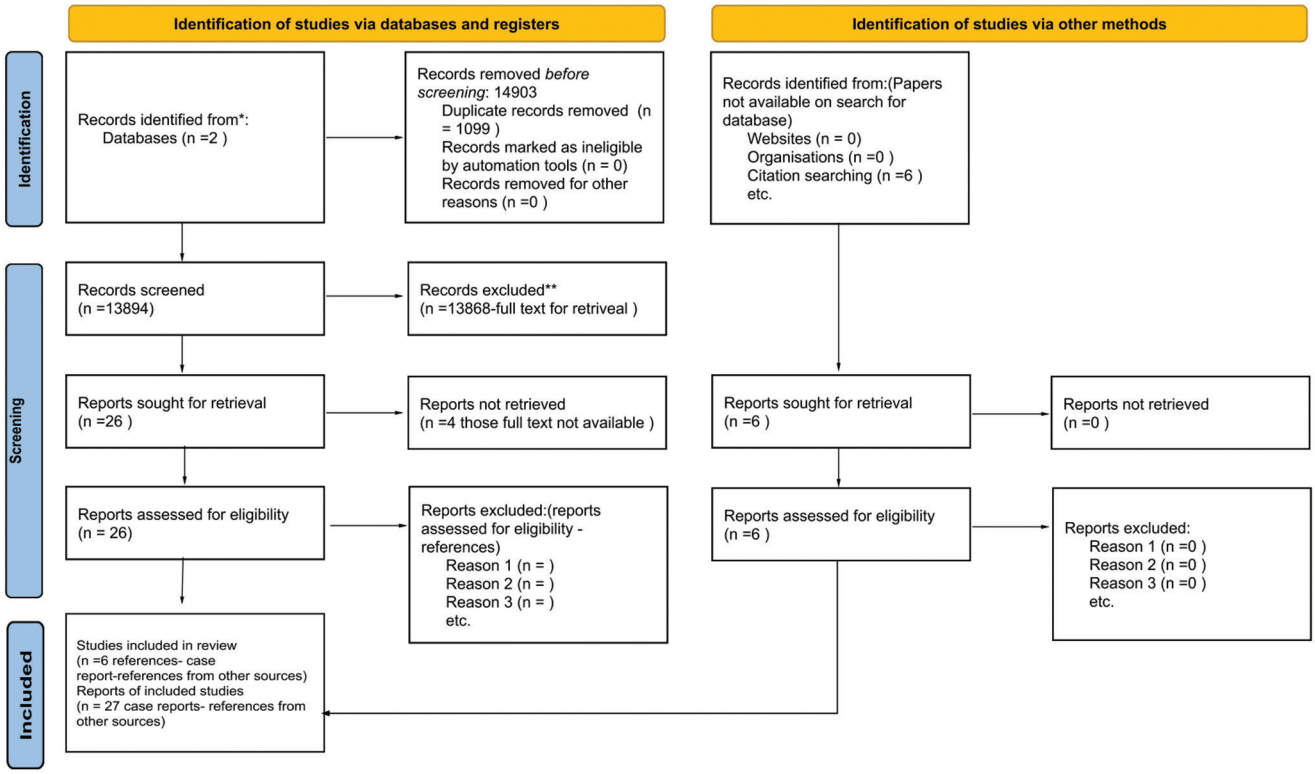

*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.

Figure 1: PRISMA flowchart depicting study selection process

between the parathyroid gland and the CV system is complex, with HPT being frequently associated with hypertension, endothelial dysfunction, and structural abnormalities in the heart. A few cases had an overlap of complications; they are included in more than one section. We will see each complication separately below.

Cardiac failure

The cardiac failure associated with PTX is different from that seen with total thyroidectomy (TX). It can be classified into two types: early reversible cardiac failure and delayed reversible cardiac failure.

Incidence and types of cardiac failure

The incidence of cardiac failure post-PTX is rare but clinically significant, with a total of eight reported cases identified in the literature. There are in total six cases of early reversible cardiac failure and two cases of delayed reversible cardiac failure cases reported in the literature[15-20] [Table 1].

Risk factors and pathophysiological mechanisms

As there are two types of cardiac failure, we have to look at the risk factors and pathophysiologies of both differently. We have made a comparison between the two types of cardiac failure [Table 2].

Risk Factors, Pathophysiological Mechanisms, and Management of Cardiac Failure Post-PTX

Reversible cardiac failure post-PTX can be classified into early and delayed types, with distinct risk factors and pathophysiological mechanisms. Early reversible cardiac failure has been reported in six cases, affecting four males and two females aged 13–60 years. Most cases (four) were linked to hypocalcaemia due to hungry bone syndrome (HBS) post-PTX, with varying aetiologies—three cases from PHPT (two after focused PTX and one after PTX with partial thyroidectomy) and two from secondary and tertiary HPT after total PTX. Additionally, Shinoda *et al*.[17] described a case where atrial fibrillation (AF) due to thyroiditis (thyrotoxicosis) led to cardiac failure following PTX. Symptoms appeared between 8 hours to 3 weeks post-surgery, with recovery spanning 4 days–4 months.

In contrast, delayed reversible cardiac failure, documented in two cases, occurred in a 61-year-old male and a 27-year-old female, both with SHPT who underwent three-and-a-half PTX with autotransplantation (ATP).[21,22] Symptoms developed 5–8 months post-surgery, primarily due to prolonged hypocalcaemia from permanent hypoparathyroidism. Unlike early cardiac failure, which results from rapid calcium depletion and myocardial dysfunction, delayed cardiomyopathy is a gradual process. Chronic hypocalcaemia impairs myocardial contractility and electrical stability, leading to progressive heart failure.[12]

Management strategies

For early cardiac failure, preoperative calcium optimisation, intraoperative monitoring of parathyroid hormone (PTH) and

Table 1: Details of cases of early reversible cardiomyopathy and delayed reversible cardiomyopathy

Author	Journal	Year	Age (years)	Gender	Preop calcium (mg/dL)	Postop nadir of calcium (mg/dL)	Hypocalcaemia				Recovered
							Aetiology	Size of the parathyroid gland	Reason surgery	Onset after PTX	
Early reversible cardiomyopathy											
Falko *et al*. 1976[15]	Am J Med Sci	1976	19	Male	16.8	6.2	Right inferior parathyroid adenoma (focused parathyroidectomy)	2 g, 1.5 cm × 3.0 cm × 1.5 cm	Primary hyperparathyroidism	10 days	1 month
Varthakavi *et al*. 1985[16]	Indian Heart J	1985	44	Female			PTX*			3 days	
Shinoda *et al*. 1992[17]	Nephron	1992	60	Male	10.1	7.8	Total parathyroidectomy with autotransplantation	4.7 g	Secondary hyperparathyroidism	1 day	4 months
Fisher *et al*. 2001[18]	Eur J Heart Fail	2001	38	Male	8.4	6.8	2 attempts of parathyroidectomy while ist unsuccessful	Not mentioned	Tertiary hyperparathyroidism	3 weeks	3 months
Maturi *et al*. 2015[19]	World J EndocSurg	2015	40	Male	12.7	6	Partial TX† and PTX	–	Primary hyperparathyroidism	8 hours	4 days
Pande *et al*. 2023[20]	IJem case reports	2023	13	Female	15	6.4	Focussed parathyroidectomy	25 g	Primary hyperparathyroidism	12 days	3 months
Delayed reversible cardiomyopathy											
Lekas *et al*. 2010[21]	AdvPeritDial	2010	27	Female		9.618	3 and 1/2 parathyroidectomy with autotransplantation		Secondary hyperparathyroidism	8 months	LongQT
Zhang *et al*. 2020[22]	J Int Med Res	2020	62	Male	9.09	6.69	Parathyroidectomy and partial parathyroid intramuscular transplantation		Secondary hyperparathyroidism	5 months	1 week

*Parathyroidectomy. †Total thyroidectomy

Table 2: Difference between early reversible and delayed reversible cardiomyopathy

	Early Reversible		Delayed Reversible
Onset	Develops within days to a few weeks after surgery		May develop in months to decades after surgery
Pathophysiological Mechanism	Hungry bone syndrome post-parathyroidectomy	Thyrotoxicosis leading to atrial fibrillation	Hypoparathyroidism secondary to surgery
Surgery	After focused parathyroidectomy and partial thyroidectomy	Parathyroidectomy	After total thyroidectomy and 3.5 parathyroidectomy
Management	Active vitamin D and calcium	Symptomatic treatment	Active vitamin D and Calcium
Duration of treatment	Resolves in days to months with calcium and vitamin D supplementation		Requires lifelong calcium and active vitamin D therapy

calcium, and postoperative aggressive calcium and vitamin D supplementation are essential. The treatment duration is short (weeks to a few months), aligning with the transient nature of the condition.[20]

For delayed cardiac failure, lifelong calcium and active vitamin D supplementation is crucial to prevent chronic myocardial dysfunction. Regular cardiac monitoring helps detect early dysfunction, and cases with resistant hypocalcaemia warrant further evaluation for hypoparathyroidism and appropriate treatment adjustments.[21,22]

This comparative approach highlights the distinct timelines, causes, and management strategies for early and delayed reversible cardiac failure, underscoring the need for proactive calcium monitoring in all patients undergoing PTX.

Tachyarrhythmias post-PTX

Tachyarrhythmias are uncommon but potentially fatal postoperative complications following PTX. These tachyarrhythmias can be ventricular or supra-ventricular in origin. Most frequently reported tachyarrhythmias are AF and ventricular tachycardia. It is important to understand that the aetiology of these arrhythmias differs.

Incidence and types of tachyarrhythmias

We found 16 cases of tachyarrhythmias associated with cardiac complications post-PTX. This includes nine cases of AF, five cases of ventricular tachyarrhythmia (VT), one case of atrial flutter (AFI), and one case of supraventricular tachycardia (SVT) [Table 3a and b]. The occurrence of these arrhythmias highlights the complexity and potential severity of cardiac issues associated with metabolic disturbances following surgery.

Interestingly, the following two cases were associated with thyrotoxicosis due to postop thyroiditis. We believe the solitary cases of AFI and SVT resulted from the biochemical changes post-PTX and the unmasking of aberrant re-entrant pathways, which are present in approximately 10% of normal individuals.[36]

Risk factors and pathophysiological mechanisms

AF has been observed in five males and four females, ranging from 38 to 75 years of age. The onset of AF typically occurs from immediate postop to 10 days post-surgery. There was one death reported in a patient who had refractory hypotension in addition to AF, and his condition did not respond even to correction of hypocalcaemia.

AF occurred in individuals from age 38 to 75 years. These individuals underwent surgery for primary, secondary, and tertiary HPT in three, four, and two cases, respectively. The surgical interventions ranged from focused PTX to total PTX with ATP. AF onset was sudden in the postoperative period, attributed to thyrotoxicosis consequent to thyroiditis post-PTX.[23,24] Kwayess *et al*.[13] reported two cases of thyroiditis post-PTX and also reviewed data on 27 cases reported in the literature. Of these 29 cases, six had AF (one case had AFI and one SVT). Symptoms began between 1–10 days post-surgery and resolved between 2 weeks to 9 months. In one case reported by Radu, symptoms began 2 days post-surgery and were severe, leading to death on the same day.[11] Another case was SVT, with symptom onset on postoperative day 1 and death occurring 18 hours after symptom onset.[30]

VT cases were younger (ages 15–59 years) than those with AF. VT onset was noted within 1 day to 1 week post-procedure, with recovery generally occurring within weeks. No mortality was observed among these patients after the correction of hypocalcaemia. One patient had ventricular fibrillation successfully reverted with direct current (DC) cardioversion, and another had frequent ventricular premature beats in the form of ventricular trigeminy.

Identifying preoperative risk factors is crucial in mitigating tachyarrhythmias post-PTX. Risk factors for VT post-PTX were similar to those of HBS.[37] VT occurred in both males and females across a varied age range within days of surgery, with recovery happening within weeks. Surgical indications included primary PHPT and secondary SHPT in two cases each, and tertiary HPT in one case. Procedures performed included focused PTX and PTX with ATP in two cases each, and four-gland parathyroid exploration with excision of the right superior and left inferior glands in one case.

Rapid changes in serum calcium levels can induce myocardial instability, leading to VT, as observed in clinical cases.[32] VT was attributed to rapid hypocalcaemia as part of HBS, occurring within days post-surgery and resolving within days to weeks postoperatively. Patients with SHPT, particularly those on dialysis, are predisposed to electrolyte imbalances such as hypomagnesemia, which are known triggers for arrhythmias.[31,38]

Table 3: Details of cases of tachyarrhythmia

(a): Details of cases of atrial fibrillation and atrial flutter

Author	Type of Atrial Flutter/ Fibrillation	Journal	Year	Age (years)	Gender	Thyrotoxicosis				Management for arrhythmia	Recovery of thyroiditis	Important point
						Aetiology	Size of the parathyroid gland	Reason surgery	Onset			
Sato *et al.* 2008[23]	Atrial Fibrillation	Intern Med	2008	59	Female	Thyrotoxicosis post-PTX*	-	Secondary hyperparathyroidism	3 days		3 months	
Mordechay-Heyn *et al.* 2022[24]	Atrial Fibrillation	Isr Med Assoc J	2022	38	Male	Thyrotoxicosis post-PTX*	3.7 × 1.5 × 0.8 cm and weighing 2.6 g.	Primary hyperparathyroidism	2 days	Oral calcium, amiodarone	Few weeks	
				66	Female	Thyrotoxicosis post-PTX*	2.1 × 1.6 × 1.4 cm and weighing 2.4 g	Primary hyperparathyroidism	3 days	Propafenone	9 months	
(Radu *et al.* 2019)[11]	Atrial fibrillation	J Crit Care Med (Targu Mures)	2019	65	Male	Thyrotoxicosis post-PTX*	1.42 g.	Secondary hyperparathyroidism	2 days	Elemental calcium, IV calcium, intravenous injection calcium gluconate, Norepinephrine, Aguettant, epinephrine	Expired	Cardiac arrest
Naber *et al.* 2010[25]	Atrial Fibrillation	American Journal of Kidney Diseases	2010	51	Female	Thyrotoxicosis post PTX*	-	Tertiary hyperparathyroidism	2 days	calcium and vitamin D, adenosine	Not mentioned	
Parker *et al.* 2010[26]	Atrial Fibrillation	The American Journal of Medical Sciences	2010	59	Male	Thyrotoxicosis post PTX*	-	Primary Hyperparathyroidism with nephrolithiasis.	10 days	Valsartan, atenolol, testosterone, omeprazole, aspirin, intravenous furosemide	Not mentioned	congestive heart failure
Chan *et al.* 2017[27]	Atrial Fibrillation	Nephrology	2017	75	Female	Thyrotoxicosis post PTX*	-	Secondary hyperparathyroidism	5 days	Diltiazem and tazocin	2 Weeks	Congestive heart failure
Shinoda *et al.* 1992[17]	Atrial Fibrillation	Nephron	1992	60	Male	Thyrotoxicosis post PTX*	4.7 g	Secondary hyperparathyroidism	1 day	Ubidecarenone and disopyramide, Deferoxamine, calcium lactate, calcitriol, calcium gluconate	4 months	
Boeder *et al.* 2022[28]	Atrial fibrillation	J Endocr Soc.	2022	66	Male	Thyrotoxicosis post PTX*		Tertiary hyperparathyroidism	Immediate post-operation	Beta-blocker	13 days	
Asmar *et al.* 2011[29]	Atrial Flutter	NDT Plus	2011	62	Male	Lobectomy with PTX*		Secondary hyperparathyroidism	2 days		1 Month	
Hodarkar *et al.* 2017[30]	Supraventricular tachycardia	J Endocrinol Diab	2017	52	Female	PTX*			1 day		Expired	

Contd...

Table 3: Contd...

(b): Summary of basic characteristics of cases with hypocalcaemia following parathyroidectomy and thyroidectomy with ventricular tachyarrhythmias

Author	Type of arrhythmia	Journal	Year	Age (years)	Gender	Hypocalcaemia				Management for arrhythmia	Recovered
						Size of the parathyroid gland	Reason surgery	Type of surgery	Duration		
Gmehlin *et al.* 1995[31]	Ventricular Fibrillation	Nephron	1995	31	Male	-	Secondary hyperparathyroidism	PTX* with autotransplantation	1 week (maybe 8 weeks)	2 g of calcium gluconate, four defibrillations by an external defibrillator, 200 mg lidocaine, and 1.5 mg epinephrine, still poor response to this.	1 week
Bacon *et al.* 1996[32]	Ventricular Tachycardia	Nephron	1996	35	Female	-	Tertiary hyperparathyroidism	Total PTX*	4 days	Spontaneous resolution with supportive care.	10 weeks
Ajith *et al.* 2022[33]	Ventricular tachycardia	BMJ case report	2022	30	Male	-	Primary hyperparathyroidism	Four-gland parathyroid exploration and right superior and left inferior gland excision	4 days	Alfacalidol, carbimazole, bisoprolol and ramipril and intravenous calcium gluconate	10 days
Hamley *et al.* 2018[34]	Ventricular tachycardia	Consultant360	2018	15	Female	-	Primary hyperparathyroidism	Partial PTX*	3 days	IV magnesium sulfate, followed by IV calcium gluconate.	8 Days
Rosenkrans *et al.* 2017[35]	Ventricular trigeminy	A A Case Rep	2017	59	Male	-	Secondary hyperparathyroidism	PTX* with autotransplantation	1 day	Intravenous calcium chloride, insulin, dextrose, albuterol, intravenous calcium gluconate and magnesium.	2 days

*Parathyroidectomy

Management of tachyarrhythmia post-PTX

Effective management of tachyarrhythmias post-PTX focuses on addressing the underlying pathophysiological defects. For VT, prompt correction of hypocalcaemia is crucial. Intravenous calcium is typically administered initially during periods of instability, followed by oral calcium supplementation with or without active vitamin D for short durations. Additionally, serum magnesium levels should be monitored and corrected if hypomagnesemia is present, as it is a known trigger for ventricular arrhythmias.

In all reported cases of VT, the outcomes were favourable with no mortality. Alongside electrolyte correction, antiarrhythmic agents were used to manage VT. In one case, a patient received four defibrillations using an external defibrillator due to instability.

AF post-PTX, typically resulting from thyrotoxicosis due to thyroiditis, was managed with agents to control heart rate, including beta-blockers and calcium channel blockers. Prompt correction of hypocalcaemia, if present, is also necessary. Various antiarrhythmic agents were employed as needed. While correcting electrolyte imbalances is paramount, it is essential to avoid inappropriate treatments such as carbimazole in cases of thyrotoxicosis due to thyroiditis, where hyperthyroidism (overproduction of thyroid hormone) is not the underlying issue.[33] In a case reported by Radu *et al*.,[11] a focus on managing hypocalcaemia overshadowed the need for treatment targeting thyrotoxicosis and AF, potentially affecting the outcome.

In any case of arrhythmia (VT or AF) accompanied by hypotension or shock, urgent DC cardioversion is the treatment of choice.

Chest Pain, Myocardial Infarction, and Myocardial Infarction MIMIc Post PTX – Incidence and Significance

Chest pain following PTX is a notable concern, even though the occurrence of actual cardiac events is minimal. In a retrospective study, 4.7% of the patients reported experiencing chest pain in the immediate postoperative period. There are a total of four cases of MI mimic. MI mimic happened in two males and two females aged 30–84 years [Table 4a].[39] MI mimic is not specific to post-PTX and has also been reported following other major surgeries.[40]

Risk factors and pathophysiology for chest pain and MI mimic post-PTX

The phenomenon of myocardial infarction (MI) mimicry post-PTX was observed in four cases, with patients presenting with chest pain and ECG changes suggestive of ST-elevation myocardial infarction (STEMI). MI mimic was seen in four patients aged 30–84 years, comprising two males and females each. Symptoms occurred 3–7 days after surgery, with normal findings on 2D echocardiograms and coronary angiograms. One of the causes of ECG abnormalities was coronary vasospasm. In an 84-year-old woman who was readmitted with sudden-onset chest pain a week post-surgery,[42] initially diagnosed with MI, subsequent tests revealed thyrotoxicosis, and treatment with propranolol and prednisone resolved her symptoms.

Upon analysis, Guo *et al*.[39] found no significant differences between patients who experienced chest pain and those who did not in terms of age, gender, body mass index, CV risk factors, American Society of Anesthesiologists score[44] score, or length of surgery. This indicates that chest pain in the postoperative setting may not be strongly associated with conventional CV risk factors typically considered in preoperative evaluations. The pathophysiological mechanisms behind postoperative chest pain could be multifactorial, involving stress, anxiety, or pain from the surgical site rather than direct cardiac pathology. Additionally, rapid shifts in serum calcium levels post-surgery can induce myocardial instability, leading to chest pain and ECG changes that mimics MI.

In summary, the occurrence of chest pain and MI mimic post-PTX appears to be influenced by factors beyond traditional CV risk indicators.

Management strategies

To minimise the risk of unnecessary cardiac workups and associated healthcare costs, it is crucial to adopt a judicious approach in managing postoperative chest pain. Preoperative evaluations should include a thorough CV risk assessment, but extensive testing should be reserved for patients with a higher pretest probability of cardiac events.[39] Intraoperatively, maintaining stable haemodynamics and monitoring for any signs of cardiac stress can help mitigate risks. Postoperatively, clinicians should balance vigilance for genuine cardiac events with the avoidance of over-testing, considering non-cardiac causes of chest pain and using less invasive initial assessments such as electrocardiograms and troponin levels. One should be careful about interpreting ECG abnormalities in these patients, as ignoring electrolyte levels may lead to erroneous over-treatment with pharmacologic or invasive therapies for CAD.[39]

Hypotension post-PTX

Hypotension following PTX is relatively uncommon, with only a few cases reported in the literature despite the frequent association of HPT with elevated blood pressure. Documented cases indicate that while a significant reduction in blood pressure is often observed post-surgery, symptomatic hypotension is rare. Hypotension can present as either early-onset, occurring within the first few days post-surgery, or as delayed-onset, persisting for an extended period.[17,45,46]

Incidence

Post-PTX hypotension was observed in four cases, three of which were male and one female, aged 30–60 years. All were operated for SHPT. Symptoms started immediately postop and persisted for a longer duration. Preoperative systolic blood pressure ranged from 118 to 210 mmHg, and diastolic blood pressure from 74 to 120 mmHg. Postoperatively, systolic blood pressure dropped to 60–105 mmHg and diastolic to 40–70 mmHg [Table 4b] These patients had undergone extensive

Table 4: Details of cases of myocardial infarction (MI) or MI mimic and hypotension

(a): Details of cases of myocardial infarction (MI) or MI mimic

Author	Journal	Year	Type of myocardial infarction suspected	Age (years)	Gender	Aetiology	Onset	Recovered
Ajith *et al.* 2022[33]	BMJ case report	2022	Inferior–posterior ST-elevation myocardial infarction (STEMI) mimic	30	Male	Hypocalcaemia	4 days	10 days (2 D-echo and coronary angiogram was normal)
Kauffels *et al.* 2012[41]	Clin Res Cardiol	2012	ST- elevation Myocardial infarction mimic	55	Female	Thyrotoxicosis	3 days	10 days (2D-echo and coronary angiogram was normal)
Fisher *et al.* 2001[18]	Eur J Heart Fail	2001	anterolateral leads mimicking a non-Q wave myocardial infarction	38	Male	Hypocalcaemia	Not mentioned	3 weeks (a typical chest pain persisted but ECG,2 D Echo, multi-gated acquisition MUGA. scan and coronary angiography was normal)
Espiritu and Dean 2010[42]	Endocr Pract	2010	ST -elevation Myocardial infarction MI Mimic	84	Female	Thyrotoxicosis	1 week	2 months

(b): Details of cases of hypotension

Author	Journal	Year	Age (years)	Gender	Hypocalcaemia		Type of surgery	Onset after PTX†	Blood Pressure		Management for hypotension	Recovered
					Aetiology	Reason surgery			Preop	Postop		
Shinoda *et al.* 1992[17]	Nephron	1992	60	Male	Thyrotoxicosis post PTX†	Secondary hyperparathyroidism	Total parathyroidectomy with autotrans-plantation	1 day	118/74	60	-	4 months
Leiba *et al.* 2013[43]	Journal of Human Hypertension	2013	45	Male	Four hyperplastic parathyroid glands	Secondary hyperparathyroidism		Immediate postoperative	140/90	60/40		
			46	Female	Two surgeries	Secondary hyperparathyroidism			180/100–200/100	80/50–90/60		
			30	Male	Subtotal parathyroidectomy	Secondary hyperparathyroidism			175/120–210/120	100/60–105/70		

†Parathyroidectomy

parathyroid exploration and removal of three and a half glands. One case by Shinoda *et al*.[17] also presented with AF.

Risk factors and pathophysiological mechanisms

Preoperative risk factors contributing to post-PTX hypotension include a history of resistant hypertension, uraemia, and chronic kidney disease. Leiba *et al*.[43] reported that patients with uraemia and preoperative hypertension experienced a significant and persistent drop in blood pressure post-surgery. The pathophysiological mechanisms underlying this phenomenon involve excessive arterial dilation, decreased systemic vascular resistance, and remodelling of large arteries with low-to-normal arterial stiffness.

Li *et al*.[47] recently investigated the mechanistic reasons for post-PTX hypotension, focusing on patients with SHPT undergoing haemodialysis. Their study identified that serum copper metabolism domain-containing protein 5 (COMMD5) levels were significantly higher post-PTX. The increase in COMMD5 expression promotes high levels of atrial natriuretic peptide (ANP) and endothelial nitric oxide synthase (eNOS) in endothelial cells, leading to vasodilation and resultant hypotension. Blood pressure was inversely correlated with changes in COMMD5 levels, suggesting that increased COMMD5 expression is related to the decrease in blood pressure after PTX.

Management strategies

To minimise the risk of hypotension post-PTX, thorough preoperative evaluation is essential. Identifying patients with risk factors such as resistant hypertension and uraemia allows for tailored perioperative management strategies. During surgery, careful monitoring of blood pressure and judicious use of antihypertensive medications are recommended.

Postoperatively, close monitoring of blood pressure is crucial, especially in patients with known risk factors. In cases of early-onset hypotension, supportive care with intravenous fluids and vasopressors may be necessary. For delayed-onset hypotension, a comprehensive approach including dietary modifications, adjustment of antihypertensive medications, and possibly the use of medications that increase vascular resistance may be required.

Limitations

This systematic review provides important insights into cardiac complications following PTX but is limited by the rarity of reported cases. To address this, we included cases across primary, secondary, and tertiary HPT, enhancing comprehensiveness but introducing variability in mechanisms and outcomes. We clarified HPT definitions whenever possible to minimise inconsistencies.

The reliance on case reports and small series, often lacking standardised methodologies, posed another challenge. To mitigate this, we prioritised studies with detailed cardiac outcomes and ensured a diverse and representative dataset. Additionally, limited robust studies on mechanisms and management strategies required careful integration of available evidence to support recommendations.

These limitations highlight the need for future research with standardised definitions, larger cohorts, and focused mechanistic studies. Despite these challenges, our comprehensive approach ensures that this review provides valuable insights and practical guidance for managing cardiac complications post-PTX.

Conclusion

This systematic review highlights the significant cardiac complications that can arise following PTX, including heart failure, tachyarrhythmias, chest pain, myocardial infarction mimics, and hypotension [Table 5]. According to published

Table 5: Post-parathyrodiectomy cardiac complications

Cardiac Complications	Timing of Complications	Underlying Cause	Pathophysiological Mechanisms	Management Strategies
Early reversible cardiac failure, ventricular tachyarrhythmia, MI mimic	Within hours to days post-surgery	Hypocalcaemia/ sudden decrease in serum calcium	Rapid calcium shifts leading to myocardial dysfunction and arrhythmias	Calcium and vitamin D supplementation, antiarrhythmic medications
Atrial fibrillation, atrial flutter, supraventricular tachycardia	Immediate to 1–10 days post-surgery	Thyroiditis related to operative trauma	Thyrotoxicosis causing metabolic and cardiac disturbances	Beta-blockers, calcium channel blockers, correction of thyrotoxicosis
Hypotension	Immediate post-surgery	Uremia in CKD* (secondary/tertiary hyperparathyroidism)	Electrolyte imbalances, vascular dysfunction, and chronic inflammation	Fluid management, control of electrolyte levels, antihypertensive medications
Delayed reversible cardiac failure	Delayed onset (weeks to months post-surgery)	Permanent hypoparathyroidism post-surgery	Chronic hypocalcaemia leading to sustained myocardial dysfunction	Lifelong calcium and active vitamin D supplementation, cardiac monitoring
Cardiomyopathy, torsades de pointes, cardiac arrest	During or shortly after Cinacalcet initiation	Cinacalcet use in SHPT† patients	Destabilisation of cardiac function due to rapid calcium drop from calcimimetic use	Avoid Cinacalcet unless absolutely necessary, close monitoring of calcium and cardiac function
Transient asystole during TOEPVA‡	During the procedure or immediate postoperative period	Other cardiac-specific postoperative complications	CO_2 embolism causing venous return obstruction and severe bradycardia	Meticulous surgical techniques, cessation of CO_2 insufflation, and resuscitation

*Chronic kidney disease. †Secondary hyperparathyroidism. ‡Transoral endoscopic parathyroidectomy vestibular approach

research, tachyarrhythmias are more common than cardiac failure post-PTX, even though cardiac failure is considered a classical complication. Early reversible cardiac failure is commonly associated with rapid postoperative hypocalcaemia and HBS, whereas delayed reversible cardiac failure is linked to prolonged hypocalcaemia due to permanent hypoparathyroidism. Both conditions require prompt calcium and active vitamin D supplementation for effective management.

Tachyarrhythmias, such as AF and ventricular tachycardia, necessitate immediate correction of electrolyte imbalances and appropriate antiarrhythmic therapy. Chest pain and myocardial infarction mimics, while frequently reported, rarely result in actual cardiac events, underscoring the need for careful diagnostic evaluation. Hypotension post-PTX, though less common, poses significant risks and requires tailored perioperative management, particularly in patients with preexisting conditions such as resistant hypertension and uraemia.

By providing detailed insights into these cardiac complications, this review aims to enhance clinical awareness and improve patient outcomes. Future research should focus on refining risk stratification tools, developing standardised management protocols, and exploring the long-term CV effects of PTX. Meticulous perioperative care and long-term follow-up will be pivotal in mitigating risks and improving the quality of life for patients undergoing this surgical procedure.

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Author's contribution

AP conceived the idea for this review and led the design and development of the manuscript. AP, with input from AJ, NT, and AK, defined the intellectual content and shaped the review's focus. All authors participated in the literature search, with AP coordinating the process and AJ, NT, and AK conducting database searches using relevant keywords. AP and AJ carefully cross-checked the selected studies for accuracy and relevance.

AP drafted the initial manuscript, and AJ, NT, and AK provided significant feedback and content refinement. All authors were involved in the editing process to ensure clarity and coherence. The manuscript was reviewed collectively, with AP taking responsibility for overseeing the final revisions.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary Material

Materials and methods

The systematic review was conducted to comprehensively assess the cardiac complications following PTX. Here is an elaboration on the methodology.

- **Database and Search Strategy:** The PubMed and Europe PMC database were utilized for the systematic review till May 2024. AKH and BR worked independently and searched both the databases using all the above keywords. The articles which were shortlisted were further cross checked by AP and AJ. Further databases were again searched by authors as follows; AP searched 'Parathyroidectomy' and ' cardiac complication', 'Parathyroid surgery' and ' cardiac complication' Parathyroidectomy' and 'heart failure' , 'Parathyroid surgery' and 'heart failure' 'Parathyroidectomy' and 'asystole', , 'Parathyroid surgery' and 'asystole', AJ searched 'Parathyroidectomy' and ' cardiomyopathy', 'Parathyroid surgery' and ' cardiomyopathy', NT searched 'Parathyroidectomy' and 'hypotension', 'Parathyroid surgery' and 'hypotension', AK search 'Parathyroidectomy' and 'tachyarrhythmias', ' 'Parathyroid surgery' and 'tachyarrhythmias', were employed to retrieve relevant literature.
- In order to avoid bias at least two independent reviewers searched for the articles using the keywords.
- **Inclusion Criteria:** The review included studies published in the English language, ensuring accessibility and understanding for the research team.
- **Screening Process:** Initially, 15,232 articles were identified through the search strategy. These articles were then thoroughly screened based on their relevance to the topic of cardiac complications post-PTX. The screening process aimed to select articles that specifically addressed the cardiac implications of the surgery. Figure 1
- **Final Selection:** After the meticulous screening process, 62 articles were deemed pertinent to the study of cardiac complications post-PTX. These articles were chosen based on their in-depth insights and contributions to understanding the cardiovascular complication of the surgical procedure.

Rare cardiac complications post-PTX

Cinacalcet, a calcimimetic agent, is primarily used for managing SHPT in patients with end-stage renal disease (ESRD) on dialysis. While effective, it has been associated with rare but severe cardiac complications, including cardiomyopathy. One documented case highlights the potential severity of this adverse effect, emphasizing the need for cautious use in patients with pre-existing heart conditions.[1]

A case of reported by Novick *et al*. had fatal outcome due to Cinacalcet-associated severe hypocalcemia leading to torsades de pointes and cardiac arrest.[2] In this case, a patient with pre-existing nonischemic dilated cardiomyopathy and severe hyperparathyroidism experienced a rapid decline in cardiac function after the administration of cinacalcet. The pathophysiological mechanism involves the destabilization of cardiac function, which has adapted to chronic hypercalcemia. Cinacalcet increases the sensitivity of the calcium-sensing receptor, causing a rapid decrease in serum calcium levels. This abrupt change induced significant cardiac stress, exacerbating the underlying heart condition and leading to cardiomyopathy.

Management of this complication requires use when there is absolute necessity. In patients with known heart conditions, alternative treatments should be considered, or cinacalcet should be introduced with extreme caution. Close monitoring of serum calcium and cardiac function during treatment is crucial. If cardiac decompensation occurs, immediate discontinuation of cinacalcet and supportive cardiac care, including inotropic support and hemofiltration, if necessary, should be initiated.

Transient asystole during TOEPVA

Transient asystole, though rare, is a significant cardiac complication that can occur during transoral endoscopic parathyroidectomy vestibular approach (TOEPVA). A documented case reveals that the incidence of transient asystole is primarily linked to carbon dioxide (CO2) embolism during the procedure. This complication involves a sudden cessation of cardiac activity, necessitating immediate medical intervention.[3]

In this case, a patient undergoing TOEPVA experienced transient asystole due to the inadvertent introduction of CO2 into the vascular system during subplatysmal dissection and insufflation. The embolized CO2 led to a rapid decrease in venous return, right ventricular outflow obstruction, and subsequent severe bradycardia and hypotension, culminating in transient asystole. The preoperative risk factors included advanced age and preexisting cardiovascular conditions.

Management of this complication involves a watchful approach from the surgeons. During the procedure, surgeons should employ meticulous techniques to avoid excessive CO2 insufflation and closely monitor hemodynamic parameters. Immediate recognition and cessation of CO2 insufflation, followed by prompt resuscitative measures such as cardiac massage, are crucial for effectively managing this complication. Postoperative monitoring should continue to ensure hemodynamic stability.

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