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Takotsubo Cardiomyopathy: An Underrecognized Cardiac Emergency

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Abstract: ***Takotsubo cardiomyopathy (TTC), also known as stress-induced cardiomyopathy or "broken heart syndrome", is a transient form of acute heart failure characterized by reversible left ventricular systolic dysfunction in the absence of significant obstructive coronary artery disease. Once considered a benign condition, TTC is now recognized as a clinically important cardiovascular syndrome associated with substantial morbidity and mortality, particularly during the acute phase. It predominantly affects postmenopausal women and is commonly triggered by emotional or physical stress, although cases without identifiable precipitating factors are increasingly recognized. The pathophysiology is multifactorial, involving catecholamine excess, autonomic nervous system dysregulation, coronary microvascular dysfunction, endothelial dysfunction, inflammation, oxidative stress, and genetic susceptibility. Clinically, TTC closely resembles acute coronary syndrome, presenting with chest pain, dyspnea, electrocardiographic abnormalities, and elevated cardiac biomarkers, making early and accurate diagnosis essential. Multimodality imaging, including echocardiography, coronary angiography, and cardiac magnetic resonance imaging, plays a pivotal role in confirming the diagnosis and excluding other cardiac disorders. Current management is primarily supportive and includes individualized hemodynamic stabilization, heart failure therapy, assessment for left ventricular outflow tract obstruction, anticoagulation in selected patients, and mechanical circulatory support in refractory cardiogenic shock. Although approximately 90-95% of patients recover left ventricular function within 4–8 weeks, acute complications such as cardiogenic shock, ventricular arrhythmias, thromboembolism, and heart failure remain significant concerns. Recent advances in strain imaging, artificial intelligence, molecular biomarkers, precision medicine, and wearable monitoring technologies are improving diagnostic accuracy, risk stratification, and long-term follow-up. This review summarizes the latest evidence regarding the epidemiology, pathophysiology, clinical presentation, diagnosis, management, prognosis, and future directions.***

Keywords: Takotsubo cardiomyopathy; Stress-induced cardiomyopathy; Broken heart syndrome; Acute coronary syndrome; Left ventricular dysfunction; Echocardiography; Cardiogenic shock; Prognosis.

1. Introduction

Takotsubo cardiomyopathy (TTC), also known as stress-induced cardiomyopathy or "broken heart syndrome," is an acute and usually reversible syndrome characterized by transient left ventricular systolic dysfunction in the absence of obstructive coronary artery disease. Since its first description in Japan in 1990, TTC has emerged as an important differential diagnosis of acute coronary syndrome (ACS), accounting for approximately 1–3 per cent of patients presenting with suspected ACS and up to 5–6 per cent of women presenting with suspected ST-segment elevation myocardial infarction.[1,2] The syndrome typically presents with acute chest pain, dyspnoea, electrocardiographic abnormalities, and modest elevation of cardiac biomarkers, closely resembling acute myocardial infarction, thereby posing a significant diagnostic challenge.[1,3] The characteristic feature of TTC is transient regional left ventricular wall-motion abnormality extending beyond the distribution of a single coronary artery. Although classical apical ballooning is the most common phenotype, atypical variants including mid-ventricular, basal (reverse), focal, and global forms are increasingly recognized owing to advances in transthoracic echocardiography and cardiac magnetic resonance imaging (CMR).[2,4] Contemporary multimodality imaging has considerably improved diagnostic accuracy and has facilitated differentiation of TTC from acute myocardial infarction and myocarditis.[4,5] Takotsubo cardiomyopathy predominantly affects postmenopausal women, suggesting an important role of estrogen deficiency in disease susceptibility. Emotional stressors such as bereavement, anxiety, fear, and interpersonal conflict, as well as physical stressors including sepsis, trauma, major surgery, acute neurological disorders, malignancy, and critical illness, frequently precede symptom onset. Nevertheless, a substantial proportion of patients have no identifiable precipitating factor, indicating that the pathogenesis is multifactorial and incompletely understood.[3,6] Accumulating evidence indicates that TTC results from a complex interaction between excessive sympathetic activation, catecholamine-mediated myocardial injury, coronary microvascular dysfunction, endothelial dysfunction, inflammation, oxidative stress, hormonal influences, and genetic susceptibility. Recent advances have further highlighted the pivotal role of the brain–heart axis, immune activation, myocardial metabolic alterations, and autonomic dysregulation in the development and recovery of the syndrome. In addition, artificial intelligence-assisted electrocardiographic interpretation, myocardial strain imaging, quantitative CMR tissue characterization, and circulating molecular biomarkers have enhanced early diagnosis and risk stratification, while ongoing translational research is exploring targeted therapeutic strategies.[5,7] Although left ventricular systolic function recovers completely in most patients within four to eight weeks, TTC is no longer considered a benign disorder. Contemporary registry data have demonstrated that acute complications, including heart failure, cardiogenic shock, ventricular arrhythmias, thromboembolic events, and in-hospital mortality, may be comparable to those observed in patients with acute coronary syndrome. Furthermore, recurrent episodes and persistent impairment of myocardial strain, endothelial function, autonomic regulation, and quality of life have been increasingly reported during long-term follow-

up.[2,6,8] Despite substantial advances in understanding the syndrome, important uncertainties remain regarding its precise pathophysiological mechanisms, optimal risk stratification, evidence-based therapeutic strategies, and long-term management. This review summarizes the current evidence on the epidemiology, pathophysiology, clinical manifestations, diagnostic evaluation, management, prognosis, and emerging developments in Takotsubo cardiomyopathy.

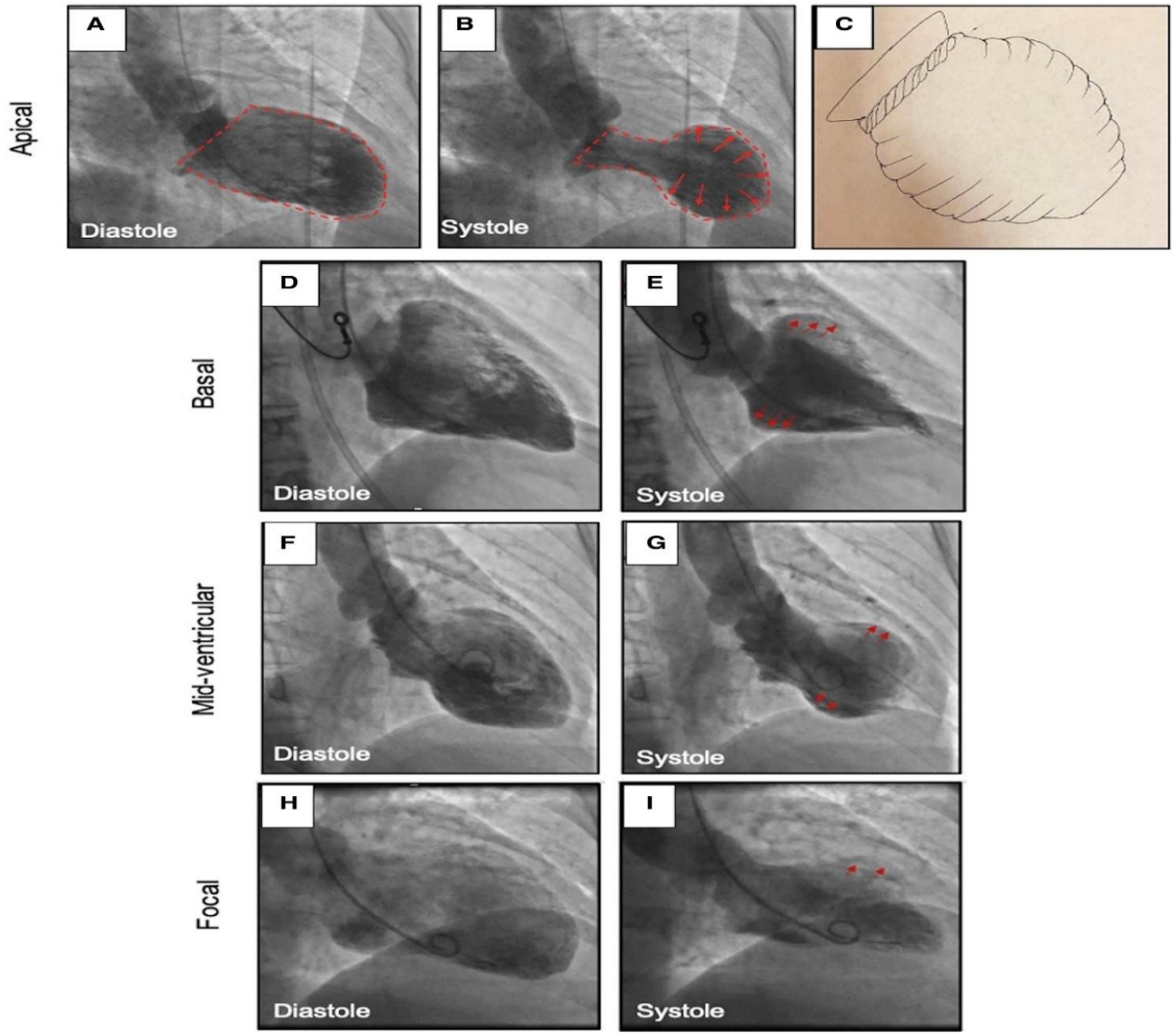


Figure 1: Takotsubo syndrome: anatomic variants. Left ventriculogram demonstrating apical (**A** and **B**) ballooning of the left ventricle, similar to the shape of a Japanese octopus trap (**C**). Basal (**D** and **E**), midventricular (**F** and **G**), and focal (**H** and **I**) variations of takotsubo syndrome.

Epidemiology and Clinical Profile

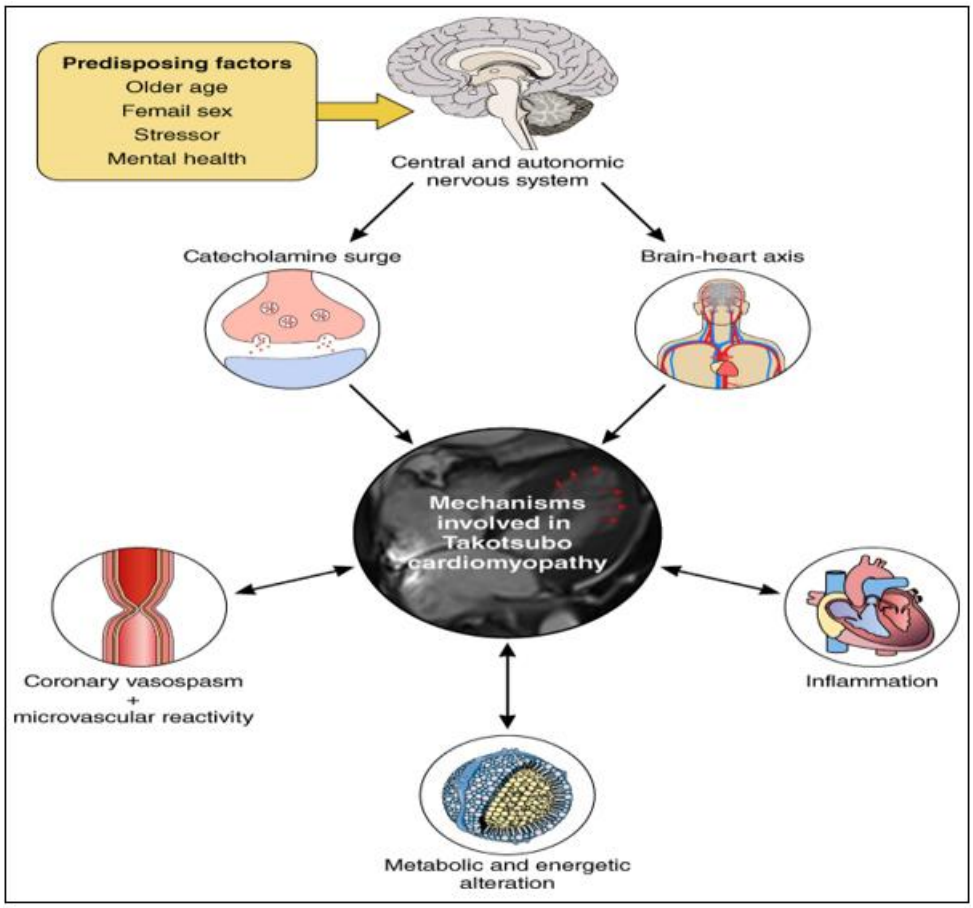
Accounts for approximately 1–3% of patients presenting with suspected acute coronary syndrome (ACS) and up to 5–6% of women with STEMI-like presentations.[9,10] It predominantly affects postmenopausal women aged 60–75 years, with a female-to-male ratio of approximately 9:1, largely due to reduced estrogen-mediated cardioprotection.[9,11] The syndrome is increasingly recognized worldwide because of improved awareness, advanced cardiac imaging, and updated diagnostic criteria.[9,12] Emotional stressors, including bereavement, anxiety, and fear, account for 30–40% of cases, whereas physical stressors such as sepsis, surgery, trauma, and stroke account for 40–50%.[10,12] Approximately 20–30% of patients have no identifiable trigger.[9,12] Neurological disorders (e.g., stroke and subarachnoid haemorrhage) and psychiatric conditions (e.g., anxiety and depression) are common associated conditions.[11,13] Patients typically present with acute chest pain and dyspnoea, closely resembling acute coronary syndrome. Despite its reversible nature, TTC can lead to serious complications, including acute heart failure, cardiogenic shock, ventricular arrhythmias, left ventricular thrombus, and left ventricular outflow tract obstruction (LVOTO).[10,14] The in-hospital mortality rate is approximately 2–5%, while the recurrence rate is 5–10% during long-term follow-up.[10,14] Recent advances in artificial intelligence, cardiac magnetic resonance imaging, strain echocardiography, wearable monitoring, and precision medicine are improving early diagnosis, risk stratification, and long-term management.[15,16] Overall, TTC is now recognized as an important acute cardiovascular syndrome requiring prompt diagnosis, individualized treatment, and structured follow-up to optimize patient outcomes.[9,10,14]

Pathophysiology

Takotsubo cardiomyopathy is caused by a complex interaction of the brain–heart axis, excessive sympathetic nervous system activation, catecholamine-mediated myocardial injury, coronary microvascular dysfunction,

inflammation, oxidative stress, hormonal factors, and genetic susceptibility.[10,12] Acute emotional stress (e.g., bereavement, anxiety, fear) or physical stress (e.g., sepsis, surgery, stroke, trauma) activates the hypothalamic–pituitary–adrenal (HPA) axis and sympathetic nervous system, leading to a massive release of epinephrine and norepinephrine.[11,12] High catecholamine levels cause direct myocardial toxicity, coronary vasoconstriction, and coronary microvascular dysfunction.[12] Excess epinephrine induces a β_2-adrenergic receptor signalling switch from stimulatory Gs proteins to inhibitory Gi proteins, producing negative inotropic effects. Since the left ventricular apex has a higher density of β_2 receptors, it is more susceptible to injury, resulting in the characteristic apical ballooning seen in classical TTC.[12,13]

Coronary microvascular dysfunction, endothelial injury, oxidative stress, intracellular calcium overload, mitochondrial dysfunction, and inflammation (mediated by cytokines such as IL-6, IL-1β, and TNF-α) further contribute to reversible myocardial stunning and transient left ventricular systolic dysfunction.[12,14] These mechanisms produce regional wall-motion abnormalities without obstructive coronary artery disease and may lead to complications such as left ventricular outflow tract obstruction, mitral regurgitation, pulmonary oedema, cardiogenic shock, and heart failure.[10,14] Postmenopausal estrogen deficiency increases sympathetic responsiveness and endothelial dysfunction, explaining the predominance of TTC in older women.[9,11] Genetic variations affecting adrenergic receptors, estrogen receptors, and inflammatory pathways may also influence disease susceptibility and recurrence.[13,14] Most patients experience complete recovery of left ventricular function within 4–8 weeks as catecholamine levels normalize and myocardial function improves. Although the prognosis is generally favourable, acute complications can occur during the early phase of the disease.[10,14]



2. Clinical Presentation

It is an acute and reversible cardiac condition that closely mimics acute coronary syndrome (ACS). It predominantly affects postmenopausal women and is commonly triggered by emotional or physical stress, although no trigger is identified in approximately 20–30% of patients.[17,18] The most common clinical manifestations include sudden chest pain (70–80%), dyspnoea (40–50%), palpitations, fatigue, nausea, and syncope (5–10%).[17,19] In severe cases, patients may develop acute heart failure, cardiogenic shock, or life-threatening ventricular arrhythmias.[20] Physical examination may reveal tachycardia, hypotension, pulmonary crackles, and signs of left ventricular outflow tract obstruction (LVOTO).[18,20] Electrocardiography typically shows ST-segment elevation or depression, followed by deep T-wave inversion and QT interval prolongation.[21] Laboratory findings include mild elevation of high-sensitivity cardiac troponin (hs-cTn) and markedly elevated BNP/NT-proBNP levels.[21,22] Echocardiography demonstrates transient left ventricular wall-motion abnormalities, most commonly apical ballooning, while cardiac magnetic resonance imaging (CMR) confirms myocardial oedema without significant fibrosis.[22,23] Recent advances (2025–2026) highlight the importance of high-sensitivity troponin assays, speckle-tracking echocardiography with global longitudinal strain (GLS), multiparametric CMR (T1/T2 mapping), and the InterTAK Diagnostic Score for improved diagnosis and risk

stratification.[23,24] Although most patients recover normal ventricular function within 4–8 weeks, careful monitoring is essential because acute complications such as heart failure, cardiogenic shock, arrhythmias, and thromboembolism may occur.[24]

Diagnostic Evaluation of Takotsubo Cardiomyopathy:

Diagnostic Component	Findings / Features	Diagnostic Significance
Initial Clinical Suspicion	Acute chest pain or dyspnoea[25,26]	Common presenting symptoms mimicking ACS.
	ECG abnormalities suggestive of ACS[25,26]	Often indistinguishable from myocardial infarction initially.
	Mild-to-moderate troponin elevation[25,27]	Biomarker rise is usually less than expected for the degree of LV dysfunction.
	Recent emotional or physical stress trigger[25,26]	Common precipitating factor, though not mandatory.
	Severe LV dysfunction disproportionate to biomarker elevation[26]	Important clue favouring TTC over ACS.
Electrocardiography (ECG)	ST-segment elevation[25,26]	Most common early ECG finding.
	ST-segment depression[26]	Less common presentation.
	Deep T-wave inversion[26,27]	Typically develops during the subacute phase.
	QT interval prolongation[26,28]	Common during recovery phase and may predispose to arrhythmias.
ECG Evolution	Acute phase: ST elevation/depression[25,26]	Mimics acute myocardial infarction.
	Subacute phase: T-wave inversion[26,27]	Reflects evolving myocardial stunning.
	Recovery phase: QT prolongation[26,28]	Gradually resolves with recovery.
Important ECG Limitation	ECG findings alone cannot reliably distinguish TTC from myocardial infarction[25,26]	Additional imaging and coronary assessment are required.
Cardiac Biomarkers	Troponin: Mild-to-moderate elevation[25,27]	Disproportionately low compared with extent of LV dysfunction.
	BNP/NT-proBNP: Markedly elevated[26,28]	Reflects ventricular wall stress and myocardial dysfunction.
	CK-MB: Mild elevation[27]	Less specific marker.
Key Biomarker Clue	High BNP with relatively low troponin[26,28]	Strongly favours TTC over ACS.
Echocardiography (First-Line Imaging)	Apical akinesis/dyskinesis[25,26]	Reduced or absent apical wall motion.
	Basal hyperkinesis[25,26]	Hypercontractility of basal segments.
	Reduced ejection fraction[25,26]	Reflects transient LV systolic dysfunction.
Variants of Takotsubo Cardiomyopathy	Apical (classic): Apical ballooning with basal hyperkinesis[25,26]	Most common phenotype.
	Mid-ventricular: Dysfunction confined to mid-ventricular segments[26,27]	Second most common variant.
	Basal (reverse Takotsubo): Basal hypokinesis with apical sparing[26,27]	More common in younger patients.
	Focal type: Localized wall-motion abnormality[27]	May closely resemble ACS.
Overall Diagnostic Principle	TTC is a diagnosis of exclusion requiring integration of clinical findings, ECG, biomarkers, echocardiography, cardiac MRI, and coronary angiography[25–29]	Multimodal assessment is essential to differentiate TTC from ACS and other cardiac disorders.

Cardiac Magnetic Resonance Imaging (CMR): is a key non-invasive tool for confirming Takotsubo syndrome and differentiating it from acute myocardial infarction and myocarditis. CMR typically demonstrates myocardial oedema on T2-weighted imaging with absent or minimal late gadolinium enhancement (LGE), indicating reversible myocardial injury rather than permanent necrosis. The absence of significant LGE helps distinguish TTC from myocardial infarction, while myocarditis usually shows patchy or subepicardial LGE. Serial CMR demonstrates gradual resolution of oedema and complete recovery of ventricular function within weeks to months, supporting the transient nature of the disease.[26,28,29]

Coronary Angiography: Coronary angiography remains the gold standard for excluding acute coronary syndrome in patients with suspected Takotsubo syndrome. The hallmark finding is normal or non-obstructive coronary arteries without plaque rupture or acute thrombotic occlusion, despite clinical and electrocardiographic features resembling acute myocardial infarction. Coronary angiography is therefore essential for confirming the diagnosis and excluding obstructive coronary artery disease.[25,29]

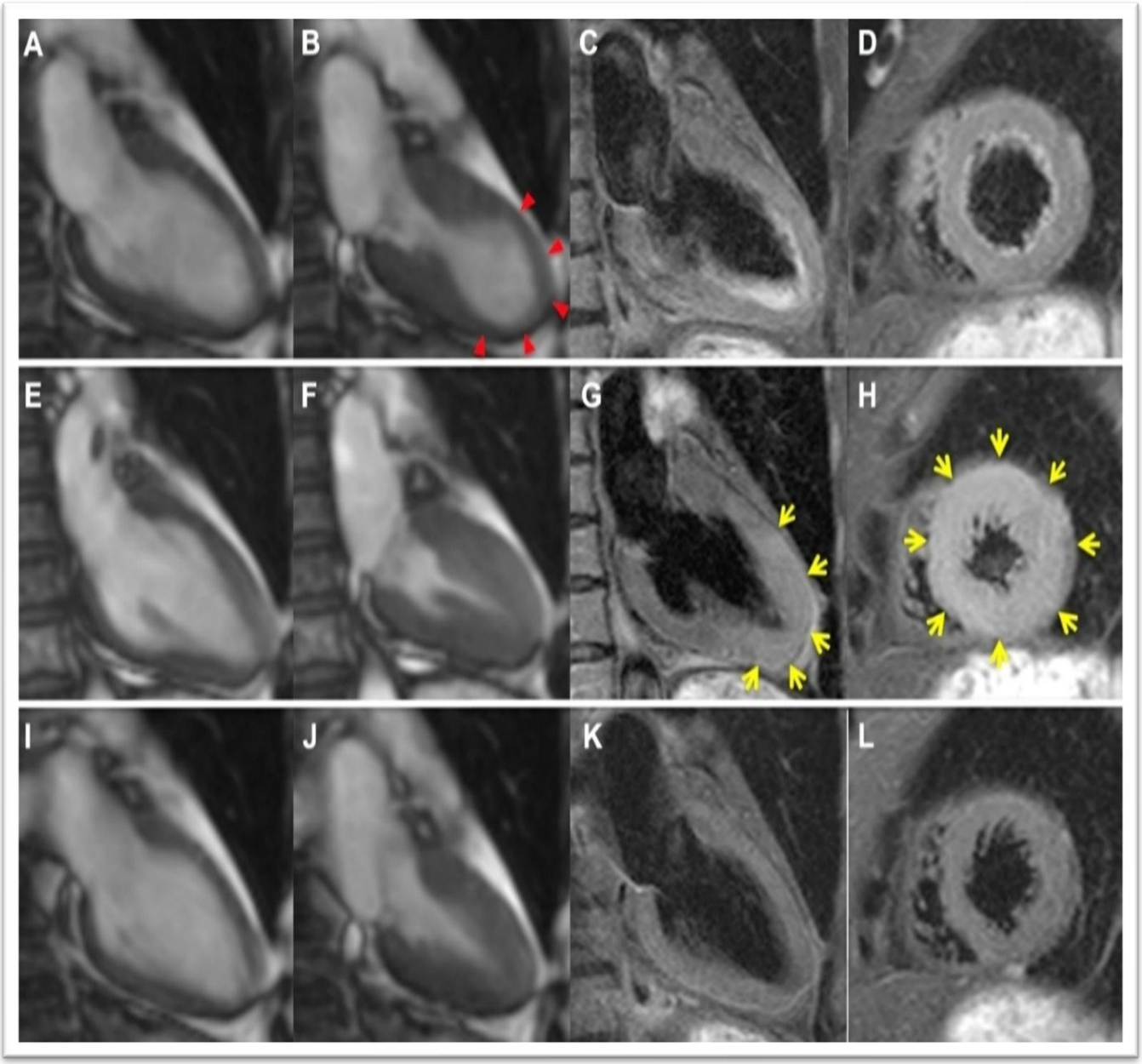


Figure 2: Cardiac Magnetic Resonance Imaging (CMR) Serial change of myocardial edema in a representative patient with TTS. In the acute phase, apical ballooning was observed ((A, B), red arrows). Myocardial edema on T2-weighted images was slight (C, D). In the subacute phase, wall motion was completely recovered (E, F), whereas more thickened apical wall with more severe myocardial edema was observed compared with the acute phase ((G, H), yellow arrows). In the chronic phase, the final CMR imaging demonstrated normal systolic function (I, J) without apical wall thickening or myocardial edema (K, L). CMR, cardiovascular magnetic resonance; TTS, takotsubo syndrome.

Takotsubo Cardiomyopathy versus Acute Coronary Syndrome

Differentiating Takotsubo cardiomyopathy (TTC) from Acute Coronary Syndrome (ACS) remains one of the major diagnostic challenges in emergency cardiology because both conditions often present with chest pain, ECG abnormalities, and elevated cardiac biomarkers.[30, 31]

Feature	Takotsubo Cardiomyopathy	Acute Coronary Syndrome
Coronary Arteries	Usually normal or non-obstructive.[30]	Significant coronary obstruction present.[32]
Trigger	Emotional or physical stress commonly present.[30]	Usually caused by atherosclerotic plaque rupture and thrombosis.[32]
Troponin Elevation	Mild to moderate elevation.[31]	Typically marked elevation.[32]
Wall Motion Abnormality	Extends beyond a single coronary artery territory.[30]	Localized to the territory supplied by the affected artery.[32]
Recovery	Usually complete recovery within days to weeks.[31]	Permanent myocardial injury and scar formation may occur.[32]

Clinical Importance: Early recognition of Takotsubo cardiomyopathy is essential because management, prognosis, and long-term outcomes differ significantly from those of acute coronary syndromes.[30,31]

Updated Evidence-Based Management of Takotsubo Cardiomyopathy (2025–2026)

Category	Clinical Situation	Management Strategy	Key Points / 2025–2026 Updates
Initial Management	Suspected ACS	Oxygen (if hypoxemic), ECG monitoring, IV access, aspirin ± anticoagulation, urgent coronary angiography	Treat as ACS until TTC is confirmed because the initial presentation closely mimics myocardial infarction.[30,33]
	Diagnostic evaluation	ECG, cardiac biomarkers, transthoracic echocardiography, coronary angiography (or coronary CT angiography in selected low-risk patients), cardiac MRI when diagnosis remains uncertain	Coronary angiography remains the gold standard for excluding obstructive coronary artery disease. Cardiac MRI helps differentiate TTC from myocarditis and myocardial infarction.[30,33]
General Supportive Care	All patients	Admission to CCU or ICU, continuous ECG and hemodynamic monitoring	Early monitoring is essential because ventricular arrhythmias, cardiogenic shock, and thromboembolic complications occur predominantly during the acute phase. Most patients recover completely within weeks.[31,34]
	Hemodynamically stable	Observation, supportive therapy, treatment of precipitating physical or emotional triggers	Mild cases often recover spontaneously with conservative management.[31]
Patients Without LVOTO	Mild to moderate LV dysfunction	ACE inhibitors/ARBs (or ARNI in selected patients), individualized β-blockers	ACE inhibitors improve ventricular remodeling and recovery. Current evidence suggests β-blockers may improve symptoms but have uncertain benefit in preventing recurrence.[33,34]
	Pulmonary oedema	Loop diuretics, oxygen therapy, non-invasive ventilation when indicated	Provides symptomatic relief and improves congestion.[33]
	Hypotension	Careful volume assessment, cautious vasopressor use (preferably norepinephrine) only when required	Excessive catecholamine exposure should be avoided because it may aggravate myocardial dysfunction.[34]
Patients With LVOTO	Dynamic LV outflow tract obstruction	Short-acting β-blockers (e.g., esmolol), followed by oral β-blockers	Reduces basal hypercontractility, myocardial oxygen demand, and LVOT gradient.[33]
	Hypotension with LVOTO	Gentle intravenous fluid administration	Increases preload and reduces dynamic obstruction.[33]
	Avoid	Inotropes, nitrates, vasodilators, excessive diuresis	These therapies worsen LVOTO and may precipitate severe cardiogenic shock.[33]
Cardiogenic Shock	Without LVOTO	Vasopressors (preferably norepinephrine) ± cautious inotropes (e.g., dobutamine) if persistent low cardiac output	Invasive hemodynamic monitoring is recommended. Catecholamines should be minimized whenever possible.[34]
	With LVOTO	Intravenous fluids plus β-blockers	Catecholamine inotropes are contraindicated because they increase LVOTO.[33]
	Refractory cardiogenic shock	Mechanical circulatory support (Impella, VA-ECMO, selected IABP use)	Early referral to advanced cardiac centres is recommended. Impella and VA-ECMO are increasingly preferred, whereas routine IABP use has declined because of limited mortality benefit.[34,35]
Pharmacological Therapy	β-blockers	Individualized treatment	Reduce sympathetic stimulation. Current evidence does not conclusively demonstrate recurrence prevention; therapy should be individualized.[33]
	ACE inhibitors/ARBs	Standard therapy for LV systolic dysfunction	Associated with improved ventricular recovery and lower long-term mortality in observational studies.[33]
	ARNI	Selected patients with persistent heart failure	May be considered although evidence remains limited.[35]
	Diuretics	Pulmonary congestion or heart failure	Use cautiously in patients with LVOTO.[33]
	Anticoagulation	Severe apical ballooning, LV thrombus, or EF <30–35%	Recommended until recovery of ventricular function (typically approximately 3 months) to prevent systemic embolism.[34]
	SGLT2 inhibitors	Emerging adjunctive therapy	Early studies suggest potential benefit in heart failure; however, routine use is not currently recommended due to insufficient evidence.[35]
Management of Complications	Acute heart failure	Guideline-directed heart failure therapy	Treatment should always be guided by the presence or absence of LVOTO.[33]
	Ventricular arrhythmias	Continuous telemetry, electrolyte correction, magnesium supplementation, antiarrhythmic drugs when indicated	Ventricular arrhythmias are most common during the acute phase.[34]
	QT prolongation	Avoid QT-prolonging medications and correct electrolyte abnormalities	Reduces the risk of torsades de pointes.[31]

	LV thrombus	Therapeutic anticoagulation with serial imaging	Repeat echocardiography before discontinuation of anticoagulation.[34]
	Cardiac rupture or ventricular septal defect (rare)	Urgent surgical consultation	Rare but life-threatening complications requiring immediate intervention.[34]
Long-Term Care	Recovery phase	Continue ACE inhibitors/ARBs until normalization of LV function; gradual withdrawal may be considered after recovery	Left ventricular function generally normalizes within 4–8 weeks.[33]
	β-blocker therapy	Continue when clinically indicated	Long-term benefit for recurrence prevention remains uncertain.[34]
	Psychological management	Stress reduction, psychiatric evaluation, cognitive behavioral therapy, and cardiac rehabilitation	Emotional stress is a major trigger, and psychological intervention may reduce recurrence and improve quality of life.[30,35]
	Lifestyle modification	Smoking cessation, regular exercise, healthy diet, and cardiovascular risk-factor control	Recommended despite the non-atherosclerotic nature of TTC.[35]
Follow-Up	4–6 weeks	Repeat echocardiography ± cardiac MRI (selected patients)	Confirms normalization of left ventricular function and excludes persistent abnormalities.[33]
	Long-term follow-up	Clinical review, reassessment of medications, and management of cardiovascular risk factors	Recurrence occurs in approximately 5–10% of patients. Long-term mortality is largely related to underlying comorbid illnesses rather than recurrent TTC.[34,35]

3. Key Clinical Updates

- β-blockers: Remain useful for LVOTO, tachycardia, and sympathetic overactivity, but current evidence does not conclusively show that they prevent recurrence.
- ACE inhibitors/ARBs: Continue to be associated with improved left ventricular recovery and better long-term outcomes in observational studies.
- ARNI: May be considered in selected patients with persistent heart failure after the acute phase; evidence is still emerging.
- SGLT2 inhibitors: Promising adjunctive therapy for heart failure, but routine use in Takotsubo cardiomyopathy is not yet supported by current guidelines.
- Mechanical circulatory support: Impella and VA-ECMO are increasingly favored for refractory cardiogenic shock; routine intra-aortic balloon pump use has decreased.
- Anticoagulation: Recommended for patients with severe apical ballooning, left ventricular thrombus, or ejection fraction <30–35%, generally for about 3 months or until ventricular recovery.
- Psychological intervention: Stress management, psychiatric assessment, and cardiac rehabilitation are increasingly recognized as integral components of long-term management because emotional stress is a major precipitating factor.
- Follow-up imaging: Repeat echocardiography at 4–6 weeks is recommended to confirm complete recovery of ventricular function, with cardiac MRI reserved for selected patients.
- Recurrence: Approximately 5–10% of patients experience recurrence, emphasizing the importance of long-term clinical follow-up and management of cardiovascular risk factors.

Prognosis of Takotsubo Cardiomyopathy: is generally a reversible cardiac syndrome with a favorable long-term prognosis; however, the acute phase can be associated with significant morbidity and mortality. Approximately 90–95% of patients recover normal left ventricular function within 4–8 weeks, although recovery may be delayed in some individuals.[36,37] During hospitalization, 15–20% of patients develop major complications, including acute heart failure, cardiogenic shock, ventricular arrhythmias, left ventricular outflow tract obstruction (LVOTO), and thromboembolic events.[36,38] The in-hospital mortality rate is approximately 2–5%, which is comparable to that of acute coronary syndrome.[37] Long-term outcomes are generally favorable, but recurrence occurs in approximately 5–10% of patients.[36,39] Patients with advanced age, male sex, physical stress triggers, severe left ventricular dysfunction, cardiogenic shock, right ventricular involvement, LVOTO, ventricular arrhythmias, or significant comorbidities have a poorer prognosis.[37,38] Conversely, early diagnosis, prompt supportive treatment, absence of major complications, and complete recovery of ventricular function are associated with excellent outcomes.[36] Current evidence (2025–2026) indicates that TTC should no longer be regarded as a completely benign condition. Although most patients recover clinically, some may experience persistent myocardial dysfunction, reduced exercise capacity, or impaired quality of life despite normalization of ejection fraction.[39,40] Therefore, regular follow-up with repeat echocardiography after 4–6 weeks, optimization of cardiovascular risk factors, stress management, and psychological support are recommended to improve long-term outcomes and reduce the risk of recurrence.[38,40]

4. Future Directions, Advantages, and Advanced Clinical Implications

It evolve cardiovascular syndrome, and future research aims to improve its diagnosis, treatment, and long-term outcomes. Advances in precision medicine, artificial intelligence (AI), genomics, novel biomarkers, and advanced cardiac imaging are expected to enable early diagnosis, accurate risk stratification, and personalized treatment. Emerging therapies such as SGLT2 inhibitors, angiotensin receptor-neprilysin inhibitors (ARNIs), anti-inflammatory agents, and regenerative therapies are under investigation. Wearable monitoring devices, telemedicine, and multidisciplinary care are also expected to improve long-term patient follow-up and reduce recurrence.[39,40] Current management strategies have significantly improved patient outcomes. Approximately 90–95% of patients recover normal left ventricular function within 4–8 weeks with appropriate supportive therapy.

Modern diagnostic tools, including echocardiography, coronary angiography, and cardiac magnetic resonance imaging (CMR), enhance diagnostic accuracy and help differentiate TTC from acute myocardial infarction.[36,38] Early risk assessment, individualized treatment, mechanical circulatory support for critically ill patients, cardiac rehabilitation, and psychological counselling have further improved recovery and quality of life.[37,40] Clinically, TTC is no longer considered a completely benign disorder, as its acute complications and mortality are comparable to those of acute coronary syndrome. Early recognition, comprehensive haemodynamic assessment, advanced imaging, long-term cardiovascular follow-up, and mental health evaluation are essential for optimal patient care.[36,39] Future integration of AI-driven decision support, precision medicine, and evidence-based international guidelines is expected to transform TTC management from supportive care to personalized, mechanism-based therapy, ultimately improving survival, reducing recurrence, and enhancing patients' quality of life.[39,40]

5. Conclusion

Now recognized as a complex and potentially life-threatening cardiovascular syndrome rather than a simple reversible disorder. Current evidence indicates that its pathogenesis involves a multifactorial interaction between catecholamine excess, autonomic nervous system dysregulation, coronary microvascular dysfunction, endothelial dysfunction, inflammation, oxidative stress, and genetic susceptibility. This evolving understanding has significantly improved the diagnosis, management, and long-term care of affected patients. Advances in electrocardiography, cardiac biomarkers, echocardiography, coronary angiography, and cardiac magnetic resonance imaging (CMR) have enhanced the differentiation of TTC from acute coronary syndrome. Emerging techniques such as speckle-tracking echocardiography, global longitudinal strain (GLS), three-dimensional echocardiography, and CMR T1/T2 mapping further improve diagnostic accuracy and assessment of myocardial recovery. Although 90–95% of patients recover normal left ventricular function within 4–8 weeks, TTC should not be considered a benign condition. Serious complications, including cardiogenic shock, ventricular arrhythmias, left ventricular outflow tract obstruction, thromboembolism, stroke, and sudden cardiac death, may occur during the acute phase. Therefore, prompt diagnosis, careful hemodynamic assessment, and individualized supportive management remain essential. Long-term care extends beyond recovery of ventricular function because some patients experience persistent myocardial dysfunction, impaired exercise capacity, psychological distress, and disease recurrence. Consequently, cardiac rehabilitation, psychological counselling, stress management, lifestyle modification, and regular follow-up are important components of comprehensive care.

Future management is expected to focus on precision medicine, artificial intelligence, molecular biomarkers, genomics, wearable monitoring technologies, and novel therapies, including SGLT2 inhibitors, angiotensin receptor-neprilysin inhibitors (ARNIs), and anti-inflammatory agents. Continued multi-centre clinical trials and international collaboration are essential to develop disease-specific therapies and evidence-based guidelines. These advances are expected to transform TTC management from predominantly supportive care to personalized, mechanism-based treatment, ultimately improving survival, reducing recurrence, and enhancing long-term quality of life.

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