

# Storm and STEMI: a case report of unexpected cardiac complications of thyrotoxicosis

Josiah Brown <sup>1</sup>, Matthew D. Cham<sup>2</sup>, and Gary S. Huang <sup>1\*</sup>

<sup>1</sup>Division of Cardiology, Department of Medicine, University of Washington, 1959 NE Pacific St, Seattle, WA 98195, USA; and <sup>2</sup>Department of Radiology, University of Washington, 1959 NE Pacific St, Seattle, WA 98195, USA

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## Background

Thyroid storm is a rare condition with well-known cardiovascular manifestations including tachycardia, atrial fibrillation, heart failure, and myocardial infarction (MI). Several uncommon conditions that can mimic MI are associated with thyrotoxicosis and discussed in this case.

## Case summary

A 23-year-old previously healthy male presented after the onset of generalized weakness and inability to rise from bed in the setting of 35 kg of unintentional weight loss, and was found to have profound hypokalaemia, elevated thyroid hormone, and suppressed thyroid-stimulating hormone consistent with thyrotoxicosis secondary to Grave's disease. Following hospital admission, he developed worsening tachycardia with dynamic anteroseptal ST-segment elevations and elevated cardiac biomarkers concerning for MI. He was treated with aspirin, ticagrelor, and a heparin infusion, but was unable to tolerate beta-blockade acutely due to hypotension. Echocardiography demonstrated a severely dilated left ventricle (left ventricular end-diastolic volume index 114 mL/m<sup>2</sup>) and severely reduced systolic function (ejection fraction 23%) with global hypokinesis. Following initiation of propylthiouracil, iodine solution, and stress-dosed steroids his tachycardia and ST-elevations resolved. Computed tomography (CT) coronary angiography demonstrated no evidence of coronary stenosis. He was discharged on methimazole, metoprolol, and lisinopril and found to have recovered left ventricular systolic function at 2-month follow-up.

## Discussion

Thyrotoxicosis can rarely cause coronary vasospasm, stress cardiomyopathy, and autoimmune myocarditis. These conditions should be suspected in hyperthyroid patients with features of MI and normal coronary arteries. Workup should include laboratory evaluation, electrocardiography (ECG), echocardiography, and non-invasive or invasive ischaemic evaluation.

## Keywords

Thyrotoxicosis • Myocarditis • Myocardial infarction • Cardiomyopathy • Vasospasm • Case report

## Learning points

- Thyrotoxicosis can be associated with cardiovascular manifestations, including stress cardiomyopathy, coronary vasospasm, and autoimmune myocarditis, all of which can mimic ST-segment elevation myocardial infarction (STEMI).
- Workup of thyrotoxicosis-induced STEMI should include laboratory evaluation, ECG, echocardiography, and non-invasive or invasive ischaemic evaluation.
- Management should include anti-thyroid agents for thyrotoxicosis and guideline-directed medical therapy for heart failure.

\* Corresponding author. Tel: 206-744-3000, Email: [garysh@uw.edu](mailto:garysh@uw.edu)

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## Introduction

Thyroid storm is a rare, life-threatening condition that can have a variety of cardiovascular manifestations including tachycardia, atrial fibrillation, and congestive heart failure.<sup>1</sup> In this case, we present a patient with thyrotoxicosis found to have dynamic ST-elevations, elevated cardiac biomarkers, and acute systolic dysfunction initially concerning for acute myocardial infarction (MI) with heart failure but who was later found to have normal coronary arteries. Here we discuss possible explanations that may inform future care of cardiovascular complications in hyperthyroid patients.

## Timeline

| 0–3 months prior to admission  | Thirty-five kilograms of unintentional weight loss.   |
|--------------------------------|---|
| Day -1                         | Vigorous exercise and heavy carbohydrate meal.  |
| Day 0                          | Awakens with profound weakness. Transferred to our hospital with severe hypokalaemia, tachycardia, and admitted to the medical intensive care unit. Found to have large ST-segment elevation on electrocardiogram (ECG) with troponin elevation. Started dual antiplatelet therapy and heparin infusion. Treatment for severe thyrotoxicosis (thyroid storm) initiated with propylthiouracil and stress-dosed steroids. Echocardiography revealed severely reduced right and left ventricular systolic function (ejection fraction 23%) and a dilated left ventricle. |
| Day 1                          | Troponins begin to downtrend, and ST-segment elevations resolve.  |
| Day 2                          | Computed tomography coronary angiography shows no evidence of atherosclerotic disease or stenosis. Dual antiplatelet therapy and heparin discontinued.  |
| Days 3–5                       | Resolving symptoms. Discharged to home on guideline-directed medical therapy for heart failure.   |
| Two months following discharge | Recovered biventricular systolic function but persistent left ventricular dilatation. Near baseline functional status.  |

## Case presentation

A 23-year-old previously healthy male was transferred to our hospital after the onset of diaphoresis, generalized weakness, and inability to rise from bed. He endorsed 35 kg of weight loss over the prior 3 months and having had a high-carbohydrate meal the evening prior to presentation. The patient was not on medications prior to presentation and denied palpitations, heat intolerance, tremor, dyspnoea,

oedema, anxiety, vision change, and change in bowel habit prior to presentation.

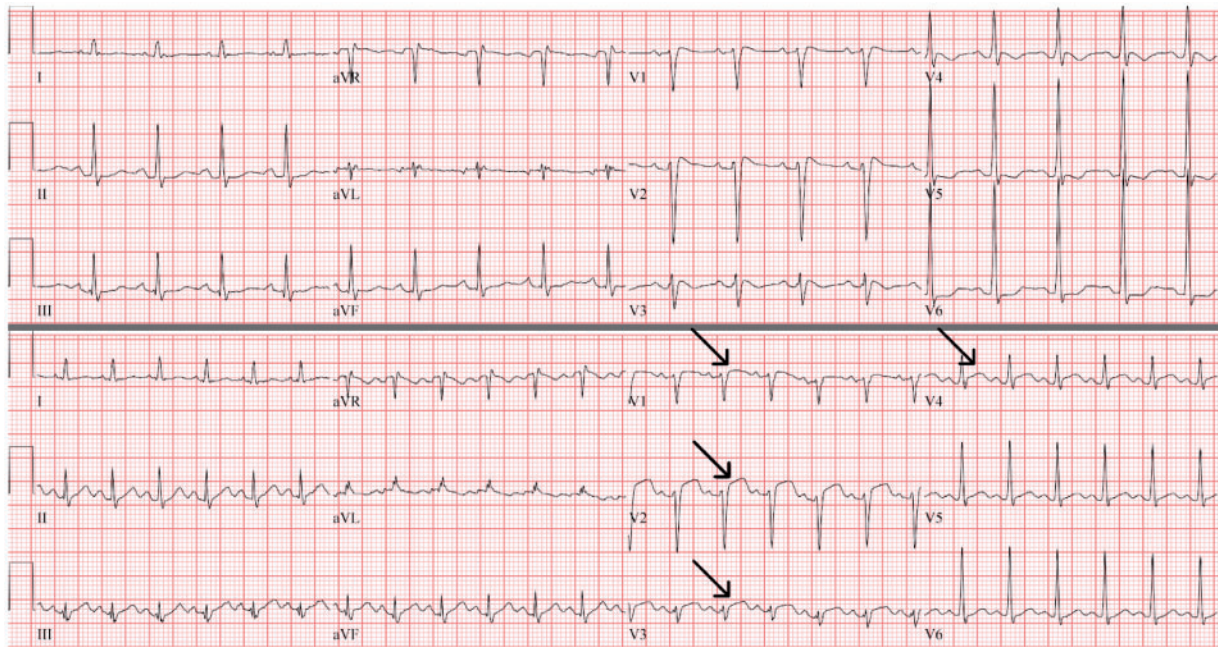
On exam, he was in moderate distress with a heart rate of 152 b.p.m., blood pressure of 89/56 mmHg, respiratory rate of 28 breaths per minute, oxygen saturation of 98% on room air, and temperature of 37.8°C. The patient had an otherwise unremarkable cardiovascular examination, including the absence of abnormal heart sounds, jugular venous distention, and lower extremity oedema. His lungs were clear to auscultation. The patient had moist mucous membranes and an enlarged thyroid but no evidence of exophthalmos, tremor, or ophthalmoplegia. He was found to have generalized weakness, predominantly in the lower extremities. Laboratory studies were notable for a potassium of 1.9 mEq/L (normal 3.7–5.2 mEq/L), an undetectable thyroid-stimulating hormone, and free T4 of 3.2 ng/dL (normal 0.6–1.2 ng/dL). Initial ECG demonstrated sinus tachycardia with prolonged QT interval (QTc 652 ms) and minimal ST-elevations in V1–V3 (Figure 1, top panel). He was admitted to the medical intensive care unit (ICU).

His weakness improved following potassium repletion and fluid resuscitation, but his tachycardia persisted. A second ECG was obtained and notable for anteroseptal (V1–V4) ST-elevations and resolution of QT prolongation (QTc 401 ms) (Figure 1, bottom panel). He denied chest pain or pressure. Troponin-I was elevated to 7.97 ng/mL (normal <0.04 ng/mL), trending upwards to 18.98 ng/mL.

Treatment was initiated with aspirin, ticagrelor, and unfractionated heparin infusion. He was unable to acutely tolerate beta-blockade due to hypotension. Urgent echocardiogram (Supplementary material online, Video S1) revealed a severely dilated left ventricle [left ventricular end-diastolic volume index (LVEDVi) 114 mL/m<sup>2</sup>] with severely reduced systolic function [ejection fraction (EF) 23%] and global hypokinesis. No focal wall-motion abnormalities were present.

Following initiation of propylthiouracil, potassium iodine solution, and stress-dosed steroids, his tachycardia and ST-elevations improved. Computed tomography (CT) coronary angiography (Figure 2) 2 days after presentation demonstrated no evidence of coronary artery atherosclerosis or stenosis. Additionally, cine cardiac CT images of the heart showed normal left ventricular systolic function (Supplementary material online, Videos S2–S4). Aspirin, ticagrelor, and heparin were stopped at this time due to a low concern for type I MI. Thyrotropin receptor antibodies returned positive, consistent with Graves' disease. Ultrasound of the thyroid gland showed thyromegaly (right lobe volume 32 cc, left lobe volume 26 cc) with heterogenous parenchyma and increased vascularity, also consistent with Graves' disease. Prior to discharge, the patient endorsed improved but persistent fatigue and dyspnoea with exertion. He continued to be free of chest pain and remained normotensive throughout the remainder of his hospital stay. The patient was discharged on methimazole in addition to guideline-directed medical therapy for heart failure, including lisinopril 2.5 mg daily and metoprolol succinate 25 mg daily. Up-titration of his lisinopril and metoprolol dosages were limited by borderline-low blood pressures. He appeared euvolemic throughout the hospitalization, so diuretics were not initiated. Mineralocorticoid receptor antagonists were not prescribed upon discharge due to borderline hypotension, as well.

At 2-month follow-up, the patient's left ventricle remained severely dilated (LVEDVi 126 mL/m<sup>2</sup>) but with recovered systolic function



**Figure 1** 12-lead ECG upon transfer to our hospital (top panel) demonstrating sinus tachycardia with minimal ST-elevations in V1–V3. Second ECG following admission to the medical intensive care unit (bottom panel) demonstrating worsening sinus tachycardia with increasing ST-elevations in leads V1–V4 (arrows). Note the lack of reciprocal ST-depressions.



**Figure 2** 3D-reconstructed image from CT coronary angiography showing the left main, proximal left anterior descending, and proximal left circumflex coronary arteries. Full linear reconstructions of the right and left coronary arteries were unable to be obtained due to significant artefact. Following radiologist review of several cardiac phases, there was no evidence of atherosclerosis, stenosis, or thrombosis.

(EF 65%) (Supplementary material online, Video S5). He had returned to normal activities without functional limitations. He was initially continued on lisinopril and metoprolol, but both were eventually discontinued over the course of several months given the patient's recovered left ventricular systolic function and successful treatment of his hyperthyroidism. He remained on methimazole and was clinically euthyroid on follow-up visits.

## Discussion

There is a well-defined association between hyperthyroidism and cardiac disease, most commonly atrial fibrillation and tachycardia-induced cardiomyopathy.<sup>1</sup> Excess thyroid hormone levels have also been independently associated with coronary events at hospital admission and over a 3-year follow-up.<sup>2</sup> In our case, we were concerned that the patient's transient ST-elevations were indicative of more rare complications including acute MI due to vasospasm, myocarditis, or stress cardiomyopathy.

The association between thyrotoxicosis and acute MI has been described in the literature, summarized in one case series of 21 patients presenting with acute MI and thyrotoxicosis from 2002 to 2014.<sup>3</sup> The authors found that among these patients, angiographically normal coronary arteries were the most common finding (13/21 patients), but vasospasm without thrombosis was occasionally found (3/21). Coronary vasospasm should be suspected among patients presenting with signs and symptoms of acute MI in the setting of a



hyperthyroid state, but with normal coronary arteries on angiography.<sup>4,5</sup>

Myocarditis represents an even more uncommon complication of Graves' disease but has been described in several case reports. One 46-year-old woman ultimately died of refractory heart failure in the setting of thyrotoxicosis found to have lymphocytic myocarditis on autopsy.<sup>6</sup> Another study evaluated 50 patients via cardiac magnetic resonance imaging (CMRI) who had persistently high anti-microsomal and anti-thyroglobulin antibodies as well as chest pain, dyspnoea, and palpitations.<sup>7</sup> Among them, 15 had CMRI findings consistent with myocarditis. Lymphocytic infiltration was found on endomyocardial biopsy in three of the five patients who had a reduced left ventricular ejection fraction (LVEF). The pathophysiology of myocarditis associated with Graves' disease is unclear, but the presence of thyrotropin receptor in cardiac tissue has been demonstrated by reverse transcriptase polymerase chain reaction, suggesting a possible mechanism for stimulation by thyrotropin receptor antibodies.<sup>8</sup> Concurrent viral infection with coxsackievirus B type 4 and autoimmune diseases such as Takayasu's arteritis, systemic lupus erythematosus, and rheumatoid arthritis have also been described to be associated with myocarditis in hyperthyroid patients.<sup>9,10</sup>

Thyrotoxicosis is additionally associated with takotsubo cardiomyopathy, also known as stress cardiomyopathy, as described in several case reports.<sup>11</sup> Takotsubo cardiomyopathy can mimic ST-segment elevation MI with similar electrocardiographic findings, though it is typically characterized by transient focal wall-motion abnormalities leading to apical-ballooning of the left ventricle.<sup>12</sup> Our patient did not have these characteristic wall-motion abnormalities, but his ST-segment elevation, transient systolic dysfunction, and elevated cardiac enzymes were consistent with acute stress cardiomyopathy. Furthermore, thyrotoxicosis causes excessive sympathetic stimulation which is thought to be the underlying pathophysiologic mechanism of takotsubo cardiomyopathy.<sup>12</sup>

In this case, the patient had localized ST-elevations that may have been due to coronary vasospasm, autoimmune myocarditis, or an acute stress cardiomyopathy. The absence of both reciprocal ST-depressions on ECG and focal wall-motion abnormalities on echocardiography suggest an alternative process to acute coronary thrombus formation. Additionally, his CT coronary angiography reassuringly found no evidence of coronary stenosis, though transient vasospasm could not be ruled out. If vasospasm had been definitively diagnosed or if the patient's hyperthyroidism had not rapidly stabilized, calcium channel blocker therapy would have been considered upon discharge. The patient was discharged on a beta-blocker, given its effects in both ameliorating symptoms in patients with hyperthyroidism and slowing progression of ventricular remodelling in patients with heart failure. Metoprolol was selected rather than propranolol, because our patient's borderline hypotension prevented the initiation of a non-selective beta-blocker such as propranolol, which is more commonly used in the management of uncomplicated hyperthyroidism. Additionally, CMRI would have been reasonable to accurately identify the presence of myocarditis and may be considered in other cases with diagnostic uncertainty. His global systolic dysfunction is characteristic of tachycardia-mediated cardiomyopathy but may also have been a sign of underlying myocarditis or stress

cardiomyopathy. Additionally, concomitant viral infection leading to myocarditis should be considered.

## Conclusion

Thyrotoxicosis can result in cardiovascular complications including acute MI, vasospasm, cardiomyopathy, and myocarditis. A clear diagnosis can be challenging, but a complete workup should include laboratory evaluation, ECG, and echocardiography. Ischaemic evaluation should also be performed, either non-invasively with CT coronary angiography for patients at low-to-intermediate cardiovascular risk, or invasively with cardiac catheterization for those at higher risk. Cardiac magnetic resonance imaging is a reasonable next step if the diagnosis remains unclear. Respectively, thyrotoxicosis should be considered in patients presenting with ST-elevation MI, autoimmune myocarditis, or a stress cardiomyopathy. Management should include anti-thyroid agents for thyrotoxicosis and guideline-directed medical therapy for heart failure.

## Lead author biography



Josiah Brown is a 3rd-year medical resident at the University of Washington in Seattle, WA, USA. He grew up in Portland, OR and went on to complete a bachelor's degree in mechanical engineering at Duke University before obtaining his medical degree at Oregon Health and Science University. Following residency, he will begin general cardiology fellowship at Cedars-Sinai Medical Center in Los Angeles, CA, USA. He plans to pursue a career in interventional and structural cardiology. He is a member of the American College of Cardiology.

## Supplementary material

[Supplementary material](#) is available at *European Heart Journal - Case Reports* online.

**Slide sets:** A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

**Consent:** The authors confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

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