

Thyroid Storm With Paroxysmal Atrial Flutter In Patients With Untreated Hyperthyroidism: Emergency Treatment And Effectiveness Of Disease Control

Si Dung Chu^{1*}, Huy Quang Doan², Minh Thi Tran³, Thu Kim Thi Tran⁴

^{1*}Directorate, Hai Phong - Vinh Bao International General Hospital, Vietnam

²Directorate, Vietnam University of Traditional Medicine

^{1*,2,3,4}Department of Internal Medicine, Vietnam University of Traditional Medicine

***Corresponding Author:** Si Dung Chu

^{*}Directorate, Hai Phong - Vinh Bao International General Hospital, Vietnam

Abstract

Objective: We describe a case of a patient with thyroid storm who had paroxysmal atrial flutter fibrillation on the background of hyperthyroidism but had not received any previous treatment for hyperthyroidism, intending to share more complex clinical scenarios as well as management, monitoring, and treatment for each different clinical entity.

Case report: This is a clinical case of a patient with a thyroid storm with paroxysmal atrial flutter fibrillation, heart failure, valvular disease, and large pleural effusion on the background of hyperthyroidism but without any previous treatment for hyperthyroidism. Perhaps the stress factor (hyper-catecholamine) of the patient in the previous case was also a factor that quickly accelerated the thyroid storm, accompanied by severe symptoms such as paroxysmal atrial fibrillation, heart failure, and open-heart valve disease, moderate pleural effusion. The patient received intensive treatment by digitalis drugs and diuretics such as furosemide in this emergency; After treatment, his overall condition was stable. We have been monitoring and treating this case during the past two years, the patient has been stable and he has had many subclinical and clinical improvements.

Conclusion: Drug therapy of combined treatment with Digitalis drugs and diuretics such as furosemide in initial emergency treatment has been effective and safe for patients. The prevention of recurrence of thyroid storm is to manage and treat stable hyperthyroidism as well as treat underlying diseases, thereby not only preventing and preventing recurrence of thyroid storm but also helping to restructure the heart brings long-term effects, improving the quality of life for patients.

Keywords: Thyroid storm, paroxysmal atrial flutter, Emergency treatment, Effectiveness of disease control.

INTRODUCTION

The thyroid gland is a relatively small gland located in the front of the neck and has the function of producing thyroid hormones. Thyroid hormone helps the body use energy and control some activities. They have an impact on the body's calorie-burning rate, breathing rate, digestive activity and even heart rate. Sometimes the thyroid gland secretes too much hormone and causes hyperthyroidism, which causes many body functions to become hyperactive [1], [2], [3], [4]. If left untreated, this condition can lead to a more dangerous condition called thyroid storm. Thyroid storm is a rare complication of thyrotoxicosis. There are 4 main clinical features of thyroid storm: mental disorders, high fever, rapid pulse, and gastrointestinal disorders [1], [2], [3], [4], [5]. If left untreated it can lead to atrial fibrillation, acute heart failure and fluid accumulation in the lungs, pulmonary edema, vascular collapse, coma, and death within 72 hours. Despite early diagnosis, the mortality rate remains high at 10-30% [3], [4], [6], [7], [8].

The underlying cause of a thyroid storm is hyperthyroidism. Thyroid storm is often precipitated by several factors such as infection, viral infection, Grave's disease, some other autoimmune diseases, use of iodine-containing contrast agents, internal medicine, pregnancy, surgery, trauma all stress cases (hyper-catecholamine), or some acute diseases [1], [2], [9], [10]. In this report, we describe a case of a patient with thyroid storm who had paroxysmal atrial flutter fibrillation, heart failure, and large pleural effusion on the background of hyperthyroidism but had not received any previous treatment for hyperthyroidism, intending to share more complex clinical scenarios as well as management, monitoring, and treatment for each different clinical entity.

CASE REPORT

A male patient, 35 years old, was admitted to the emergency room (ER) one evening in March 2022 at the International Hospital in Vietnam because of chest pain, rapid heartbeat, severe shortness of breath, and fatigue; The patient's recent medical history shows fatigue, palpitations, and weight loss of about 6 kg/ month Today, the patient felt chest pain,

increased shortness of breath, had difficulty breathing, so he was admitted to the hospital's emergency department, examined and had a monitor his vital signs. Examination found that the patient was awake, able to contact, nauseous, with blue skin, pale pink mucous membranes, mild fever with a temperature of 37.6 degrees Celsius, slightly lethargic and sluggish, very tired, thin, and no edema. bulging eyes, chest pain, difficulty breathing, breathing rate 31 times/minute, SpO2 94%, dull percussion and palpable reduced vibratory sounds at both lung bases, heard on auscultation There are moist rales and slightly reduced alveolar murmurs at the 2 lung bases, the heart has a systolic murmur 2/6 in the mitral valve and tricuspid valve, the heart is completely arrhythmic, the heart beats fast at 193 cycles/minute sometimes jumping to 240 - 250 cycles/minute, blood pressure 120/72 mmHg. The Abdomen is soft, not bloated.

The patient is breathing oxygen at 3 liters/minute. Images on the Monitor recorded a heart rate ranging from 193 - 250 cycles/minute, with episodes of atrial fibrillation. A regular electrocardiogram (ECG) showed images of paroxysmal atrial fibrillation with a frequency of 197 cycles/minute.

Initial diagnosis aims to urgently treat the patient with the diagnosis of paroxysmal atrial fibrillation, heart failure, moderate to severe mitral regurgitation and tricuspid regurgitation, and monitoring for pleural effusion. to erectile dysfunction in patients with undetected hyperthyroidism.

While waiting for the results of acute blood tests and subsequent paraclinical tests, the patient was given Digoxin (1 tube of digoxin 0.25 mcg mixed with distilled water for slow intravenous injection) and a diuretic (Furosemide 20mg-1ml x 2 tube) injected slowly by intravenous infusion to treat the patient's critical condition, reduce symptoms of heart failure and prevent acute pulmonary edema.

During the emergency treatment process and waiting for blood test results, the patient continued to be prescribed an emergency Doppler echocardiogram, pleural ultrasound, thyroid ultrasound, and chest X-ray, followed by an electrocardiogram. initial treatment. The results show that:

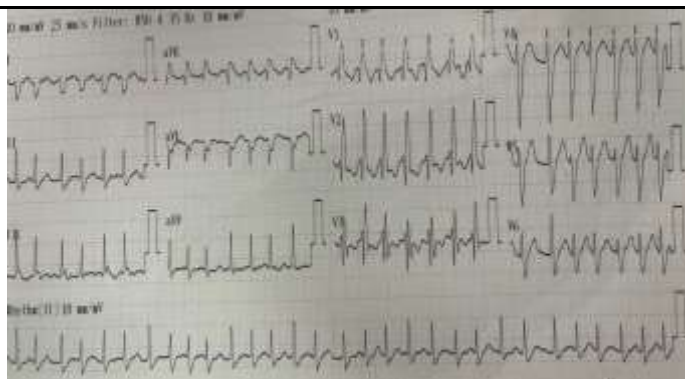


Figure 1a: ECG of paroxysmal atrial fibrillation at hospital admission

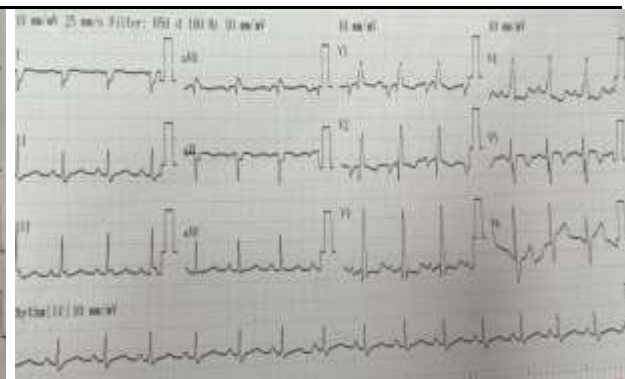


Figure 1b: ECG of atrial fibrillation after sinus rhythm resuscitation

Figure 1: Electrocardiogram results before and after emergency treatment

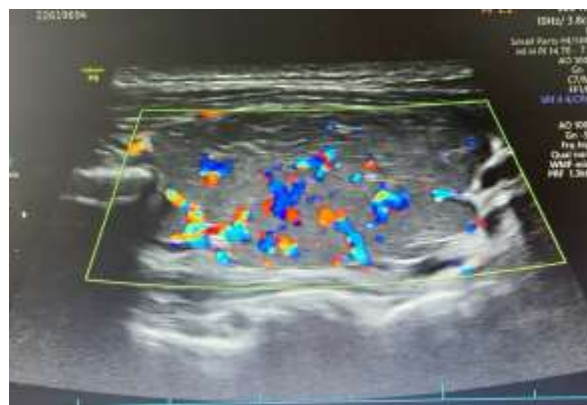
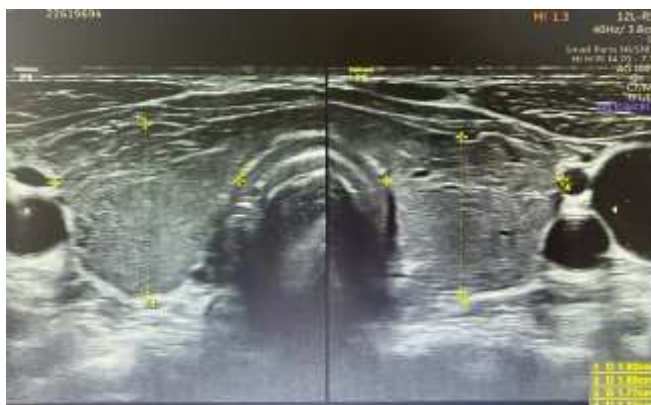


Figure 2: Thyroid Ultrasound: 2-lobed parenchyma thyroid is hypoechoic at the level of neck muscles, hypervascularity on Doppler ultrasonography



Figure 3a: Plain chest radiography



Figure 3b: Lateral chest radiography

Figure 3: Chest X-ray: Obtuse costophrenic angle on both sides - dominant right side, enlargement of the cardiac silhouette, prominent pulmonary artery arch.



Figure 4a: Right pleura



Figure 4b: Left pleura

Figure 4: Pleural Ultrasound: The right pleural cavity has fluid about 55.2 mm thick, with collapsed lung parenchyma inside. The left pleural cavity has fluid about 20.0 mm thick.

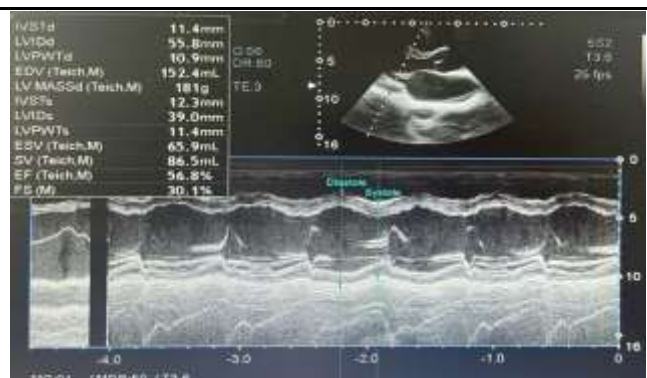


Figure 5a: Initial Doppler echocardiography: Mild aortic valve regurgitation, moderate 2/4 mitral valve regurgitation, 2/4 tricuspid valve regurgitation, and 2/4 pulmonary valve regurgitation, less pericardial fluid. Mild increase in pulmonary artery pressure (35 mmHg), dilated cardiac chambers, no cardiac movement disorders, preserved left ventricular systolic function (EF 62.6%).

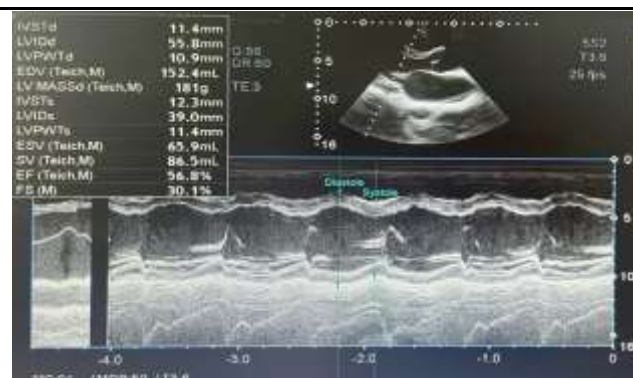


Figure 5b: Doppler echocardiography after 6 months: Mild aortic valve regurgitation, moderate 2/4 mitral valve regurgitation, 2/4 tricuspid valve regurgitation, and 2/4 pulmonary valve regurgitation. Pulmonary artery pressure still increased slightly (33 mmHg), and the heart chamber did not dilate. Preserved left ventricular systolic function (EF 56.8%).

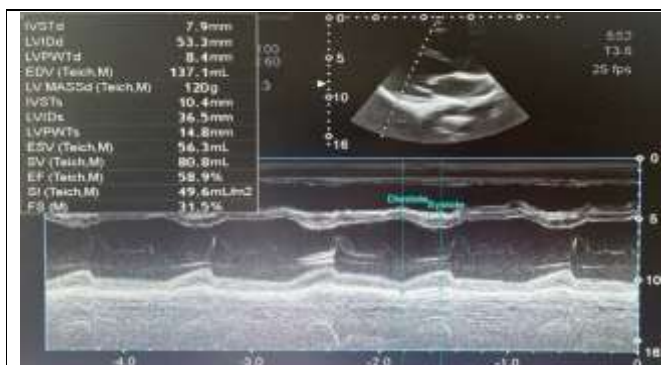


Figure 5c: Doppler echocardiography after 9 months: Micro aortic valve regurgitation, 1/4 mitral valve regurgitation, 2/4 tricuspid valve regurgitation, and 1/4 pulmonary valve regurgitation. Pulmonary artery pressure did not increase (26 mmHg). The heart chamber did not dilate. Preserved left ventricular systolic function (EF 58.9%).



Figure 5d: Doppler echocardiography after 12 months: Micro aortic valve regurgitation, 1/4 mitral valve regurgitation, Mitral tricuspid valve regurgitation, and 1/4 pulmonary valve regurgitation. Pulmonary artery pressure did not increase (25 mmHg), and the heart chamber did not dilate. Preserved left ventricular systolic function (EF 67.8%).

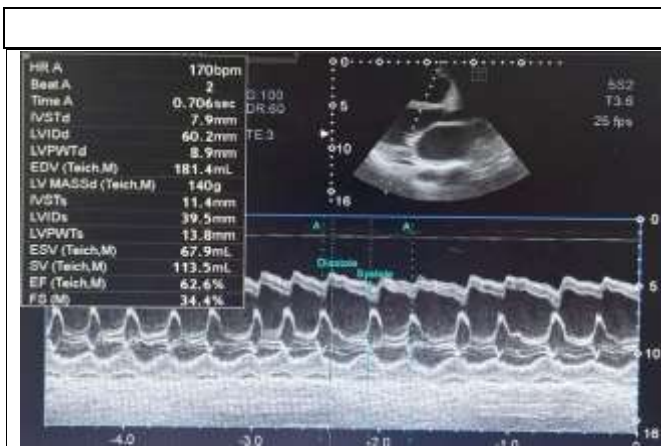


Figure 5e: Doppler echocardiography after 18 months: Micro aortic valve regurgitation, micro mitral valve regurgitation, micro tricuspid valve regurgitation, and 1/4 pulmonary valve regurgitation. Pulmonary artery pressure did not increase (23 mmHg), and the heart chambers did not dilate. Preserved left ventricular systolic function (EF 74.8%).



Figure 5f: Doppler echocardiography after 24 months: Micro aortic valve regurgitation, micro mitral valve regurgitation, micro tricuspid valve regurgitation, and micro pulmonary valve regurgitation. Pulmonary artery pressure did not increase (21 mmHg), and the heart chambers did not dilate. Preserved left ventricular systolic function (EF 73.6%).

Figure 5: Initial Doppler echocardiography results, after 6 months, 18 months, and 24 months.

Blood test results showed White blood cells (WBC) 10^9 /l, Red blood cells (RBC) 10^{12} /l, Hemoglobin HGB 10^9 /l, and platelets PLT 10^9 /l.

Biochemical tests showed: Blood Glucose 6.5 mmol/L, Urea/Creatinine: 4.22/78.9 mmol/L, GOT/GPT 66.8/41.8 mmol/L, Calcium total/ Ca^{++} : 2.25/1.37, $Na^+ /K^+ /Cl^-$ 135.0/4.0/108 mmol/L. CRP: 6.0 mg/L, BNP (B-Type Natriuretic Peptide) Index: 279, thyroid hormone test FT3 6.71, FT4 45.11, and TSH 0.002.

Blood test results confirmed that the patient had a history of hyperthyroidism but had not yet been detected for treatment. It also shows that recently, in the context of the recent COVID-19 pandemic, there have been certain effects to the patient's work environment, leading to the patient having excessive anxiety and stress, this can be one of the risk factors that promote the risk of thyroid storm complications.

Immediately after the first dose, within about 10 minutes, the heart rate decreased to 173 cycles/minute and continued to decrease gradually, the patient felt slightly more comfortable. After about 1 hour of monitoring, the heart rate returned to sinus rhythm at a frequency of 102 cycles/minute, blood pressure was stable at 112/70 mmHg, breathing rate was 17 cycles/minute, the patient no longer felt chest pain, and had less difficulty breathing. Moreover, the patient's symptoms improved quickly.

After 1 week of treatment and monitoring, the patient no longer had difficulty breathing, no chest pain, no recurrence of tachycardia or atrial fibrillation, his heart rate returned to normal and his blood pressure was stable, his overall condition was stable, and was discharged from the hospital.

When discharged from the hospital, patients continue to receive regular follow-up examinations and treatment once a month or when there are abnormalities, using and adjusting the drug therapy of Betaloc Zok (Metoprolol), Thyrozol (Thiamazole), Aldactone (Spironolactone), and other medications when it is needed in subsequent outpatient treatment for the patient. We have been monitoring and treating this case during the past two years, the patient has been stable and he has had many subclinical and clinical improvements.

Thyroid hormone test results before discharge FT3/FT4/TSH 4.64/9.64/ 0.002, test after one half a month FT3/FT4/TSH 6.71/36.15/0.017 and test after 1 month FT3/FT4/TSH 4.02/4.78/6.798 and stable thyroid hormone control during regular follow-up visits, continuous monitoring up to now of 24 months with results of FT3/FT4/TSH 4.89/9.36/0.789 is also euthyroid.

DISCUSSION

Thyroid storm, also known as paroxysmal hyperthyroidism, is also quite rare and is a decompensation of hyperthyroidism leading to fulminant thyrotoxicosis, which is life-threatening to the patient if not detected and treated. promptly can cause a high risk of death for the patient [1], [2], [3], [4]; Therefore, we need to diagnose and detect thyroid storms early to promptly treat complications as well as intervene at the root cause of the disease to help limit the risk of death. Clinical signs such as systemic, neurological, cardiovascular, digestive, etc. are the basis for diagnosing thyroid storm, referring to the diagnostic criteria for thyroid storm by authors Burch HB and Wartofsky L (1993) [4] and according to the guidelines of the American Thyroid Association (2016) [5]; In which, when the disease causes cardiovascular complications such as atrial flutter, congestive heart failure, hemodynamic instability, etc, it can lead to bad consequences; If not promptly intervened, it can lead to heart failure, death in acute pulmonary edema, congestive heart failure or vascular collapse, etc. [1], [2], [6].

Table 1: Diagnostic criteria for thyroid storm

Body temperature disorders: Degree Celsius	Point	Heart rate (beats/minute)	Point
37.2 – 37.7	5	99-109	5
37.8 – 38.2	10	110-119	10
38.3 – 38.8	15	120-129	15
38.9 – 39.4	20	130-139	20
39.4 – 39.9	25	≥ 140	25
≥ 40	30		
Perception disorder	Point	Heart failure	Point
Are not	0	None	0
Mild: Agitation	10	Mild: Lower extremity edema	5
Moderate: Delirium, confusion, lethargy, drowsiness	20	Moderate: Pulmonary rale	10
Severe: Convulsions, coma	30	Severe: Pulmonary edema	15
Digestive disorders	Point	Atrial fibrillation	Point
Are not	0	None	0
Moderate: Diarrhea, vomiting/nausea, abdominal pain	10	Yes	10
Severe: jaundice	20	Motivating factors	Point
		None	0
		Yes	10

Note: If the total score is ≥ 45 points: High risk of thyroid storm; Total score is < 25: Low risk of thyroid storm, according to Burch and Wartofsky (1993) [4], and the American Thyroid Association (2016) [5].

In this case, the patient had a mild fever, lethargy, sluggish consciousness, and nausea. Monitor recorded heart rate ranging from 193 - 250 cycles/minute, atrial fibrillation appeared, and the lungs had many moist rales, on a plain chest X-ray, there is an enlarged heart silhouette. Tests containing thyroid hormones indicate that the patient has underlying hyperthyroidism but has not been treated. Emergency Doppler echocardiography showed moderate to severe Mitral and Tricuspid valve regurgitation, with pleural effusion. Clinical signs and acute tests, referenced with the author's criteria for diagnosing thyroid storm Burch HB and Wartofsky L (1993) [4] and recommendations of the American Thyroid Association (2016) [5] have also pointed out that this condition is a thyroid storm; The prognosis is very severe and there is a risk of death if not treated promptly and properly.

A Thyroid storm is a very dangerous condition. While waiting for the results of a blood test to evaluate thyroid hormones, treatment for paroxysmal atrial fibrillation is something that needs immediate attention, for atrial fibrillation. Based on heart failure, the use of antiarrhythmic and cardiac support drugs such as cardiac glycoside in this case is the first choice to control paroxysmal atrial fibrillation. Digoxin is a cardiac glycoside, obtained from *Digitalis Lanata* leaves. Digoxin inhibits the Na-K ATPase channel, so it works by increasing the force of myocardial contraction, has a positive muscle fiber contraction effect, and has the effect of reducing cardiac activity. properties of the sympathetic nerve, the parasympathetic effect leads to a decrease in heart rate and conduction through the atrioventricular node, thereby reducing heart rate in people with heart failure because the increased force of myocardial contraction improves circulation.. *Digitalis* also has the effect of reducing direct rhythm regulation (direct effect on heart rate) and reducing heart rate through parasympathetic nerve stimulation (stimulating the vagus nerve). Digoxin also slows conduction in the atrioventricular node. Digoxin's bioavailability is very high. When injected, clinical effects begin to appear after about 10 minutes and are complete within 2-4 hours [11], [12], [13]. This patient also has no contraindications or extreme caution when using digoxin because the electrocardiogram does not show atrioventricular block, Wolff-Parkinson-White syndrome [11], [14], nor does the electrocardiogram suggest the disease. hypertrophic cardiomyopathy, even if there is hypertrophic cardiomyopathy, when there is concurrent atrial fibrillation and heart failure on the background of hypertrophic cardiomyopathy, the use of digoxin is still reasonable [11], [15], [16], of course, the echocardiogram results later did not show any dilated heart disease.

The reason we did not use Amiodarone infusion to intervene in atrial fibrillation in this case is that Amiodarone is a powerful class III antiarrhythmic drug indicated in the treatment of paroxysmal supraventricular tachycardia and malignant ventricular tachyarrhythmia. atrial fibrillation, atrial flutter, it is an iodine-rich compound with a molecular structure similar to Thyroxine (T4) and Triiodothyronine (T3), so Amiodarone can cause serious thyroid dysfunction in human's disease with or without underlying thyroid disease, causing a dangerous condition and can aggravate existing heart disease [11], [12], [13]. Beta-blockers should also be used with caution in this early stage because patients with heart failure have many moist rales in the lungs [11], [12], [13].

According to recommendations, treatment measures include: Restore and ensuring vital signs such as intravenous fluids, treating electrolyte disorders, if fever is reduced with Acetaminophen, if heart failure is present, treating with *Digitalis* (rate control dose when there is no secondary route is recommended as 0.25 mg intravenously every 2 hours, maximum intravenous dose is 0.5-1 mg, maintenance dose 0.125 - 0.375 mg/day intravenously) and diuretics, treatment of arrhythmias with Conventional antiarrhythmic drugs such as Beta blockers to control cardiovascular symptoms. Inhibit the synthesis and release of hormones with synthetic Propylthiouracil (PTU) Antithyroid drugs. If PTU is not available, Methimazole can be used. Potassium iodine if available (give only 1-2 hours after taking synthetic Antithyroid drugs). Glucocorticoids can be used such as Dexamethasone 2 mg every 6 hours orally or intravenously or Hydrocortisone 50-100 mg intravenously every 6-8 hours. At the same time, find and treat favorable factors such as antibiotic treatment if there is an infection... However, specific treatment for thyroid storm must be started first, and you should not wait for complete test results to proceed. treatment [17], [18], [19], [20], [21], [22].

Patients can prevent this thyroid storm by identifying the cause, identifying comorbidities, and accurately treating and adhering to the treatment regimen for controlling the patient's hyperthyroidism. Treatment of hyperthyroidism depends on the patient's age, cause, severity, and other comorbidities. In addition to complying with treatment according to the doctor's orders, people with hyperthyroidism also need to follow a healthy diet, exercise, and control stress to the lowest level possible.

Effective treatment of thyroid storm: A Thyroid storm is a medical emergency, any patient with symptoms of thyroid storm should be treated immediately and should be treated in an intensive care unit. rescue and active resuscitation. In most cases, determining the cause and correct treatment will improve the symptoms of thyroid storm within 24 hours as well as be effective in emergency management. Recovery time depends on the factors that caused the thyroid storm and can last about 1 week.

Thyroid storm is a very dangerous condition, waiting for test results can waste a valuable amount of time for the patient, so in the case of patients with paroxysmal atrial fibrillation or heart failure such as In this case, we treated arrhythmia control, paroxysmal atrial fibrillation with a combination of beta blocker and digoxin immediately while waiting for thyroid hormone test results, and treated pneumonia. with antibiotics, after treatment, the pneumonia stabilized and the pleural fluid subsided. Immediately after, the patient had less chest pain, and less difficulty breathing, and the heart rate on the electrocardiogram returned to medium-frequency sinus rhythm.

After emergency treatment for this patient, the next treatment strategy is to restore thyroid function to normal as soon as possible, control complications caused by thyroid storm, and eliminate precipitating factors. Thyroid storm appeared like pneumonia and stress in this patient. After about 1 week of treatment, stable patients are discharged from the hospital to continue monitoring and outpatient treatment. Management of the later stages is extremely important in complying with the treatment regimen to control thyroid function. Stabilize and prevent the risks of diseases that are likely to be factors that promote the aggravation of hyperthyroidism and the occurrence of thyroid storms. The patient's outpatient treatment regimen continues to use and adjust the drugs Betaloc Zok 50 mg (Metoprolol), Thyrozol 5mg (Thiamazole), and Aldactone 25 mg (Spironolactone) per day in the patient's next outpatient treatment [21], [22]. This patient has been followed for the past 2 years, with stable thyroid function control and no recurrence of thyroid storm. Patients also improved many other functions. Clinically, the patient regained weight, had no chest pain, no difficulty breathing, and was Euthyroid.

Evaluation on echocardiography shows that many indicators have improved significantly (**Figure 5**), it can be seen that the degree of mitral and tricuspid valve regurgitation, aortic and pulmonary valve have improved significantly since the 9 third month so far. Pulmonary artery pressure improved significantly after 9 months (initially increased pulmonary artery pressure from 35 mmHg to 26 mmHg) months until 2 years ago (initially 35 mmHg to 17 mmHg). systolic left ventricular diameter (initial Vd from 181, after 6 months clearly improved to 152, and after 2 years to 101) and diastolic left ventricular diameter (initial Vd from 68, after 6 months no improvement was seen clearly, however after 9 months the score improved to 56, and after 2 years the score to 29) gradually improved over time of treatment (**Figure 5**). Several studies around the world have also recorded the results in myocardial restructuring after a certain period of treatment [23], [24], [25], [26], [27].

Regarding dilated heart chambers, after 6 months of stable treatment, the condition of initially dilated heart chambers has improved significantly. Continued monitoring and treatment during the past 2 years, the results are clear. The condition of the degree of regurgitation of the heart valves has improved very clearly, the heart chambers are no longer dilated (**Figure 5**). Even though it is functionally preserved in heart failure, the left ventricular myocardial contractile function has also significantly improved after prolonged treatment management [23], [24], [25], [26], [27] which shows that thyroid hormone control treatment in the treatment of hyperthyroidism is very important in preventing thyroid storm and improve heart function.

CONCLUSION

This is a clinical case of a patient with a thyroid storm with paroxysmal atrial fibrillation, heart failure, valvular disease, and large pleural effusion on the background of hyperthyroidism but without any previous treatment for hyperthyroidism. Perhaps the stress factor (hyper-catecholamine) of the patient in the previous case was also a factor that quickly accelerated the thyroid storm, accompanied by severe symptoms such as paroxysmal atrial fibrillation, heart failure, and open disease. heart valve, moderate pleural effusion. The choice of drug therapy of combined treatment with Digitalis group drugs and diuretics such as furosemide in initial emergency treatment has been effective and safe for patients. The prevention of recurrence of thyroid storm is to manage and treat stable hyperthyroidism as well as treat underlying diseases, thereby not only preventing and preventing recurrence of thyroid storm but also helping to restructure the heart brings long-term effects, improving the quality of life for patients.

REFERENCE

1. Chiha M, Samarasinghe S, and Kabaker AS. Thyroid storm: an updated review. *J Intensive Care Med.* 2015; 30 (3): 131-40.
2. Akamizu T, et al. Diagnostic criteria, clinical features, and incidence of thyroid storm based on national surveys. *Thyroid.* 2012; 22 (7): 661-79.
3. Takashi A. Thyroid Storm: A Japanese Perspective. *Thyroid* 2018; 18 (1): 32-40.
4. Burch HB and Wartofsky L. Life-Threatening Thyrotoxicosis: Thyroid Storm. *Endocrinology and Metabolism Clinics of North America.* 1993; 22 (2): 263-277.
5. Douglas SR, Henry BB, David SC. 2016 American Thyroid Association Guidelines for Diagnosis and Management of Hyperthyroidism and Other Causes of Thyrotoxicosis. *Thyroid.* 2016; 26 (10): 1343-1421.
6. Baker SP, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma and Acute Care Surgery.* 1974; 14 (3),
7. Lahey FH. Apathetic thyroid. *Annals of surgery.* 1931; 93 (5): 1026-1030.
8. Wang HI, et al. Thyroid Storm in a Patient with Trauma – A Challenging Diagnosis for the Emergency Physician: Case Report and Literature Review. *The Journal of Emergency Medicine.* 2017; 52 (3): 292-298.

9. Feldt-Rasmussen U and Emerson CH (2012). Further thoughts on the diagnosis and diagnostic criteria for thyroid storm. *Thyroid*. 2012; 22 (11), 1094-5.
10. Nayak B and Burman K. Thyrotoxicosis and Thyroid Storm. *Endocrinology and Metabolism Clinics of North America*. 2006; 35 (4): 663- 686.
11. Galen S, Wagner, David G, Strauss. *Marriott's Practical Electrocardiography*; 12th edition. Wolters Kluwer, 2013.
12. McDonagh TA et al. 2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure: ESC Clinical Practice Guidelines. *European Heart Journal*. 2021; 42 (36): 3599-3726.
13. Virani SS, Alonso A, Benjamin EJ et al. American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. Heart Disease and Stroke Statistics – 2020 Update: A Report from the American Heart Association. *Circulation*. 2020; 141 (9): e139-3596.
14. Chu SD, Pham KQ, Tran DV. Development and evaluation of 12-lead electrocardiogram in the left free wall of accessory pathway localization in patients with typical Wolff-Parkinson-White syndrome. *Biomedical Research and Therapy* 2018; 5 (11): 2832-2840.
15. Felker MG, Shaw KL. A Standardized Definition of Ischemic Cardiomyopathy for Use in Clinical Research. *J Am Coll Cardiol*. 2002; 39: 210-8.
16. Chu SD, Doan HQ, Tran MT. Individualized treatment strategy for acute exacerbation of chronic heart failure in patients with dilated cardiomyopathy: what is the optimal treatment? *Pakistan Heart Journal* 2024; 57 (1): 192-198.
17. Hagiwara A, et al. Thyroid Storm After Blunt Thyroid Injury: A Case Report. *Journal of Trauma and Acute Care Surgery* 2007; 63. (3).
18. Kasagi K and Hattori H. A case of destructive thyrotoxicosis induced by neck trauma. *Thyroid* 2008; 18 (12): 1333-5.
19. Delikoukos S and Mantzos F. Thyroid storm induced by trauma due to spear fishing-gun trident impaction in the neck. *Emergency Medicine Journal* 2007; 24. 355-6.
20. Delikoukos S and Mantzos F. Thyroid storm induced by trauma due to spear fishing-gun trident impaction in the neck. *Emergency Medicine Journal*. 2007; 73. 1247-9.
21. Gregg-Smith SJ. Thyroid storm followed chest trauma. *Injury*. 1993; 24 (6)
22. Jacobs RR. Acute hyperthyroidism precipitated by trauma. *South Med J*. 1979; 72 (7): 890-1.
23. Hussein SA, Abdulrahman MA, Rieda MEO. Surgical treatment of functional mitral regurgitation in dilated cardiomyopathy. *Journal of the Saudi Heart Association*. 2011; 23: 125-134.
24. Rory BW, Aaron LB, Annabel CT, et al. Improvement in structural and functional echocardiographic parameters during chronic heart failure therapy guided by natriuretic peptides: mechanistic insights from the ProBNP Outpatient Tailored Chronic Heart Failure (PROTECT) study. *European Journal of Heart Failure*. 2013; 15: 342-351.
25. Haozhang H, Jin L, Min L, et al. A Universal New Definition of Heart Failure with Improved Ejection Fraction for Patients with Coronary Artery Disease. *Frontiers in Physiology* 2021; 12 (770650): 1-9.
26. Jacinthe B, Mandeep RM. Left Ventricular Reverse Remodeling in Heart Failure: Remission to Recovery. *Structural Heart*. 2021; 5 (5): 466-481.
27. Rutger-Jan N, Joanna MR, Francisco LJ, et al. Treatment Decision in Aortic Stenosis – Look at the Valve but Do Not Forget the Ventricle. *SN Comprehensive Clinical Medicine*. 2023; 5 (101): 2023.