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Chapter

Thyroid Storm: Clinical Manifestation, Pathophysiology, and Treatment

Rahul Pandey, Sanjeev Kumar and Narendra Kotwal

Abstract

Thyroid storm is a rare but life-threatening endocrine emergency. It is an acute exaggerated clinical manifestation of thyrotoxic state. The exact incidence is unknown. It occurs in 1–2% of patients admitted for thyrotoxicosis. It has a mortality of 10–20%. This chapter would help us to understand its clinical manifestations, pathophysiology, and effective treatment. Terminal learning objective would be to diagnose impending storm early and start prompt treatment in day-to-day practice. The chapter would cover pathophysiology including triggers, clinical features including various diagnostic criteria, diagnosis, and treatment of thyroid storm. Indications of surgical treatment in storm will be discussed.

Keywords: thyroid storm, endocrine emergency, thyroid crisis, thyrotoxic storm, thyrotoxic crisis

1. Introduction

Thyroid storm, also known by its synonyms thyroid crisis, thyrotoxic storm, or thyrotoxic crisis, is an extremely rare but life-threatening endocrine emergency. It is an acute exaggerated clinical manifestation of thyrotoxic state [1]. It was first described by Frank Howard Lahey in 1926 as "the crisis of exophthalmic goiter" [2]. Till date, clinicians are puzzled to accurately describe the signs and symptoms of thyroid storm as it involves almost all systems of the body. Accurately diagnosing the condition is very difficult, and groups around have been working to define a clear diagnostic criterion based on universal clinical parameters [3]. Diagnosing the storm early is crucial in order to improve the morbidity and mortality associated with it.

2. Epidemiology

2.1 Incidence

Incidence of thyroid storm is not precisely known. Incidence in general population was reported as 0.57-0.76 per lac per year in USA and 0.20 per lac per year in Japan, whereas incidence in hospitalized patients was 4.8-5.6 per lac per year [4–6]. Hospital data suggest that it occurs in 1–2% of patients admitted for thyrotoxicosis [5]. It occurs more commonly in women and patients with Graves' disease [7]. Autonomous nodules are the culprit in elderly patients [8].

2.2 Mortality

Seventy-five percent of patients hospitalized with thyroid storm die [9]. Overall mortality rate has been reported to be 10–20% [4, 10–12]. Multiple system dysfunction is the commonest cause of death, followed by heart failure [13], respiratory failure [13], and sepsis [3, 14].

3. Pathophysiology of storm

In order to understand the pathophysiology and rationale of treatment for thyroid storm, we need to understand the normal thyroid hormone physiology. Normal thyroid function is under control of feedback mechanisms between the hypothalamus, anterior pituitary and thyroid gland. "Thyrotropin-releasing hormone" (TRH) stimulates anterior pituitary to release "thyroid-stimulating hormone" (TSH), which binds to its receptor on thyroid gland and stimulates the synthesis and secretion of thyroid hormone. The thyroid hormone synthesis is a five-step process comprising of: (a) iodide trapping; (b) organification—oxidation and iodination; (c) coupling; (d) storage; and (e) release. Transport of iodide into the thyroid follicular cell via a sodium-iodide symporter is the first step in hormone synthesis, known as "iodide trapping." Iodide is then "oxidized and organified" by thyroid peroxidase enzyme (TPO). Iodination of tyrosine residues on thyroglobulin (framework protein for thyroid hormone synthesis) is catalyzed by TPO forming thyroxine (T4) and triiodothyronine (T3). Thyroid hormone acts through intranuclear action of T3 with T4 acting more as a "prohormone" [15]. Twenty percent of T3 comes directly from thyroid gland and 80% of circulating T3 comes from peripheral conversion of T4 to T3. The entire process is controlled by a negative feedback loop with peripheral thyroid hormone inhibiting the release and synthesis of TSH and TRH. Majority of the thyroid hormone is protein-bound (>99%) to thyroid-binding globulin (TBG), transthyretin, and albumin [16] making a "circulating storage pool," while unbound or free hormone is available for uptake into the tissues.

Peripheral conversion of T4 to T3 is done by the 5′-deiodinases. The deiodinase D2 is active in euthyroid state whereas in hyperthyroid state deiodinase D1 is more prevalent. The deiodinase D1 is susceptible to inhibition by thionamide and propylthiouracil (PTU). Glucocorticoids and β-blockers inhibit peripheral conversion of T4 to T3. This understanding will help us understand the rationale behind use of various classes of drugs in the treatment of thyroid storm.

Exact pathophysiology of thyroid storm is poorly understood. Several hypotheses have been postulated for the storm, which are as follows:

3.1 Acute increase in release of T4 or T3 from thyroid gland

It is the most important mechanism behind thyroid storm [17]. Acute increase in T4 or T3 hormones is seen after radioiodine therapy, thyroidectomy, discontinuation of antithyroid drugs, and administration of iodinated contrast agents or iodine [18]. Rapid improvements in clinical condition after reduction in T4 or T3 concentration after peritoneal dialysis or plasmapheresis support this theory [19].

3.2 Acute illness causes decrease in protein binding of T4 and T3 in serum resulting in increase of free T4 and T3

Acute illnesses lead to decrease in protein binding of T4 and T3 [20], either due to decrease in production of transthyretin or due to production of inhibitors of T4- and T3-binding protein [21]. They lead to decrease in bound form of T4 and T3,

which ultimately leads to relative increase in serum concentration of the hormones, which causes storm [22].

3.3 Role of sympathetic nervous system activation

Many symptoms and signs of thyroid storm mimic those of catecholamine excess, suggesting the role of sympathetic nervous system activation [23]. Dramatic improvement in symptoms following beta blocker administration supports this hypothesis [24].

3.4 Augmentation of cellular responses to thyroid hormone

In patients with condition of hypoxemia, ketoacidosis, lactic acidosis, and infection, there is augmentation of cellular response to thyroid hormone [25]. There is uncoupling of oxidative phosphorylation leading to generation of ATP, which results in excess utilization of substrate, increased oxygen consumption, thermogenesis, and hyperthermia [26]. Excess heat is dissipated by increased sweating and cutaneous vasodilation, the most common symptoms of thyroid storm.

4. Triggers of thyroid storm

The transition from simple thyrotoxicosis to thyrotoxic crisis requires a superimposed insult. Any primary cause of hyperthyroidism can escalate into thyrotoxic crisis. There are triggers that can induce thyroid storm in patients with unrecognized thyrotoxicosis, which includes nonthyroidal surgery, parturition, major trauma, infection, or iodine exposure from radiocontrast dyes or amiodarone [27]. Common and rare triggers are listed in **Table 1**. Infection is the most common precipitant of thyroid storm in the hospitalized patients [3, 17, 27, 28]. There is no identifiable precipitating factor in about 25–43% of patients of storm [29].

Common	Rare
Infection [6]	Vigorous palpation of thyroid gland [30]
Acute medical illness	Subacute thyroiditis [31]
Acute psychosis [32]	Thyroxine overdosage [33]
Nonthyroidal surgery [18]	Aspirin intoxication [34]
Parturition [35]	Hydatidiform mole [36]
Trauma [37]	OP poisoning [38]
Discontinuation of antithyroid drugs [39]	Neurotoxins [40]
After radioactive iodine therapy [41]	Cytotoxic chemotherapy [42]
Post-thyroidectomy [43]	
After high dose of iodine administration [44]	
Iodinated radiographic contrast agents [45]	

Table 1.
Triggers of thyroid storm.

5. Clinical features and diagnosis

The diagnosis of thyroid storm is purely clinical, and if suspected, treatment should be initiated simultaneously without any delay. Clinical picture comprises

of an exaggerated feature of hyperthyroidism accompanied by manifestations of multiorgan dysfunction, with the presence of an acute precipitating factor [46]. Symptoms, signs, and clinical features are listed in **Tables 2–4** respectively.

Hyperpyrexia (104–106°F) with diaphoresis is the key presenting feature. High fever induces profuse sweating and leads to insensible fluid losses, which is a differentiating feature between thyroid storm and thyrotoxicosis [1]. Cardiovascular manifestations include palpitations, tachycardia, exercise intolerance, dyspnea on exertion, widened pulse pressure, myocardial ischemia, and atrial fibrillation. Heart rate > 140/min is out of proportion to the underlying illness [47]. The increased cardiac output and tachyarrhythmia may progress to cardiogenic shock [48, 49]. The central nervous system (CNS) manifestations include agitation, delirium, confusion, stupor, obtundation, and coma. CNS involvement is a poor prognostic factor for mortality [3]. Gastrointestinal (GI) symptoms include nausea, vomiting, diarrhea, abdominal pain, intestinal obstruction, and acute hepatic failure [29]. Vomiting and diarrhea add to significant fluid loss. Liver dysfunction and hepatomegaly are due to hepatic congestion and hypoperfusion, or directly due to hyperthyroidism [17]. Jaundice is a poor prognostic indicator [50]. Unusual presentations include acute abdomen, status epilepticus, rhabdomyolysis, hypoglycemia, lactic acidosis, and disseminated intravascular coagulation [51–54].

Various clinical entities that mimic thyroid storm exist, which confounds the existent diagnostic dilemma, namely, peritonitis [55], sepsis/septic shock [56], heat stroke [57], malignant hyperthermia [58], acute pulmonary edema [59], neuroleptic malignant syndrome [60], and serotonin syndrome [61]. The mimics of thyroid storm are listed in **Table 5**.

Hyperactivity, irritability, dysphoria
Heat intolerance and sweating
Palpitations
Fatigue and weakness
Weight loss with increased appetite
Diarrhea
Polyuria
Oligomenorrhea, loss of libido

Table 2.
Symptoms of thyroid storm.

Tachycardia, atrial fibrillation
Tremor
Goiter
Warm, moist skin
Muscle weakness, proximal myopathy
Lid retraction or lag
Gynecomastia
Signs of ophthalmopathy and dermopathy specific for Grave's disease

Table 3.
Signs of thyroid storm.

Abrupt onset
Fever—high grade
Progressively increasing to lethal levels within 24–48 h
Warm skin, flushing, profuse diaphoresis
Goiter and exophthalmos ±
Tachycardia >140 beats/min, atrial fibrillation
Agitation, delirium, psychosis, coma
Diarrhea, nausea, vomiting, pain abdomen, unexplained jaundice

Table 4.
Clinical features of thyroid storm.

Peritonitis
Sepsis/septic shock
Heat stroke
Malignant hyperthermia
Acute pulmonary edema
Neuroleptic malignant syndrome
Serotonin syndrome
Peritonitis

Table 5.
Mimics of thyroid storm.

Burch and Wartofsky's Diagnostic Criteria for Thyroid Storm

Factor	Score
Thermoregulatory dysfunction (temperature ,°F)	
99-99.9	5
100-100.9	10
101-101.9	15
102-102.9	20
103-103.9	25
>=104	30
Central nervous system effects	
Absent	0
Mild	10
Agitation	
Moderate	20
Delirium	
Psychosis	
Extreme lethargy	
Severe	30
Severe	
Coma	
Gastrointestinal-hepatic dysfunction	
Absent	0
Moderate	10
Diarrhea	
Nausea-vomiting	
Abdominal pain	
Severe	20
Unexplained jaundice	

Factor	Score
Cardiovascular dysfunction (tachycardia, beats per minute)	
90-109	5
110-119	10
120-129	15
130-139	20
>=140	25
Congestive heart failure	
Absent	
Mild	0
Pedal edema	5
Moderate	
Bibasilar rales	10
Severe	
Pulmonary edema	15
Atrial fibrillation	
Absent	0
Present	10
Precipitant History	
Negative	0
Positive	10

No storm	<25
Impending storm	25-44
Thyroid storm	45

Figure 1.
Burch and Wartofsky's diagnostic criteria for thyroid storm [28].

Burch and Wartofsky [28] assigned a numerical score to each of the different signs and symptoms of thyroid storm to establish a diagnostic criterion based on the total score calculated as shown in **Figure 1**. Japan Thyroid Association surveyed the incidence of thyroid storm in Japan and formulated population-specific diagnostic criteria based on the presence of the classic organ system manifestations as shown in **Table 6**.

Both Burch and Wartofsky score (BWS) and the Japan Thyroid Association (JTA) guidelines are acceptable. However, in one study, BWS ≥45 was reported to

Prerequisite for diagnosis		
Presence of thyrotoxicosis with elevated levels of free triiodothyronine (FT3) or free thyroxine (FT4)		
Symptoms		
1. Central nervous system (CNS) manifestations: restlessness, delirium, mental aberration/psychosis, somnolence/lethargy, coma (≥1 on the Japan Coma Scale or ≤14 on the Glasgow Coma Scale)		
2. Fever: ≥ 38°C		
3. Tachycardia: ≥130 beats per minute or heart rate ≥ 130 in atrial fibrillation		
4. Congestive heart failure (CHF): pulmonary edema, wet crackles over more than half of the lung field, cardiogenic shock, or Class IV by the New York Heart Association or ≥Class III in the Killip classification		
5. Gastrointestinal (GI)/hepatic manifestations: nausea, vomiting, diarrhea, or a total bilirubin level ≥ 3.0 mg/dL		
Diagnosis		
Grade of thyroid storm (TS)	Combinations of features	Requirements for diagnosis
TS1	First combination	Thyrotoxicosis and at least one CNS manifestation and fever, tachycardia, CHF, or GI/ hepatic manifestations
TS1	Alternate combination	Thyrotoxicosis and at least three combinations of fever, tachycardia, CHF, or GI/ hepatic manifestations
TS2	First combination	Thyrotoxicosis and a combination of two of the following: fever, tachycardia, CHF, or GI/ hepatic manifestations
TS2	Alternate combination	Patients who met the diagnosis of TS1 except that serum FT3 or FT4 level are not available
Exclusion and provisions		
Cases are excluded when clear cut underlying pathology is present for the following symptoms: fever (e.g., pneumonia and malignant hyperthermia), impaired consciousness (e.g., psychiatric disorders and cerebrovascular disease), heart failure (e.g., acute myocardial infarction), and liver disorders (e.g., viral hepatitis and acute liver failure). Therefore, it is difficult to determine whether the symptom is caused by TS or is simply a manifestation of an underlying disease; the symptom should be regarded as being due to a TS that is caused by these precipitating factors. Clinical judgment in this matter is required.		

TS1, "Definite" TS; TS2, "Suspected" TS.
Adapted from: Akamizu et al. [3].

Table 6.
The diagnostic criteria for thyroid storm (TS) of the Japan Thyroid Association.

be more sensitive than JTA guidelines in detecting patients with storm [62, 63]. It is recommended to use both criteria to increase the accuracy of the diagnosis of thyroid storm [44, 63].

Although diagnosis of thyroid storm is clinical, laboratory values aid in the diagnosis and treatment. A complete workup including estimation of TSH, free T4, and free T3 should be done in the intensive care unit (ICU) setting. Leukocytosis indicates infection (commonest factor for storm). Elevated blood urea nitrogen [3] and liver function abnormalities with elevation in the transaminases and hyperbilirubinemia indicate irreversible abnormalities. Hypercalcemia may be found due to the high bone resorption that accompanies hyperthyroidism and can exacerbate dehydration. Hyperglycemia is due to a combination of increased catecholamine inhibition of insulin release and increased gluconeogenesis [64].

6. Management

The treatment of thyroid storm should be initiated as soon as the diagnosis is suspected. Patients should be triaged to an intensive care setting for close monitoring and aggressive treatment. A multidisciplinary team approach is important in order to successfully offer the patient all possible therapeutic options. Immediate goals of thyroid-specific therapy should be targeted to decrease thyroid hormone synthesis and release, decrease peripheral action of thyroid hormone, and treat the precipitating cause.

6.1 Inhibiting new thyroid hormone synthesis

The first-line therapy in treating thyroid storm consists of inhibiting new thyroid hormone production. This approach most commonly utilizes thionamides which includes thiouracils (PTU) and imidazoles (methimazole and carbimazole). They inhibit thyroid peroxidase (TPO), thereby inhibiting formation of T3 and T4 from thyroglobulin [65]. Both methimazole and PTU are used but PTU is favored during thyroid storm due to its additional benefit over carbimazole and methimazole, namely rapid onset of action and inhibition of peripheral conversion of T4 to T3 mediated by peripheral deiodinase. In addition, PTU can be safely used in pregnancy.

The dose of PTU is 600–1500 mg/day in divided doses every 4–6 h [27, 28, 66] with a loading dose of 600 mg. Dose of methimazole is 80–120 mg daily in divided doses every 4–6 h [27, 28, 66]. The American Association of Clinical Endocrinologist/American Thyroid Association guidelines recommend 500–1000 mg loading dose of PTU followed by 250 mg every 4 h and 60–80 mg/day of methimazole in divided doses [67]. Routes of administration include intravenous, enteral, and per rectal as suppository or retention enema. PTU is relatively insoluble at physiologic pH, therefore its intravenous preparation and administration are difficult. Intravenous methimazole can be prepared easily by dissolving methimazole powder in normal saline [68].

Nonradioactive iodine also decreases new thyroid hormone synthesis. It is due to the inhibition of organic binding of iodide to thyroglobulin as plasma iodide levels reach a critical threshold, a phenomenon known as the Wolff-Chaikoff effect. The effect is transient, lasting for about 50 h, as the thyroid eventually escapes/adapts to prolonged iodide excess [69]. Inorganic iodine may be given orally as a saturated solution of potassium iodide (SSKI) by administering five drops (0.25 mL or 250 mg) every 6 h or as Lugol's solution (eight drops given every 6 h) [28, 67]. Routes can be enteral, rectal, or intravenous. SSKI is prepared for rectal dosing by

mixing 1 g of iodide in 60 mL of water and administering 2 g/day in divided doses [70]. Lugol's solution can be given rectally in doses of 4 mL (80 drops) per day [71]. Iodine should be given at least 30 min after administering thionamides to avoid the iodine serving as a substrate for new thyroid hormone production and worsening the hyperthyroidism. Thionamides must be continued during therapy with iodine to avoid organification of iodine and increased thyroid hormone production. Iodine administration delays definitive treatment of patients' hyperthyroidism with radioactive iodine [27, 28]. Therefore, iodine should be used only when the end goal is thyroidectomy.

Lithium hampers T4 and T3 synthesis by inhibiting the coupling of iodotyrosine residues. When iodine administration is not possible (secondary to iodine induced anaphylaxis) or desired, lithium may be substituted. It is administered at doses of 300 mg every 6–8 h with monitoring of serum levels.

6.2 Inhibiting thyroid hormone release

The next line of treatment is inhibiting the release of preformed hormone. Iodine administration, additionally, blocks the release of preformed hormone by inhibiting the release of iodothyronines (T3 and T4) from thyroglobulin [28, 72]. This effect of iodine has a faster onset than PTU, which blocks synthesis in a thyroid gland that has a large store of already formed hormone [73]. The combination therapy of thionamides and iodine decrease serum T4 levels to normal range in 4–5 days [74].

6.3 Inhibiting the peripheral effect of thyroid hormone

Both α- and β-adrenergic stimulation are enhanced in thyroid storm. Thus, adrenergic blockade is an integral part of the treatment. β-Blockers have been used in treatment of both uncomplicated and complicated hyperthyroidism [75]. Propranolol is the most commonly used β-blocker due to its nonselective β-adrenergic antagonism and its ability to block the peripheral conversion of T4 to T3. The recommended dose is 60–120 mg orally every 6 h [64]. For a more rapid effect, intravenous propranolol or a shorter acting β-blocker such as esmolol can be used. The dose of intravenous propranolol is 0.5–1.0 mg slow infusion for an initial dose and then 1–2 mg at 15-min intervals while monitoring the heart rate carefully. Esmolol is given as an initial bolus of 0.25–0.5 mg/kg followed by a continuous infusion rate of 0.05–0.1 mg/kg per minute [73].

6.4 Inhibiting enterohepatic circulation of thyroid hormone

Enterohepatic circulation of thyroid hormone is targeted for severe and refractory thyroid storm. Thyroid hormone is metabolized in the liver where it is conjugated to glucuronides and sulfates. Conjugated products are excreted into the intestine through bile, where free hormones are released, reabsorbed, and circulated. This is enterohepatic circulation of thyroid hormone. Cholestyramine binds the conjugation products and promotes their excretion, and can be used to decrease thyroid hormone levels. The recommended dose is 1–4 g twice a day [76–78].

6.5 Other therapies

The oral iodinated contrast agents are inhibitors of both deiodinases D1 and D2 and help in lowering T3 levels. Additionally, they inhibit new thyroid hormone

synthesis and release of preformed hormones from the gland. They are given as 2 g loading dose followed by 1 g daily [74, 79]. Lower doses are given for preoperative preparation for thyroid surgery [80, 81] and as an adjunct to thionamides in treatment of Graves' disease [82].

6.6 Supportive and resuscitative measures

Resuscitative measures should be initiated immediately in an ICU setting. Urgent addressal of systemic decompensation requires correction of hyperthermia, dehydration, congestive heart failure, dysrhythmia, and prevention of adrenal crisis [73]. Hyperthermia should be controlled with peripheral cooling and antipyretics. Acetaminophen is preferred over salicylates as salicylates increase free hormone levels by decreasing binding to T4-binding globulin, thereby exacerbating thyroid storm [83]. The peripheral cooling should be done with ice packs, cooling blankets, or alcohol sponges. Fluid loss due to hyperpyrexia, diarrhea, and vomiting should be corrected immediately.

The hypothalamo-pituitary-adrenal axis is impaired in thyrotoxicosis with a decrease in adrenal reserve. Despite increased production of cortisol by the adrenal gland to compensate for accelerated glucocorticosteroid metabolism in hyperthyroid states, a subnormal response of the adrenal glands to adrenocorticostimulating hormone occurs. Corticosteroids are therefore used as adjunct therapy in thyroid storm to prevent adrenal insufficiency. It also helps in decreasing the peripheral conversion of T4 to T3 [84]. A loading dose of 300 mg of hydrocortisone intravenously followed by 100 mg every 8 h is recommended [67].

The treatment of thyroid storm is not complete and effective until correctable precipitating factors are addressed (**Table 1**). Any focus of infection should be thoroughly investigated and proper antibiotics should be started based on sensitivity. In addition, any metabolic abnormalities, such as diabetic ketoacidosis, stroke, or pulmonary emboli, should be treated as per standard protocols.

6.7 Therapeutic plasma exchange

In refractory cases of thyrotoxic crisis with no clinical improvement alternative measures to clear thyroid hormone from the circulation should be instituted. Therapeutic plasma exchange (TPE) is effective in rapidly reducing thyroid hormone levels [85]. The patient's plasma is extracted from the components of blood, and replaced with albumin or fresh frozen plasma [85, 86]. TBG with bound thyroid hormone is removed from circulation, and the colloid replacement (usually albumin) provides unsaturated binding sites for circulating free thyroid hormone. Various techniques of exchange transfusion have evolved since its first description in 1970 by Ashkar et al. [87]. Plasma exchange, single pass albumin dialysis, and charcoal hemoperfusion have all demonstrated a reduction in free T3 and free T4 levels [85].

TPE is an option when clinical deterioration in thyroid storm occurs despite the use of first- and second-line therapies. Muller et al. suggested early initiation of TPE with the following indications: severe symptoms (cardio-thyrotoxicosis, neurologic manifestations, and severe myopathy); rapid clinical deterioration; contraindications to other therapies; and failure of conventional therapeutics [88]. The American Society for Apheresis (ASFA) recommends that TPE be performed at a frequency of daily to every 2–3 days until clinical improvement is noted. Complications of TPE are seen in 5% of patients and include hypotension, hemolysis, allergic reactions, coagulopathy, vascular injury, and infection [86, 88, 89].

Absolute indication	Relative indication
Failed medical therapy	Symptomatic goiter
Severe reaction to antithyroid drugs	Pregnancy
Not a candidate for radio ablation therapy	Severe Grave's ophthalmopathy
Persistent thyrotoxicosis despite maximum antithyroid drug/radio ablation therapy Underlying thyroid carcinoma Suspicious/malignant nodules on FNAC	Refractory thyroiditis Amiodarone related Toxic adenoma

Table 7.
Indications of surgery.

6.8 Surgical management

Achieving a euthyroid state is first and foremost requisite prior to surgical management using the above-mentioned medical treatment strategies [27]. However, there is a subset of patients who fail medical management despite all of the most aggressive treatment modalities. This occurs more commonly in iodine-deficient areas, where thyroid storm is mostly related to iodine contamination in patients with thyroid autonomy. These patients are particularly resistant to even high-dose thionamides or iodine therapy because of the large intrathyroidal iodine pool [90]. The broad indications of surgery have been listed in **Table 7**.

All measures should be employed to stabilize the patient prior to considering emergent surgical management. Surgical team should be involved early (within 12–72 h) if the patient is not responding to medical therapy. The surgical options involve a subtotal or near-total thyroidectomy [73]. The surgery produces rapid resolution of the hyperthyroidism as very little thyroid tissue remains. This allows cessation of the thionamides soon after the surgery. Corticosteroid and β-blocker should be continued perioperatively and slowly weaned off over the ensuing weeks [27].

6.9 Newer agents

Biological agent Rituximab (anti-CD20 monoclonal antibody which depletes B lymphocytes) and various other emerging therapies have shown promise in the treatment of Graves' ophthalmopathy, but the role of these agents in the management of the thyrotoxic state is less clear [17, 91–93].

7. Conclusion

Thyroid storm is an endocrine emergency that is associated with high morbidity and mortality if not promptly recognized and treated. Multidisciplinary treatment

Block synthesis (anti thyroid drugs)
Block release (iodine)
Block T4 to T3 conversion (high dose PTU, propranolol, corticosteroid)
Beta blocker
Block enterohepatic circulation (cholestyramine)

Table 8.
Five B's of thyroid storm.

in an intensive care setting is usually needed. Treatment involves addressing all steps of thyroid hormone synthesis, release, and action, in a well-defined order, while providing supportive care. Remember five B's in thyroid storm as listed in **Table 8**. Treating precipitating factors is an integral part of the management.

Conflict of interest

The authors declare no conflict of interest.

Author details

Rahul Pandey*, Sanjeev Kumar and Narendra Kotwal
Armed Forces Clinic, New Delhi, India

*Address all correspondence to: rahuladviksimpy@gmail.com

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