

Hyperthyroidism

Hyperfunctioning thyroid gland with excessive secretion of active thyroid hormones resulting in a hypermetabolic state. The majority of cases (99%) are due to 1 of 3 conditions: Graves' disease, toxic multinodular goiter or a toxic adenoma.

ANESTHETIC CONSIDERATIONS:

- Hyperthyroidism
 - **Euthyroid for elective surgery** with heart rate < 85
 - Potential **difficult airway** (goiter and edematous vocal cords)
 - **Hyperdynamic** circulation (esmolol infusion, avoid sympathetic stimulants)
 - Continue medications till morning of surgery (antithyroid / beta-blockers)
 - **Volume depletion**
 - **Thyroid storm** intra- / postoperatively (even in euthyroid, can look like MH)
 - Thyroidectomy → RLN palsy, hematoma, airway collapse if tracheomalacia, hypoparathyroidism (acute hypocalcemia, laryngospasm), pneumothorax
 - **Corneal abrasion risk** with ophthalmopathy (i.e. Graves disease)
- Altered response to medications (increased or decreased)
- Co-existing disease

ANESTHETIC GOALS:

- Preoperative assessment of airway compression
- Euthyroid state if possible prior to surgery
- Hemodynamic stability
- Prompt recognition & treatment of potentially life-threatening thyroid storm should it occur

HISTORY

- **AMPLE**
- **GENERAL**
 - History of thyroid disease, autoimmune disease, thyroidectomy, Graves, etc.
 - Heat intolerance
 - Weight loss
- **HEENT** – snoring, hoarse voice (tracheomalacia), ophthalmopathy
- **CVS** – palpitations, ↑ HR (a.fib), SOBOE, orthopnea (MVP, CHF, cardiomyopathies)
- **GI** – diarrhea, constipation
- **CNS** – shaking, anxiety, emotional lability
- **METAB** – determine whether euthyroid: reflexes, tremor, heat intolerance, fatigue, weakness, weight loss, anorexia, ↑ appetite

PHYSICAL

- **GENERAL** - Coarse hair, dry and scaly skin, edema, peripherally “shut down”
- **Hyperthyroid**
 - **HEENT** – goiter, airway / neck exam, eye exam
 - **CVS** – standard exam; tachycardia, atrial arrhythmias, hyperdynamic circulation, skin turgor, volume status (orthostatic vitals); look for SVC syndrome if huge goiter
 - **CNS** – reflexes, tremor, nervousness, mental status alterations; wasting, weakness and fatigue of proximal limb muscles

INVESTIGATIONS

- **Labs**
 - Hyperthyroid
 - **CBC (anemia, thrombocytopenia, agranulocytosis 2° to propylthiouracil or methimazole)**
 - **TSH, Free T₄, FT3 (assess euthyroid)**
- **Imaging**
 - **EKG**
 - Conduction abnormalities – a.fib, VT, particularly Torsade de Pointes
 - **CXR**
 - Pleural and pericardial effusions
 - **ECHO** – to evaluate contractility/effusion
 - Severe hypothyroidism typically displays systolic and diastolic dysfunction
 - Can have CHF, cardiomyopathies in hyperthyroidism
 - **CT neck, neck films** if tracheomalacia suspected in hyperthyroidism
 - **Radioactive iodine uptake** increased
- **Special**
 - **Consults** – Endocrinology, Cardiology

OPTIMIZATION

- Cancel elective surgery for 6-8 weeks until euthyroid
- Endocrinology consult
- Volume depletion may require repletion
- Consider steroid stress dose
- Continue meds until morning of surgery (beta-blockers, antithyroid)
- Prone to anemia - preoperative CBC / transfusion +/- x-match as indicated by preoperative status and procedure
- If emergency and not euthyroid consider esmolol infusion (or other beta-blockers) and iodides

ANESTHETIC OPTIONS

- Elective case - Safer to postpone and aim for euthyroid state

- Emergency surgery – beta-blockers / antithyroid medications, steroids, iodides
- **Severe hyper- / hypothyroidism** likely to necessitate **GA for airway and ventilatory support**
- **Regional** is acceptable option if CNS, ventilation, and cardiac status appropriate and no coagulopathy
 - Maintain intravascular volume

ANESTHETIC SETUP

- **Drugs**
 - Standard emergency drugs
 - Esmolol (or appropriate beta-blocker) and iodides
- **Equipment**
 - CAS monitors + temperature + 5 lead EKG
 - Difficult airway cart if large tongue, goiter, etc.
 - Invasive monitors d/t LV dysfunction
 - Arterial line
 - PAC / TEE indicated if ischemia and / or CHF
 - Cooling strategies (forced air, chilled NS, etc.)
 - PNS

MANAGEMENT OF ANESTHESIA

- **Induction**
 - Benzos for preop sedation
 - AFOI if distortion / involvement of trachea
 - Armored tube if tracheal rings affected
 - Adequate anesthetic depth is extremely important to avoid exaggerated SNS activity
 - Avoid ketamine, pancuronium, indirect adrenergic agonists (sympathetic stimulants), and anticholinergics (alter heat regulation)
 - **Thiopental** ideal d/t thiourylene nucleus that ↓ peripheral conversion T4 → T3
 - Protect eyes
 - Underlying muscle weakness may produce exaggerated response to relaxants so ensure full reversal, use PNS
- **Maintenance**
 - MAC may be minimally altered with hyper- / hypothyroidism
 - Conflicting sources: Barash/Coexisting – clinically insignificant change
 - Miller: increased MAC with hyperthyroidism in ANIMALS
 - Volatiles may cause exaggerated cardiac depression
 - Maintain normothermia
 - Halothane hepatitis & enflurane nephrotoxicity risk d/t hypermetabolism
- **Emergence**
 - Use **glyco** instead of atropine with an anticholinesterase for reversal

DISPOSITION & MONITORING

- Beware additive respiratory depression from opiates
 - Emphasize non-opiate modalities (NSAIDs, acetaminophen, LAs)
- Ventilate until normothermic and behaving “normally”
- Beware of complications associated with thyroidectomy (see below; especially hematoma, tracheomalacia, hypoCa with laryngospasm, and bilat RLN palsy all requiring a/w intervention)

COMPLICATIONS

- **Thyroid storm** (life-threatening situation, can look like MH)
 - Hyperthermia, tachycardia, alteration in consciousness (delirium, confusion, mania, excitement)
 - DDx: MH, pheochromocytoma, NMS
 - Treatment
 - B-blockade
 - Propranolol (0.2-1mg IV boluses) best as decreases peripheral conversion of T4 → T3
 - Esmolol also effective and more easily titrated
 - Antithyroid medication (PTU or methimazole) → po only
 - Corticosteroids – hydrocortisone 50-100mg IV or dex 8-12mg/d IV help decrease peripheral conversion of T4 to T3
 - Iodides
 - SSKI (supersaturated solution of potassium iodide) must be given orally or Lugol’s solution (NaI)
 - Give 5 drops orally
 - Inorganic iodide **inhibits iodide organification and thyroid hormone release** by Wolff-Chaikoff effect
 - Wait 2 hours after antithyroid med given!
 - May also use radiographic contrast dye iopanoic acid or ipodate
 - Lithium carbonate 300mg orally may also be used if pt allergic to iodide
- **Thyroidectomy**
 - Hematoma – can lead to airway compromise – needs a/w control and evacuation of hematoma
 - RLN palsy – hoarseness (unilateral) or stridor / aphonia (bilateral) – may need intubation / examination fiberoptically
 - Superior laryngeal nerve palsy – decreased phonation intensity
 - Bullous glottic edema can require immediate reintubation
 - Hypoparathyroid – leading to late hypocalcemia, tetany and **laryngospasm**
 - Pneumothorax
 - Tracheomalacia requiring intubation for patent a/w

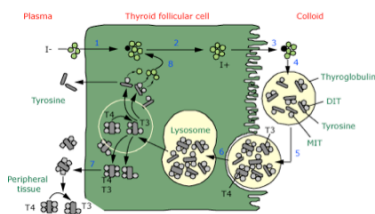
PREGNANCY

- Gestational trophoblastic neoplasms are frequently associated with elevated serum hCG concentrations
 - hCG may possess significant thyroid stimulating bioactivity
- Radioactive iodine ^{131}I is contraindicated in pregnancy b/c all forms of iodine readily cross the placenta
- Delay pregnancy for 4-6 months after radioactive iodine therapy
- PTU and MMZ should be dosed downward as tolerated
 - Major complications of these are agranulocytosis
 - **PTU** advocated in pregnancy as MMZ may cause fetal scalp defects
- “Treatment of thyroid storm is identical for both pregnant and nonpregnant patients” (Chestnut 4th)
 - Conflict
 - **B-blockade may be associated with preterm labour and IUGR**
 - However, benefit likely outweighs risks
- Either neuraxial or GA can be safely administered in hyperthyroid parturients
 - May want to avoid epinephrine in LA solutions (theoretical risk of \uparrow SNS activity) though likely safe to use
- **Phenylephrine** likely best for hypotension
- Avoid the same medications in non-pregnant patients as you would in parturients (ketamine, pancuronium, atropine, ephedrine, etc.)

PATHOPHYSIOLOGY

- **Physiology of the thyroid:**
 - Iodine from diet \rightarrow GI tract \rightarrow active transport into thyroid as iodide ion \rightarrow converted to iodine again \rightarrow bound to tyrosine (triiodothyronine [T_3] & thyroxine [T_4]) \rightarrow protein bound and stored in thyroid
 - More T_4 than T_3 released but T_3 much more potent and less protein bound (most T_3 formed peripherally via deiodination of T_4)
 - Elaborate feedback mechanism \rightarrow hypothalamus (TRH) \rightarrow anterior pituitary (TSH) \rightarrow autoregulation at thyroid via iodine concentration
 - Thyroid hormone:
 - Increases carbohydrate & fat metabolism & growth / metabolic rate
 - Increased metabolic rate increases O_2 consumption & CO_2 production, indirectly increasing MV
 - HR and contractility also increased (adrenergic-receptor physiology altered)
- **Hyperthyroidism**
 - Etiologies
 - Graves' disease, toxic multinodular goiter, Thyroiditis, thyroid-stimulating-hormone-secreting pituitary tumors, functioning thyroid adenomas, overdose of thyroid replacement hormone
 - Graves' disease
 - AutoAbs to thyroid receptors (TRAbs) stimulate thyroid gland in most cases
 - May also have Abs against Thyroid peroxidase, thyroglobulin and another cotransporter
 - Clinical manifestations
 - Weight loss, heat intolerance, muscle weakness, diarrhea, hyperactive reflexes, nervousness
 - May have fine tremor, exophthalmos, goiter (esp. with Graves')
 - CVS – tachycardia to atrial fibrillation to CHF
 - Diagnosis: increased total (bound & unbound) serum thyroxine, T_3 & free T_4
 - Treatment:
 - Drugs which inhibit hormone synthesis (propylthiouracil, methimazole)
 - Prevent hormone release (potassium, sodium iodide)
 - Mask the signs of adrenergic overactivity (propranolol)
 - Do not affect thyroid but decrease peripheral conversion of T_4 to T_3
 - Radioactive iodine destroys thyroid cell function (not used in pregnancy)
 - Subtotal thyroidectomy less common as alternative
 - Reserved for patients with large, multinodular goiters or solitary toxic adenomas
 - Graves' treated with thyroid drugs or radioiodine

Thyroid hormone biosynthesis



Thyroid hormone synthesis includes the following steps: (1) iodide (I^-) trapping by the thyroid follicular cells; (2) diffusion of iodide to the apex of the cells; (3) transport of iodide into the colloid; (4) oxidation of inorganic iodide to iodine and incorporation of iodine into tyrosine residues within thyroglobulin molecules in the colloid; (5) combination of two diiodotyrosine (DIT) molecules to form tetraiodothyronine (thyroxine, T_4) or of moniodotyrosine (MIT) with DIT to form triiodothyronine (T_3); (6) uptake of thyroglobulin from the colloid into the follicular cell by endocytosis, fusion of the thyroglobulin with a lysosome, and proteolysis and release of T_4 , T_3 , DIT, and MIT; (7) release of T_4 and T_3 into the circulation; and (8) deiodination of DIT and MIT to yield tyrosine. T_3 is also formed from monodeiodination of T_4 in the thyroid and in peripheral tissues.

REFERENCES

- Lange 3rd Edition: p742-43; Roizen; Essence of Anesthesia Practice..., p 182 & 190
- Coexisting 5th, Barash 6th, Chestnut 4th, UpToDate 2010