MHA Anesthesia and Hyperthryoidism

**Etiology**

Graves' disease
toxic multinodular goiter
thyroiditis
TSH-secreting pituitary tumor
functioning thyroid adenoma
overdose of thyroid replacement hormone

**Clinical Manifestations**

- weight loss
- heat intolerance
- muscle weakness
- diarrhea
- hyperactive reflexes
- nervousness
- Graves' disease: fine tremor, exophthalmos or goiter
- tachycardia, atrial fibrillation, congestive heart failure
- elevated serum total thyroxine, triiodothyronine and/or free thyroxine

**Thyroid tests**

- $T_4$
  - elevated in 90% of hyperthyoroid patients
  - low in 85% of hypothyroid patients
- $T_3$ elevation helps confirm hyperthyroidism
- $T_3$ falsely low (decreased peripheral conversion from $T_4$) in
  - hepatic cirrhosis
  - uremia
  - malnutrition
- TSH
  - elevation (plus low $T_4$, $T_3$) confirms primary hypothyroidism
  - low TSH and $T_4$ indicates secondary hypothyroidism
- thyroid scan shows normally functioning thyroid tissue
- ultrasound differentiates cystic from solid masses
- antibodies to thyroid components elevated in Hashimoto's thyroiditis

**Medical Treatment**

Inhibit hormone synthesis (propylthiouracil, methimazole)
Prevent hormone release (potassium, sodium iodine)
Mask signs of adrenergic overactivity (propranolol)
Destroy thyroid cell function (radioactive iodine)

## Anesthetic Considerations

**Preoperative**

Postpone elective surgery until patient euthyroid
Normal thyroid function studies
Resting heart rate < 85
Continue antithyroid medications and beta-blockers through day of surgery
Emergency case: control hyperdynamic circulation with **esmolol infusion**

**Intraoperative**

Closely monitor
- Cardiovascular function
- Temperature
- Eyes (exophthalmos of Graves' disease)

Thyroid surgery, consider:
- Elevation of head of bed 10-20 degrees
- Armoured endotracheal tube passed beyond goiter

Avoid stimulation of sympathetic nervous system
Thiopental good induction agent (antithyroid activity at high doses)
Beware chronic hypovolemia -> induction hypotension
Accelerated drug biotransformation
No change in MAC
Increased incidence of myopathies and myasthenia gravis

**Postoperative**

thyroid storm
- hyperpyrexia
- tachycardia
- agitation, delirium, coma
- hypotension
- may occur intraop, but usually 6-24 hours postop
- treatment
  - hydration
  - cooling
  - beta-blockade

esmolol infusion or
propranolol 0.5 mg increments until heart rate < 100

propylthioruacil 250 mg Q6H PO or NG followed by
sodium iodide 1 Gm IV over 12 hours
correct any precipitating stimulus (e.g. infection)
cortisol 100-200 mg Q8H (possible coexisting adrenal gland suppression)

postop complications of subtotal thyroidectomy

recurrent laryngeal nerve palsy

unilateral -> hoarseness
bilateral -> aphonia and stridor

- consider evaluating vocal cord movement immediately post extubation (e.g. fiberoptically)
- may require reintubation, re-exploration

hematoma formation

may cause airway compromise
Rx: open wound, evacuate clot
may require reintubation

hypoparathyroidism

acute hypocalcemia within 24-72 hours

pneumothorax

## Anesthesia and Hypothryoidism

**Clinical Manifestations**

Etiology

autoimmune disease (Hashimoto's thyroiditis)
thyroidectomy
radioactive iodine
antithyroid medications
iodine deficiency
failure of the hypothalamic-pituitary axis (secondary hypothyroidism)

Neonatal hypothyroidism -> cretinism with physical and mental retardation

Adult manifestations

weight gain
cold intolerance

- muscle fatigue
- lethargy
- constipation
- hypoactive reflexes
- dull facial expression
- depression
- decreased heart rate, contractility, stoke volume, cardiac output
- cool, mottled extremities (peripheral vasoconstriction)
- pleural, pericardial, abdominal effusions
- low free T4
- TSH elevated in primary hypothyroidism

Treatment

- thyroid hormone administration
- several days for physiologic effect
- weeks until definite clinical improvement

Myxedema coma

- extreme hypothyroidism
- impaired mentation
- hypoventilation
- hypothermia
- hyponatremia (SIADH)
- CHF
- more common in elderly
- precipitating factors
  - infection
  - surgery
  - trauma
- treatment
  - intravenous thyroid hormone, T3 or T4, as bolus + infusion
  - monitor ECG for ischemia and dysrhythmia
  - hydrocortisone 100 mg IV Q8H (possible coexisting adrenal gland suppression)
  - ventilatory support may be needed

## Anesthetic Considerations

**Preoperative**

Postpone elective surgery until correction of severe hypothyroidism (T4 < 1 mg%) or myxedema coma

Slow gastric emptying

Prone to drug-induced respiratory depression
Continue usual thyroid hormone

**Intraopreative**

Susceptible to induction hypotension with most agents
If refractory hypotension, consider
additional adrenal insufficiency
CHF
Ketamine may be good induction agent
Inhalation induction faster with decreased cardiac output
No significant effect on MAC
Large tongue
Other potential problems
hypoglycemia
anemia
hyponatremia
hypothermia

**Postoperative**

Delayed emergence/recovery
hypothermia
respiratory depression
slowed drug biotransformation
May need prolonged ventilatory assistance
Ketorolac

## Anesthesia and Hyperparathryroidism

**Clinical Manifestations**

Etiology

- Primary hyperparathyroidism

  adenoma
  carcinoma
  hyperplasia of the parathyroid gland

- Secondary hyperparathyroidism

  renal failure
  intestinal malabsorption sydromes

- Ectopic hyperparathyroidism

  tumors outside the parathyroid gland

parathyroid hormone-related peptide
hepatoma
bronchogenic carcinoma

Manifestations (of hypercalcemia)
Cardiovascular
hypertension
ventricular dysrhythmias
ECG changes (shortened QT interval; or prolonged QT if Ca > 16 mg%)
Renal
impaired concentrating ability
hyperchloremic metabolic acidosis
polyuria
dehydration
polydipsia
renal stones
renal failure
Gastrointestinal
ileus
nausea and vomiting
peptic ulcer disease
pancreatitis
Musculoskeletal
muscle weakness
osteoporosis
Neurologic
delirium
psychosis
coma
Other causes of hypercalcemia
bone metastases
vitamin D intoxication
milk-alkali syndrome
sarcoidosis
prolonged immobilization

**Anesthetic Considerations**

**Preoperative**

Assess volume status
NS and furosemide as needed to decrease serum calcium to acceptable levels (< 14 mg% = 7 mEq/L)
Rarely, need more aggressive therapy:

- intravenous biphosphonates

    pamidronate (Aredia)
    etridronate (Didronel)

- plicamycin (Mithramycin)
- glucocorticoids
- calcitonin
- dialysis

**Intraoperative**

Hydrate well to minimize induction hypotension
Avoid hypoventilation acidosis (increases ionized calcium level)
Cardiac dysrhythmias
Osteoporosis

**Postoperative**

Complications of parathyroidectomy are those of subtotal thyroidectomy

## Anesthesia and Hypoparathryroidism

**Clinical Manirestations**

Usually follows parathyroidectomy
Manifestations (of hypocalcemia)

- Cardiovascular

    hypotension
    CHF
    ECG changes (prolonged QT interval)

- Musculoskeletal

    muscle cramps
    weakness

- Neurologic

    neuromuscular irritability

        **laryngospasm**
        inspiratory stridor
        tetany

seizures
Chvostek's sign

facial nerve tap -> face twitches painfully

Trousseau's sign

tourniquet for 3 minutes -> carpopedal spasm

perioral paresthesia
mental status changes

dementia
depression
psychosis

Other causes of hypocalcemia
renal failure
hypomagnesemia
vitamin D deficiency
acute pancreatitis
Treatment of symptomatic hypocalcemia
calcium chloride IV slow

**Anesthetic Considerations**

- $CaCl_2$ to normalize Ca if cardiac manifestations
- Avoid hyperventilation (or sodium bicarbonate) which will decrease ionized Ca level
- Beware citrate-containing blood products (decrease Ca level)
- Avoid 5% albumin (may lower ionized Ca level)
- May be more sensitive to neuromuscular blocking drugs

## Anesthesia and Mineralocorticoid Abnormalities

**Adrenal Physiology**
**adrenal cortex**

- androgens
- mineralocorticoids (e.g., **aldosterone**)
  - Increases distal tubular sodium reabsorption in exchange for (increased secreation of) potassium and hydrogen ions.

        - So, increases extracellular fluid volume while tending to produce a hypokalemic metabolic alkalosis.
        - aldosterone levels are increased by:
            - renin-angiotension system (angiotensin II)
            - adrenocorticotropic hormone (ACTH)
            - hyperkalemia
            - hypovolemia
            - hypotension
            - CHF
            - surgery
    - glucocorticoids (e.g., **cortisol**)
        - metabolic actions
            - increased gluconeogenesis
            - inhibition of peripheral glucose utilization
            - increased blood glucose concentration
            - required for bronchial and vascular smooth muscle responsive to catecholamines
            - some mineralocorticoid (aldosterone like) effect
        - anterior pituitary ACTH secretion (principal regulator)
            - diurnal rhythm
            - stimulated by stress
            - inhibited by circulating glucocorticoids
        - endogenous cortisol production = 20 mg/day

**adrenal medulla**

- catecholamines (epinephrine, norepinephrine, dopamine)
    - 80% epinephrine
    - stimuli to release
        - cholinergic preganglionic fibers of the sympathetic nervous system
        - hypotension
        - hypothermia
        - hypoglycemia
        - hypercapnia
        - hypoxemia
        - pain
        - fear

**Mineralocorticoid Excess**

**Clinical Manifestations**

- Etiology
    1. Primary hyperaldosteronism (Conn's syndrome)
        - unilateral aldosteronoma (50%)
        - bilateral hyperplasia (40%)
        - aldosterone secreting carcinoma (adrenal gland)
    2. Secondary hyperaldosteronism (via the renin-angiotensis system)
        - congestive heart failure
        - hepatic cirrhosis with ascites
        - nephrotic syndrome
        - renal artery stenosis
- Signs
    - hypertension
    - hypervolemia
    - hypokalemia
        - renal concentrating defect
        - polyuria
    - metabolic alkalosis
        - decreased ionized calcium level
        - tetany
    - muscle weakness

### Anesthetic Considerations

- Correct fluid and electrolyte abnormalities
    - supplemental potassium
    - spironolactone (potassium-sparing diuretic with antihypertensive properties)

## Mineralocorticoid Deficiency

### Clinical Manifestations and Anesthetic Considerations

- Atrophy or destruction of both adrenals leads to combined deficiencies of both mineralocorticoids and glucocorticoids
- Isolated hypoaldosteronism
    - unilateral adrenalectomy
    - diabetes
    - heparin therapy
- Signs
    - hyperkalemic
    - acidotic

    - usually hypotensive
- Preoperative preparation
    - exogenous mineralocorticoid (e.g., fludrocortisone)

## Anesthesia and Glucocorticoid Abnormalities

Adrenal Physiology

### Glucocorticoid Excess

**Clinical Manifestations**

- Etiology
    - Exogneous administration of steroids
    - Hyperfunction of adrenal cortex (e.g., adrenocortical adenoma)
    - Non-pituitary tumor secreting ACTH (ectopic ACTH syndrome)
    - Cushing's disease (pituitary adenoma hypersecreting ACTH)
- Signs (Cushing's syndrome)
    - muscle wasting and weakness
    - osteoporosis
    - central obesity
    - abdominal striae
    - glucose intolerance
    - hypertension
    - mental status changes

**Anesthetic Conciderations**

- Correct fluid and electrolyte abnormalities (hypokalemic metabolic alkalosis) with supplemental potassium and spironolactone (Aldactone)
- Gentle positioning (osteoporosis)
- Sensitivity to muscle relaxants
- Continue exogenous supplemental steroids
- Adrenalectomy
    - hydrocortisone succinate 100 mg Q8H
    - prepare for blood loss from vascular tumor
    - unintentional pleural penetration -> pneumothorax

### Glucocorticoid Deficiency

**Clinical Manifestations**

1. Primary adrenal insufficiency (Addison's disease)
    - Destruction of adrenal gland
    - Combined mineralocorticoid and glucocorticoid deficiency

- Signs
  - hyponatremia
  - hyperkalemia
  - hypovolemia
  - hypotension
  - metabolic acidosis
  - weakness
  - fatigue
  - hypoglycemia
  - hypotension
  - weight loss
- **etomidate**
  - longterm administration (hours to days) suppresses adrenal function

2. Secondary adrenal insufficiency
   - Inadequate pituitary ACTH secretion
   - Most commonly due to exogenous steroid administration
   - Mineralocorticoid secretion usually adequate
   - Acute adrenal insufficiency (**addisonian crisis**)
     - During stress (infection, trauma, surgery) in steroid-dependent patients not treated with increased doses
     - Signs
       - circulatory collapse
       - fever
       - hypoglycemia
       - depressed mentation

**Anesthetic Conciderations**

- Ensure adequate steroid replacement during perioperative period
  - Patients after > 5 mg prednisone (or equivalent) daily for > 2 weeks any time in preoperative year
  - Hydrocortisone phosphate 100 mg Q8H, starting preop
  - Alternately: hydrocortisone 25 mg at induction, then 100 mg over next 24 hours
    - Achieves cortisol levels at least as high as in normal patients during elective surgery
    - May be especially appropriate for diabetics (better blood glucose control)

## Anesthesia and Pheochromocytoma

## Clinical Manifestations

- catecholamine-secreting tumor
- cells from embryonic neural crest (chromaffin tissue)
- 1 of 1,000 hypertension patients
- most unilateral and benign
- 10-15% malignant
- 10-15% bilateral or extra-adrenal
- Signs
    - paroxysmal headache
    - hypertension
    - sweating
    - palpitations
- rarely presents with unexpected intraoprative hypertension and tachycardia

## Anesthetic Considerations

- Preoperative considerations
    - evaluate
        - arterial blood pressure
        - orthostatic blood pressure and heart rate changes
        - evidence of myocardial ischemia
    - adrenergic blockade
        1. alpha blockade
            - phenoxybenzamine
            - helps correct
                - volume deficit
                - hypertension
                - hyperglycema
        2. consider additional beta blockade *after* alpha blockade if
            - no cardiomyopathy (check ECHO)
            - persistent tachycardia
            - persistent dysrhythmia
    - volume replacement
        - chronic hypovolemia
        - decrease in RBC mass and plasma volume
        - aided by alpha-adrenergic blockade
        - may unmask underlying anemia
- Operating room considerations
    - arterial line

- good IV access
- monitor urinary output
- central venous pressure (CVP) monitoring
- maybe pulmonary artery catheter (e.g. evidence of catecholamine cardiomyopathy)
- intubate deep
- treat intraop hypertension
    - phentolamine
        - specific adrenergic blocker
    - nitroprusside
        - rapid onset
        - short duration of action
        - familiarity
    - nicardipine
- best **avoid**
    - sypathetic nervous system stimulants
        - ephedrine
        - ketamine
        - hypoventilation
    - potentiating catecholamine dysrhythmias due to
        - halothane
    - inhibit parasympathetic nervous system
        - pancuronium
    - histamine release caused by
        - atracurium
        - morhpine sulphate
- after tumor resection
    - hypotension
        - hypovolemia
        - persistent adrenergic blockade
        - abrupt drop in circulating catecholamine level
    - fluid resuscitation based on
        - arterial blood pressure
        - urinary output
        - CVP
        - pulmonary capillary occlusion pressure
        - surgical bleeding
        - third-space losses
    - adrenergic agent infusion occasionally necessary
        - phenylephrine
        - norepinephrine

- Postoperative
    - hypertension may indicate
        - occult tumor(s) or
        - volume overload

## Anesthesia and Obesity

**Definitions**
**body mass index**, **BMI**
BMI = weight/height$^2$ in kg/m$^2$
**overweight**: BMI > **30**
**extreme obesity** (old "morbid obesity"): BMI > 40
Health risk increases with

- BMI
- abdominal distribution of weight
    - men: waist > 40 inches
    - women: waist > 35 inches

### Clinical Manifestations

- Associated diseases
    - type II diabetes
    - hypertension
    - coronary artery disease
    - cholelithiasis
- Physiologic consequences
    - metabolic rate is proportional to body weight
        - increased $O_2$ demand
        - increased $CO_2$ production and alveolar ventilation
    - restrictive lung disease
        - decreased chest wall compliance
        - diaphragm forced cephalad
        - decreased lung volumes
        - accentuated by supine and Trendelenberg postions
        - functional residual capacity (FRC) may fall below closing capacity leading to
        - alveolar collapse with ventilation/perfusion mismatch
        - often relatively hypoxemic
        - occasionally hypercapnic (obesity-hypoventilation or *Pickwickian* syndrome)
            - obesity usually extreme

        - hypercapnia
        - cyanotic
        - polycythemia
        - right-sided heart failure (cor pulmonale)
        - somnolence
        - often have obstructive sleep apnea syndrome (OSAS)
- **obstructive sleep apnea syndrome** (OSAS)
    - snoring
    - dry mouths and short arousal during sleep reported
    - partners report apnea pauses during sleep
    - associated with perioperative
        - hypertension
        - hypoxia
        - dysrhythmias
        - myocardial infarction
        - pulmonary edema
        - stroke
        - difficult airway management during induction
        - perioperative airway obstruction
    - more vulnerable to airway obstruction after opioids or sedatives
    - more vulnerable in supine or Trendelenberg position
    - consider trial of postoperative coninuous positive airway pressue (CPAP)
- heart
    - increased workload
    - hypertension
    - left ventricular hypertrophy (LVH)
    - increased pulmonary blood flow and hypoxic pulmonary vasoconstriction leads to
    - pulmonary hypertension and
    - cor pulmonale
- gastrointestinal
    - hiatal hernia
    - gastroesophageal reflux
    - poor gastric emptying
    - hyperacidic gastrc fluid
    - increased risk of gastric cancer
    - fatty infiltration of the liver
    - elevated liver function tests

# Anesthetic Considerations

## Preoperative

- increased risk for aspiration pneumonitis
  - consider $H_2$ antagonist (e.g. ranitidine, Zantac) and/or
  - metoclopramide (Reglan)
- avoid unnecessary respiratory depressants
- assess
  - cardiopulmonary reserve
    - chest X-ray
    - ECG
    - arterial blood gases
    - pulmonary function tests
  - blood pressure with appropriate size cuff
  - plan/examine for venous and arterial access, possible regional anesthesia
  - airway
    - limited TM joint mobility
    - limited atlanto-occipital mobility
    - narrow upper airway
    - small space between mandible and sternal fat pads

## Intraoperative

- awake fiberoptic intubation good choice if difficult direct laryngoscopy expected
- breath sounds distant, $ETCO_2$ more important
- relatively high $FIO_2$ may be needed
  - lithotomy
  - Trendelenberg
  - prone
- more extensive metabolism of volatile anesthetics
- increased volume of distribution (and delayed clearance) of lipid-soluble drugs
  - suggests larger loading (and less frequent maintenance) doses
  - rationale to dose based on actual body weight
  - opioids
  - benzodiazepines
- water-soluble drugs
  - limited volume of distribution, uninfluenced by fat stores
  - rational to base dose on ideal body weight

    - neuromuscular blocking agents
- regional anesthesia
    - technically more difficult
    - usually need 20-25% LESS local anesthetic for spinal or epidural anesthesia because of epidural fat and distended epidural veins
    - epidural anesthesia may lessen postoperative respiratory complications

**Postoperative**

- respiratory failure risk increased by
    - preoperative hypoxia
    - thoracic or upper abdominal (especially with vertical incision) surgery
- delay extubation until
    - complete revesal of muscle relaxation
    - patient awake, following commands
- provide supplemental $O_2$ after extubation (including during transport from OR to recovery room)
- 45-degree head up position helps
    - unload diaphragm
    - improve oxygenation and ventilation
- wound infection risk increased
- deep venous thrombosis risk increased
- pulmonary embolism risk increased

## Anesthesia and Carcinoid Syndrome

**Carcinoid tumors**

- enterochromaffin tumors
- secrete *vasoactive substances*
    - serotonin
    - kallikrein
    - histamine
- most located in the gastrointestinal tract
    - vasoactive substances secreted into portal circulation, so
    - most are destroyed by the liver

- nonintestinal tumors
    - pulmonary
    - ovarian
    - hepatic metastases
    - secretions bypass liver and cause systemic manifestations

## Clinical Manifestations

- sertonin
    - vasoconstriction
        - coronary artery spasm
        - hypertension
    - increased intestinal tone
    - water and electrolyte imbalance (diarrhea)
    - tryptophan deficiency (hypoproteinemia, pellagra)
- kallikrein
    - vasodilation
        - hypotension
        - cutaneous flushing
    - bronchoconstriction
- histamine
    - vasodilation
        - hypotension
        - cutaneous flushing
    - dysrhythmias
    - bronchoconstriction
- right-sided heart disease
    - due to valvular and myocardial plaque formation
    - lung metabolism protects left heart
- diagnosis
    - suggested by elevated plasma chromogranin A
    - confirmed by elevated urinary serotonin metabolites
        - 5-hydroxyindoleacetic acid
- treatment
    - depends on tumor location
    - surgical resection
    - serotonin and histamine antagonists
    - somatostatin
        - inhibitory peptide
        - reduces release of vasoactive tumor products

## Anesthetic Considerations

- minimize release of vasoactive substances from tumor
- treat hypotension with volume expansion
- beware: catacholamine administration may activate kallikrein
- regional anesthesia may limit perioperative stress
- avoid histamine-releasing drugs (e.g. morphine, atracurium)
- beware: surgical manipulation of tumor
- monitors
    - arterial line
    - CVP line
    - consider pulmonary artery catheter
- monitor blood glucose
- **consult endocrinologist** to clarify role of
    - antihistamines
    - antiserotonin drugs
        - methysergide
        - octreotide (long-acting somatostatin analog)
    - antikallikrein drugs (e.g. corticosteroids)