

Risk

- Greater in infants and children
- Greater in longer, larger operations
- Similar in RA and GA

Perioperative Risks

- Surgical wound infections
- Coagulopathy
- Reduced drug metabolism
- Prolonged recovery and hospitalization
- Shivering and thermal discomfort

Overview

- Benefits:
 - Improved neurologic recovery in asphyxiated neonates
 - Decreases triggering and severity of malignant hyperthermia.

- Core temperature normally protected by responses that include sweating, vasoconstriction, and shivering.
- Typical doses of GA have little effect on the sweating threshold but decrease vasoconstriction and shivering thresholds 2–4° C, thus increasing the range of temperatures not triggering protective responses 10-fold from approximately 0.4–4° C.
- RA inhibits thermoregulatory control by preventing peripheral responses (such as vasoconstriction) and centrally by reducing afferent input.

Etiology

- Initial 0.5–1.5° C decrease in core temperature from core-to-peripheral redistribution of body heat.
- Subsequently, slow, linear decrease in core temperature from heat loss exceeding heat production.

- Finally, a core-temperature plateau results when thermoregulatory vasoconstriction decreases cutaneous heat loss and constrains metabolic heat to core thermal compartment.

Usual Treatment

- Forced-air is by far the most commonly used warming method, typically increasing mean body temperature 1° C/h.
- 1 L of crystalloid at 20°C or 1 U of blood at 4° C decreases mean body temperature approximately 0.25° C in adults. Fluid warming should be restricted to pts given large volumes of fluid (i.e., ≥2 L/h).
- Passive insulation (e.g., surgical drapes, cotton blankets) decreases heat loss 30%, which is usually insufficient to maintain periop normothermia.
- Airway heating and humidification is ineffective.

Assessment Points

System	Effect	Dx	Treatment
CNS	Ischemia protection Thermal discomfort	None Visual analogue scale	Induce and maintain hypothermia Active cutaneous warming
VASC	Precapillary dilation; reduced SVR Arteriovenous shunt constriction, increased BP, decreased HR	Associated with sweating Fingers feel cold, approximately 10 mm Hg increase in mean arterial pressure	Active or passive cooling Active cutaneous warming
MS (shivering)	Two-fold to three-fold increase in metabolic rate Pt discomfort Interference with monitoring	Visual inspection O ₂ consumption	Prevent hypothermia Meperidine 10–25 mg IV Clonidine 75 mcg IV Active cutaneous warming
IMMUNE	Increased risk of surgical site infection	Clinical infections	Prevent hypothermia
HEME	10% increase/° C in blood loss	Bleeding time PT/ PTT falsely normal	Prevent hypothermia Defect probably not reversed by FFP and platelet transfusions
METAB (increased drug action)	MAC decreases approximately 5%/° C Decreased drug metabolism	Monitor drug action (rather than dose)	Titrate drug administration to desired endpoint Monitor twitch depression

Key Reference: Sessler DI: Perioperative thermoregulation and heat balance, *Lancet* 387: 2655–2664, 2016.

Perioperative Implications

Preoperative Preparation

- Active prewarming for 30–60 min helps prevent redistribution hypothermia.

Monitoring

- Four core temperature sites are accurate: pulm artery, distal esophagus, tympanic membrane (with a contact thermometer), nasopharynx.
- Three additional sites suitable except during cardiopulmonary bypass: mouth, axilla, bladder.
- Best site for postop temperature monitoring is the mouth.

Intraoperative Period

- Maintain normothermia (core temperature >36° C) unless otherwise indicated.
- Sufficient passive or active reduction of heat loss will prevent hypothermia; however, active warming is usually required.
- Once triggered, thermoregulatory vasoconstriction effective in preventing further core hypothermia.
- Community standard of care is to monitor core temperature in pts having general anesthesia lasting more than 30 min and to keep core temperature ≥36°C.

Postoperative Period

- Hypothermic pts should be rewarmed with forced air.
- Shivering and thermal discomfort can be specifically treated.
- Postop warming not a substitute for maintaining intraop normothermia.

Anticipated Problems/Concerns

- Hypothermia has been proven to cause numerous life-threatening complications and should be actively prevented unless therapeutic hypothermia is specifically indicated.

Hypothyroidism

Risk

- Hypothyroidism may be present in 2–5% of the general population and is more common in women and the elderly.
- Approximately 3% of adults receive chronic thyroid replacement.

Perioperative Risks

- If inadequately treated, increased risk for hypothermia, hypotension, cardiac failure, and GI dysfunction.
- Periop mortality rate not increased unless overtly hypothyroid.

- Inadequate thyroid replacement associates with adverse obstetric outcomes and developmental delays in the offspring, but screening for hypothyroidism during pregnancy remains controversial.

Worry About

- Predisposition to hypothermia.
- Neuromuscular weakness may impair weaning from mechanical ventilation.

Overview

- Common condition, particularly in adult women.
- Elevated TSH concentration in blood is hallmark lab finding.

- Subclinical hypothyroidism (persistent increase in TSH despite normal T₄) sometimes present month to year before decreased T₄ concentration.
- Adequacy of T₄ replacement defined by TSH concentrations in the low-normal range.
- Total and free T₄ (and usually T₃) concentrations typically reduced.
- Symptomatic pts with TSH >10 mU/L should receive maintenance thyroid hormone replacement (T₄ 0.8–2 mcg/kg daily).
- Pts presenting with severe, untreated hypothyroidism or myxedema coma may also demonstrate hypothermia, hypoventilation, hyponatremia, hypotension, heart failure, bowel obstruction, and hypoglycemia.

Etiology

- Hypothyroidism (decreased thyroid hormone secretion) most often results from primary disease of thyroid gland (most commonly autoimmune thyroiditis). Less frequently, it results from disorders of the pituitary gland or hypothalamus.
- Previous treatment for hyperthyroidism and previous total thyroidectomy are also relatively common causes of hypothyroidism.
- Pts with critical illness may have reduced T₄ and T₃ despite normal TSH concentrations (nonthyroidal illness syndrome) but usually do not require thyroid hormone replacement.

- Primary TSH deficiency may result from pituitary tumors and cysts or their treatment (either surgery or radiation), pituitary infiltration, necrosis, or infarction; secondary TSH deficiency may result from congenital deficiency of TRH, radiation therapy, infections, or tumors or cysts that impinge on the hypothalamic-pituitary portal circulation.

Usual Treatment

- Maintenance outpatient therapy for adults consists of oral T₄ 0.1–0.2 mg (0.8–2 mcg/kg) daily.
- There may be a delay of up to 4 wk for TSH to stabilize after T₄ dosage adjustment (T_{1/2} of T₄ about a wk).

- Chronic rifampin, carbamazepine, phenobarbital, and phenytoin, and increase T₄ dosage requirements by increasing metabolism or clearance of T₄.
- Pts with CAD should have T₄ replacement initiated at a reduced dose and only cautiously increased to avoid precipitating increased anginal symptoms.
- Myxedema coma may require use of IV T₃ (liothyronine) 0.15–0.3 mcg/kg every 6 h and IV hydrocortisone 0.5–1 mg/kg every 8 h to cover for possible hypothyroid-impaired adrenal response to stress.
- IV T₃ may also be indicated in other circumstances when peripheral conversion of T₄–T₃ is impaired (e.g., hypothermic cardiopulmonary bypass).

Assessment Points

System	Effect	Assessment by Hx	PE	Test
HEENT	Puffiness below eyes, enlarged tongue	Snoring	Enlarged tongue	TSH, T ₄ (or T ₃) concentrations
CV	Bradycardia, decreased BP, heart failure	Palpitations, myocardial ischemia, arrhythmias, peripheral edema	Bradycardia, tachycardia	TSH, T ₄ (or T ₃) concentrations, ECG
RESP	Hypoventilation			TSH, T ₄ (or T ₃) concentrations, arterial Pco ₂ , or venous HCO ₃ ⁻
GI	Ileus, weight gain	Constipation, ascites	Decreased bowel sounds	TSH, T ₄ (or T ₃) concentrations
RENAL	Decreased free water clearance	Fluid retention, edema	Edema	TSH, T ₄ (or T ₃) concentrations; serum Na ⁺ concentration
CNS	Obtundation, depression, muscular weakness, cold intolerance	Lethargy, weakness, mental slowness	Decreased deep tendon reflexes, impaired mental status examination	TSH, T ₄ (or T ₃) concentrations

Key References: Biondi B, Wartofsky L: Treatment with thyroid hormone. *Endocr Rev* 35(3):433–512, 2014; Fliers E, Bianco AC, Langouche L, et al.: Thyroid function in critically ill patients. *Lancet Diabetes Endocrinol* 3(10):816–825, 2015; Hennessey JW: The emergence of levothyroxine as a treatment for hypothyroidism. *Endocrine* 55(1):6–18, 2017.

Perioperative Implications**Preoperative Preparation**

- Chronic thyroid replacement to maintain euthyroid state.
- Hypothyroid pts who are inadequately treated require different periop management from those who receive adequate maintenance T₄ therapy.
- If pt is receiving chronic thyroid replacement and is euthyroid, likely no additional concerns.
- Long T_{1/2} of T₄ (approximately a week) permits oral T₄ to be withheld safely for several NPO days.

Monitoring

- Temperature
- Other monitors as indicated by surgery

Airway

- Rare cause of macroglossia with congenital hypothyroidism

Maintenance

- No effect of hypothyroidism on MAC for inhaled anesthetics.
- Keep the pt warm.
- Potential increased periop risk of heart failure, hypotension, and GI dysfunction (controversial).

Extubation

- Weaning from mechanical ventilation may be impaired with inadequate hormone replacement.

Adjuvants

- None needed (except in cases of myxedema coma, in which IV liothyronine and hydrocortisone may be indicated)

Anticipated Problems/Concerns

- Only those hypothyroid pts who have been inadequately treated with T₄ carry risks; those who chronically receive an appropriate dose of T₄ have almost no increased risk compared with other pts.
- Inadequately treated hypothyroidism can lead to lethargy and fatigue, weight gain, dementia, heart failure, respiratory insufficiency, fluid retention and edema, hyponatremia, clotting abnormalities, and generalized weakness.

Hypoxemia

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Risk

- All pts undergoing anesthesia and surgery (7–35% in large series have PaO₂ <60 mm Hg in OR or PACU).
- Pts with pulm disease, difficult airway management, severe hemodynamic instability.

Perioperative Risks

- Hypoxemia may lead to hypoxia and eventual severe neurologic/cardiac sequelae or death.

Worry About

- Inadequate delivery of O₂ to lungs and blood is the greatest concern to the anesthesiologist because it will lead to tissue hypoxia.
- Differential Dx is critical for successful causal treatment.
- Misinterpretation of certain clinical manifestations of hypoxemia (anxiety, tachycardia, dysrhythmias).

Overview

- Hypoxemia denotes low PaO₂ in blood (vs. hypoxia, which refers to inadequate delivery of O₂ to tissues).
- Hypoxemia is defined as resting PO₂ greater than two SD below normal for age and FIO₂ and SpO₂ less than 90%, PaO₂ less than 60 mm Hg on room air, and/or a fall in SpO₂ greater than 5%.
- Multiple symptoms and vital signs that should be considered possibly related to hypoxemia.

Etiology

- Decreased FIO₂: Failure to provide adequate inspired O₂ (e.g., O₂ supply failure, anesthesia machine failure, airway disconnect, pts at high altitude)
- Inadequate alveolar ventilation: Difficult airway management, low minute ventilation (respiratory depression or residual muscle paralysis in spontaneous breathing pt), severe laryngospasm/bronchospasm

- V/Q mismatch: Asthma, COPD, pulmonary embolism, pulm vascular disease, atelectasis, pneumonia, alveoli filled with blood or vomitus, FRC >closing capacity
- Diffusion problems: Very rare cause (massive pulm edema)
- R-to-L cardiac shunts: ASD, VSD (may not respond to increased FIO₂)
- Inadequate delivery of O₂ to tissues: Extremely low cardiac output, severe anemia, extremely decreased release of O₂ from Hb to tissue (left shift Hb dissociation curve: CO intoxication, metHb, severe hypothermia)

Usual Treatment

- Determine cause of decreased O₂ delivery and treat.
- Increase FIO₂ (may not help if hypoxemia is due to R-to-L shunts).