NON-SHIVERING THERMOGENESIS

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Question

Which of the following pathways is MOST likely responsible for the induction of non-shivering thermogenesis in pediatric patients when they become cold?

A. Brown adipose tissue stimulation
B. Increased thyroid hormone secretion
C. Activation of the parasympathetic nervous system
D. Increased cortisol release

Key Points

- Children and neonates have a greater surface area to body weight ratio compared to adults, which predisposes them to greater heat loss.
- Temperature regulation occurs in the hypothalamus, which is immature in newborns. Preterm infants are even more vulnerable to hypothermia because they possess less brown fat and have an even more immature hypothalamus.
- Non-shivering thermogenesis is the primary way neonates, premature infants, and low body weight infants produce heat.
- The sympathetic nervous system initiates metabolism of brown fat that results in non-shivering thermogenesis.
- Hypothermia can lead to complications such as coagulopathy, arrhythmias, respiratory depression, delayed emergence, and increased susceptibility to infections.

Description of Non-shivering Thermogenesis

Thermoregulation is controlled by a negative feedback loop in the hypothalamus. In utero, the fetus is bathed in warm amniotic fluid, and the hypothalamus is not involved in temperature regulation. At birth, the hypothalamus is immature, requiring a few days for term neonates, or longer for premature neonates, to effectively regulate temperature. Non-shivering thermogenesis (NST) is a physiologic mechanism for heat production, particularly in neonates and infants, that relies primarily on the metabolism of brown adipose tissue (BAT). BAT is highly populated with mitochondria and densely innervated by sympathetic fibers. When exposed to cold environments the sympathetic stimulation results in norepinephrine binding to B-3 adrenergic fibers in the BAT, triggering lipolysis and the release of free fatty acids resulting in heat production. In neonates, this process is crucial due to their limited ability to shiver, particularly in those under 3 months of age and under anesthesia. This process, coupled with their greater surface area-to-body ratio, makes this population more susceptible to heat loss. The thermogenic capacity of NST begins within hours of birth and can persist until approximately 2 years old. However, premature infants and low birth weight infants have limited BAT stores, since it typically accumulates in the third trimester, and thus, is often sparse. Additionally, premature infants have an immature hypothalamus, significantly impairing their ability to generate heat through NST.

Importance of Temperature Management in Pediatrics

- Temperature management is critical during anesthesia, particularly in children and neonates, due to their thinner skin, lower fat content, and higher metabolic rates.
- The primary routes of heat loss in the operating room include radiation, convection, evaporation, and conduction, each necessitating specific strategies for prevention (image 1).
- Hypothermia in this population can lead to serious complications, including coagulopathy, impaired platelet function, arrhythmias, delayed wound healing, and increased risk of infection.
- Effective warming techniques, such as warming the operating room, using heated mattresses, applying forced air warmers, and administering warmed intravenous fluids, are essential to minimize heat loss and maintain normothermia.

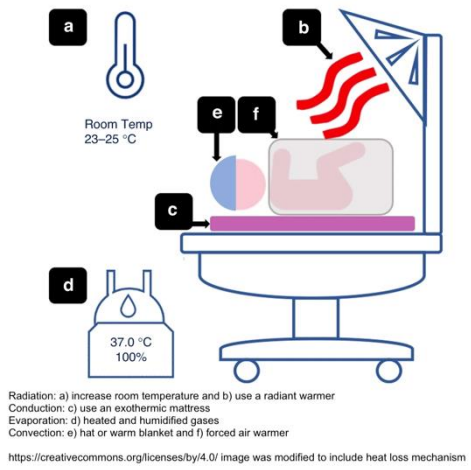

Image 1: Primary methods of heat loss in the operating room with interventions to improve thermoregulation and decrease heat loss in neonates and infants.

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Answer: **A**

BAT stimulation, the most immediate and relevant pathway for non-shivering thermogenesis in pediatric patients is sympathetic nervous system activation, which stimulates BAT. While thyroid hormones (primarily T3 and T4) do play a role in overall metabolic rate and thermogenesis, they are not the **primary** mechanism for **immediate** non-shivering thermogenesis in response to cold (B). Activation of the parasympathetic nervous system, generally works to **decrease** energy expenditure and promote "rest and digest" functions. It is not involved in the acute thermogenic response to cold (C). Cortisol is released in response to stress, and while it does have metabolic effects, it is not directly involved in non-shivering thermogenesis (D).

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