

THERMOREGULATION

- Mean core temperature - $36.5^{\circ}\text{C} - 37.3^{\circ}\text{C}$ / 97.7 to 99.5°F
- Peripheral temperature - 2 to 4°C lower than core temp
- HYPOTHALAMUS is the centre for thermoregulation.
- Body's thermoregulation controls:
 - BMR
 - Muscular activity
 - Sympathetic activity
 - Vascular Tone
 - Hormonal activity
- Basal heat production is about $0.83 \text{ kcal/kg/}^{\circ}\text{C}$
- Primary mechanism of heat loss:
 - * RADIATION: (largest contribution) Air movt. displaces heat near skin with cool air.
? 40%
 - * CONVECTION: Blood redistributes heat from core to periphery.
 - * CONDUCTION: Heat transfer from core to adjacent tissue.
 - * EVAPORATION: - Via intact skin.
- Core consists of well perfused organs like brain & organs within trunk - These are well perfused.

- Peripheral compartment consists of skin, s/c tissue, upper & lower extremities.
- Hypothalamus regulates only core body temp.

INTER THRESHOLD RANGE:

- Range over which autonomic response to temp. are not activated.
- Bound by:
 - Sweating threshold @ upper end
 - Vasoconstriction threshold @ lower end.
- (N) range is $\approx 0.2^{\circ}\text{C}$. But it $\uparrow$ with anaesthesia. Thus thermoregulatory responses are blunt under anaesthesia.

Measuring Core Temperature:

- Pulmonary A
- Distal esophagus
- Nasopharynx
- Tympanic membrane
- Rectal / bladder temperature

PATHWAY OF THERMOREGULATION:

- Afferent Sensing Pathway
- Central regulation
- Efferent response.

* Afferent Sensory Pathway:

- Thermoregulatory cells are found in most part of body like
 - Hypothalamus
 - Spinal cord - Dorsal root ganglia
 - Skin
- Cold receptors
 - ↓
 - Aδ fibres (cold receptor)
 - ↓
 - Unmyelinated C fibres (warm receptor)
(carries even pain sensation)
 - ↓
 - Anterior spinothalamic tract
 - ↓
 - Thermoregulatory centre in hypothalamus
(pre-optic region)

* Central Regulation

- Hypothalamus integrates the afferent input & co-ordinate various efferent output.
- Autonomic control centred in anterior hypothalamus.
- Behavioral control centred in posterior hypothalamus.
- Threshold temp. for Vasoconstriction :- 36.5°C
- Threshold temp. for Shivering :- 36°C .

* Efferent Response:

- First response to ↓ Core temp. is peripheral vasoconstriction $\xrightarrow{\text{fib}}$ Shivering.

BEHAVIOURAL RESPONSE:

- ~ Dressing appropriately
- ~ Body positions which oppose skin surface
- ~ ↑ Voluntary move.

AUTONOMIC RESPONSE:

- ~ Vasoconstriction : Reduces redistribution of heat to periphery
- ~ Non-shivering thermogenesis → New born
- ~ Shivering.

Hypothalamic thermoregulatory control (Spino-reticulo-hypothalamic axis)

Brain temperature
SC temperature
Visceral temperature
Pyrogenic mediators

Feedback

Behavioral response
Cutaneous vasomotor response
Cardiovascular response
BAT thermogenesis
Shivering "

Core Temperature

Heat flux

Skin temperature

Ambient temperature

Thermoregulation during GA

- Behavioral regulation is not applicable
- GA alters the autonomic threshold
 - $\sim \uparrow$ in warm response threshold
 - $\sim \downarrow$ in cold " "
- Interthreshold range $\uparrow$ from 0.2°C to $2-4^{\circ}\text{C}$.

Phases of Heat loss:

PHASE I (Rapid reduction phase)

- Core temp. falls by $1-1.5^{\circ}\text{C}$ within 1st 30-45mins
- Due to Vasodilation effect of GA.
- This leads to redistribution of core temp to peripheral tissue.

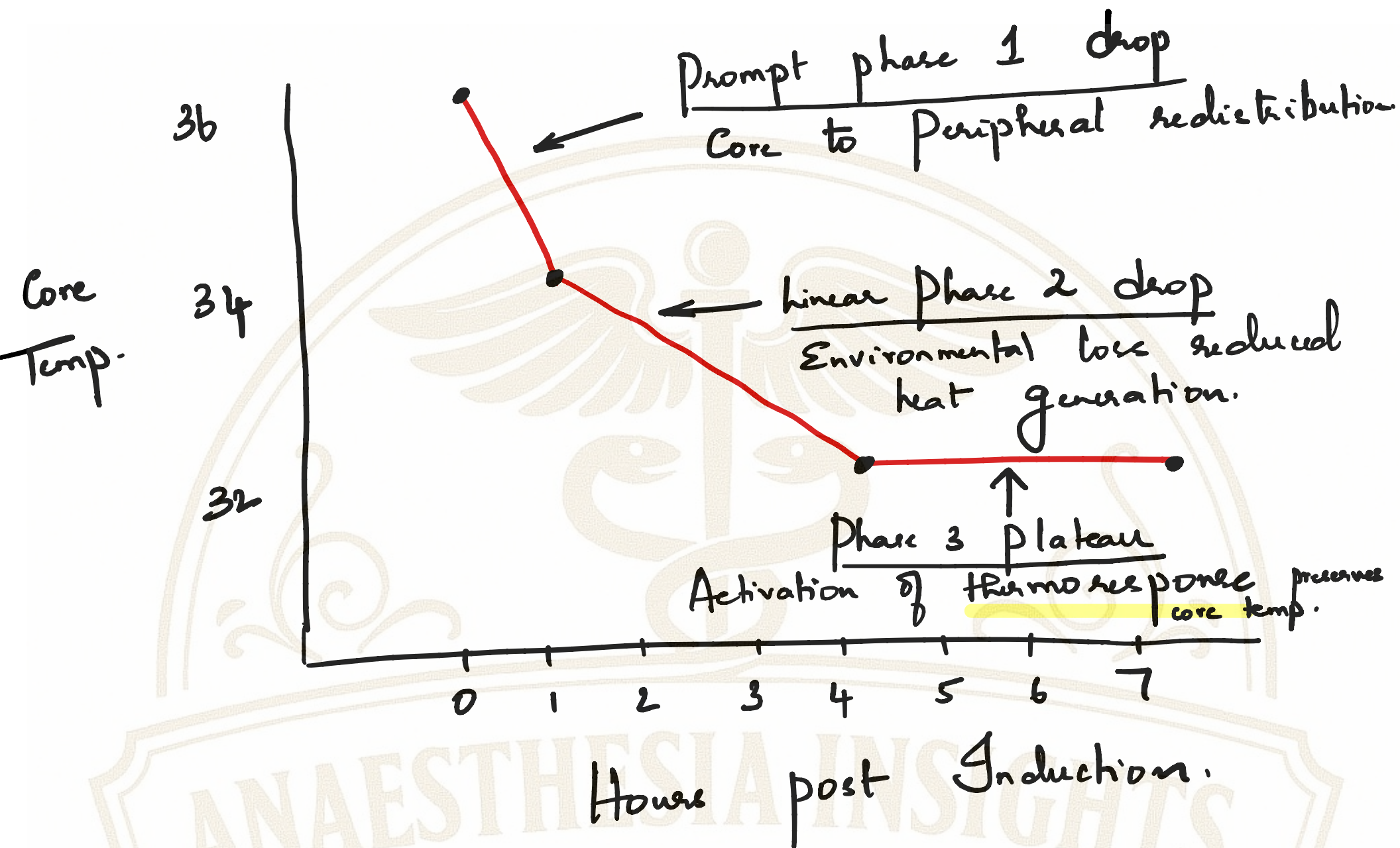
PHASE II (Linear reduction)

- Core temp. falls further by 1°C over 2-3 hrs
 - This is due to heat loss by radiation, conduction, convection, evaporation which exceeds heat production
- ↓

During major sx where greater surface area of tissue is exposed more heat is lost by evaporation.

PHASE III (Plateau phase)

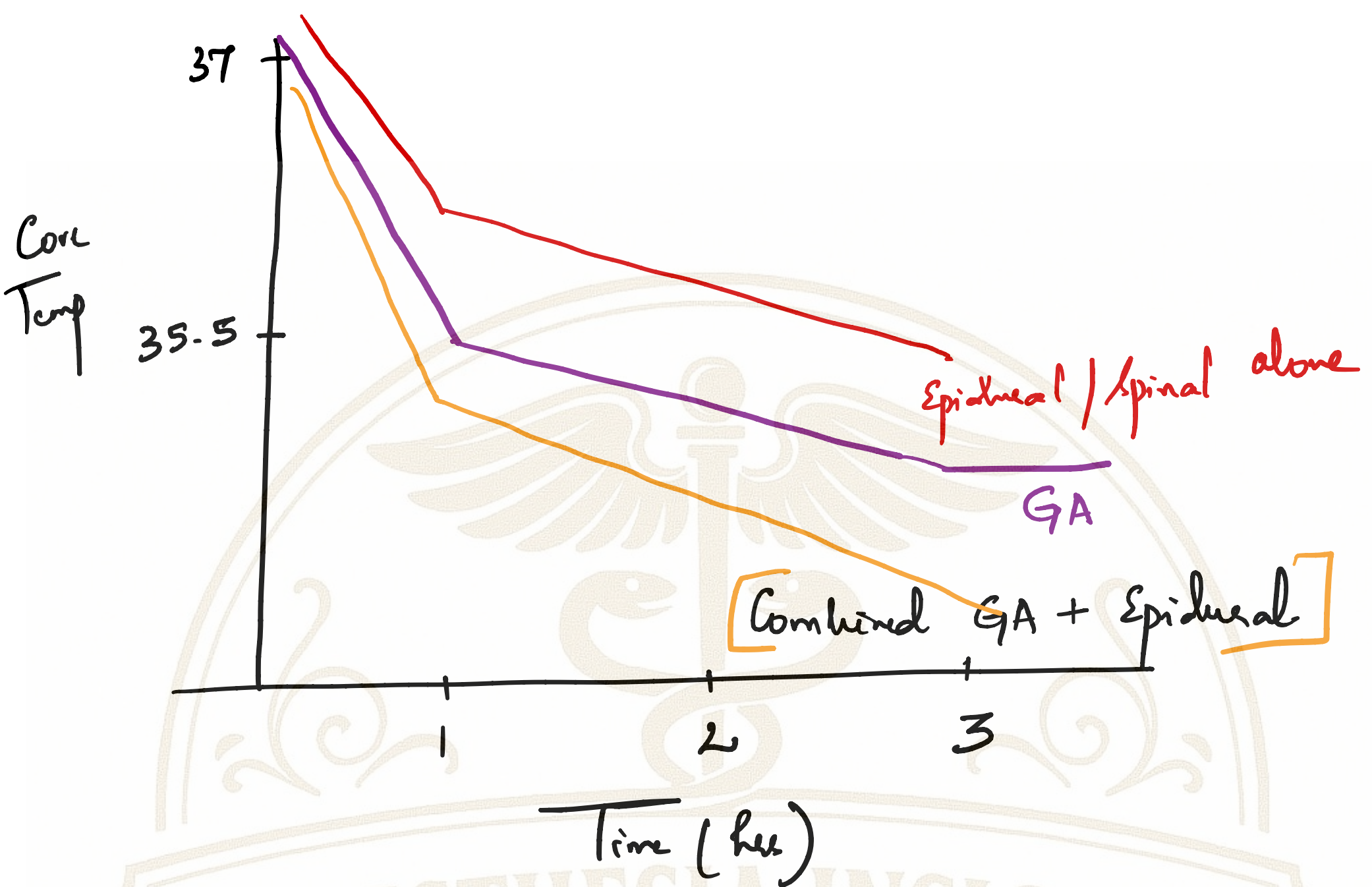
- Heat loss is matched by metabolic heat production.
- This phase is absent in peripheral / autonomic neuropathy



Thermoregulation under Regional Anae.

- Redistribution of heat from core to peripheral tissue due to vaso dilation is the main cause of hypothermia. But it is less pronounced than GA as it is confined only to a part of the body.
- Plateau phase is also absent in Regional Anae as they prevent vasoconstriction

Effects of Anaesthesia on Thermoregulation.



Consequences of Perioperative hypothermia.

- Cardiac arrhythmias
- ↑ peripheral Vascular resistance
- ⊖ Shift of O_2 -Hb dissociation curve
- Impaired renal fn.
- ↓ drug metabolism
- Poor wound healing
- ↑ risk of Infection
- Coag. dysfunction
- Delayed recovery

Prevention & Rx of Peri-op Hypothermia

- ① Minimize redistribution of heat
- ② Cutaneous warming during anaesthesia
- ③ Internal warming.

→ Minimize redistribution of heat:

- Pre-op warming of peripheral tissue
 - This ↓ core to peripheral temp. gradient
- Pre-op pharmacological vasodilatation.
 - Facilitate core to peripheral redistribution of heat before anaes. Since thermoregulatory responses are intact core temp. is not compromised

→ Cutaneous Warming:

- Passive Insulation → Blankets
- Active warming → Heating blankets, heater fan

→ Internal Warming

- IV fluids warmed to body temp. prior to infusion.
- Airway humidification

Thermoregulation in New born.

- New borne have large skin surface area compared with their body mass.
- They also have ↑ thermal conduction d/t thin layer of slc fat. Hence they lose more heat thro' skin than adults.
- New born head comprises 20% of total skin surface area. Hence they lose a lot of heat via head

Physiological changes in Hypothermia

① Thermoregulatory responses:

- VASOCONSTRICTION: In an attempt to conserve heat, blood vessels in the skin constrict, reducing blood flow to periphery & helping to maintain core body temperature.
- SHIVERING: The body generates heat through muscle activity, which is an involuntary response to cold. This shivering can help to elevate body temperature.

② Cardiovascular changes:

- BRADYCARDIA: A slowed heart rate occurs as the body temperature drops, which can lead to inadequate cardiac output & blood flow.

- HYPOTENSION: Blood pressure may decrease d/t $\downarrow$ C.O & SVR as vasodilation occurs in late stages

③ Neurological changes:

- COGNITIVE IMPAIRMENT: As body temp. declines, cognitive fn deteriorate, leading to confusion, memory loss, poor decision-making.
- LOSS OF CO-ORDINATION: Fine motor skills are affected, leading to difficulty with tasks requiring dexterity & co-ordination.
- $\downarrow$ CONSCIOUSNESS: In severe hypothermia, individuals may become lethargic or lose consciousness.

④ Respiratory Changes:

- ↓ RESPIRATORY RATE: As metabolic process slow, RR may ↓, leading to inadequate ventilation & possible respiratory acidosis if prolonged.
- ↑ AIRWAY RESISTANCE: Cold air may cause bronchoconstriction, ↑ airway resistance & leading to difficulty in breathing.

⑤ Impaired Immune response: Prolonged exposure to cold may lead to a ↓ immune response, making individuals more susceptible to infections.

⑥ ↓ Gastrointestinal Motility: Blood flow to GIT ↓ which can slow digestion. & lead to nausea & abdominal pain.

⑦ Skin change: Pallor & Cyanosis
As vasoconstriction occurs, the skin can become pale, gray or blue indicating inadequate blood flow & oxygenation!

Ways to prevent hypothermia in Neonates

- ① PRE-WARMING: Warm the OT to a temperature comfortable for neonate (24-26°C)
- ② Pre warm the baby if feasible under a radiant warmer or heated environment just before Sx.
- ③ Maintaining Core Temp: Utilize radiant warmer to help maintain the neonate's core body temperature throughout surgical procedure.

- ④ Forced air warming blankets (Bair Hugger) around the neonate. to prevent heat loss during Sx.
- ⑤ Apply warm, moist compresses in areas that are exposed during the procedure to help maintain temperature.
- ⑥ Cover exposed areas with surgical drapes to ↓ heat loss
- ⑦ Utilize warm IV fluids for maintenance & resuscitation.
- ⑧ Continuous temperature monitoring (esophageal or rectal)
- ⑨ Minimize Anaesthesia Induced Vasodilation
Ensure proper dosing & monitoring of anesthetic agents to avoid excessive vasodilation & heat loss

(10) Once Sx is complete, encourage skin-to-skin contact with a caregiver post-op to help with rewarming.

