Temperature Control in the Neonate

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Heat Processing

- Three heat processing steps must be understood in order to understand temperature control.
  - Heat Generation – the process which heat is produced (generally in the body core)
  - Heat Conservation (Insulation) - the mechanisms by which heat is restricted from reaching the body surface (generally done at the periphery).
  - Heat Loss – physical processes of heat loss from the body surface.

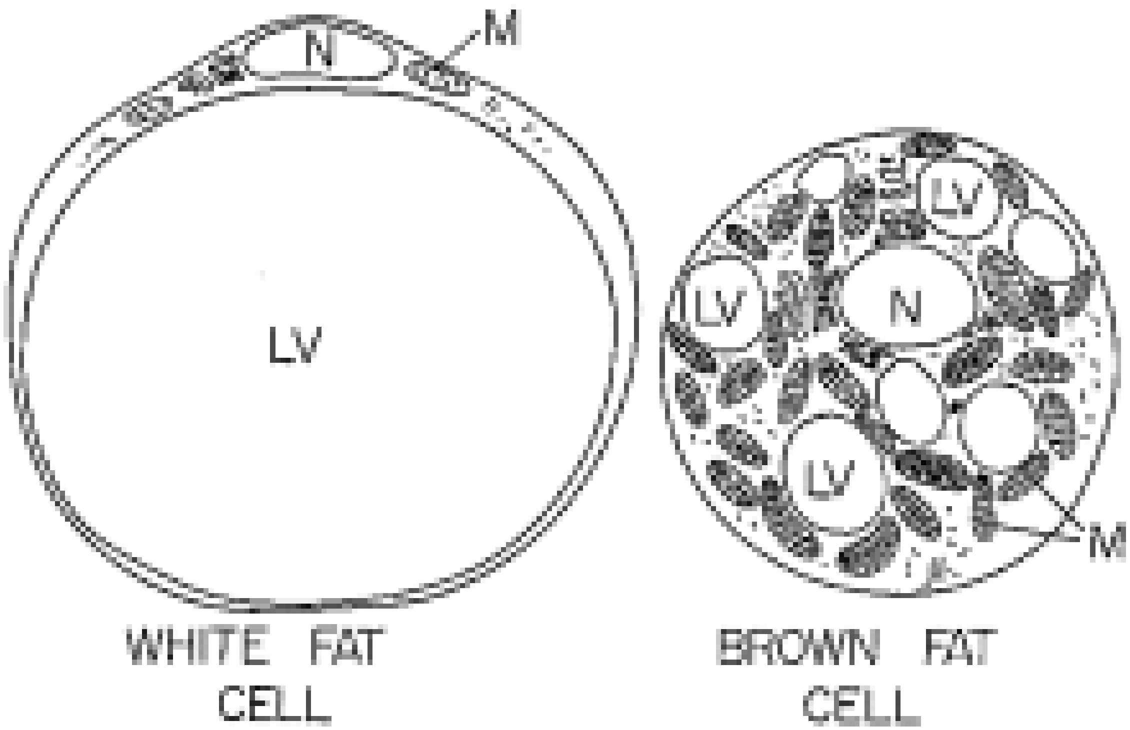
Mechanisms of Heat Generation

- Basal Metabolism – biochemistry is inefficient, the result is heat. The heat generated by this mechanism is proportional to mass.
- Shivering – not used by neonates
- Large body movements – minimally used by neonates
- Brown Fat – a neonatal organ

Brown Fat vs.. White Fat

- Brown Fat
  - A neonatal organ: It is not used in older humans to any degree.
  - Located in the core of the body – under scapula and in retro-peritoneal cavity.
  - An organ of heat generation
- White Fat
  - Present throughout life
  - Located subcutaneously in the periphery .
  - An organ of storage and insulation.

Brown Fat vs. White Fat



The White fat cell has single fat globule and only a few mitochondria.
The Brown Fat Cell has many fat globules and many mitochondria.

Brown Fat vs. White Fat

- Brown Fat
  - **Has many globules of fat** this allows incremental release of fat to feed its heat generation machinery
  - **The large number of mitochondria** are necessary as the metabolism of this fat occurs locally, in the brown fat cell.
  - **The mitochondria have a special protein – uncoupling protein 1** which allows the proton gradient of the external mitochondrial membrane to be dissipated without making ATP. **The result is heat production**
- White Fat
  - Has a **single globule** of fat that is released all at once – all or nothing.
  - The **small number of mitochondria** demonstrate that very little fat is metabolized here. The metabolism of the fat in these cells takes place in the liver after release.
  - **Uncoupling Protein 1 is not present** in these cells. Very little heat is generated.

Prematures and Heat Generation

- Prematures have little mass – thus minimal generation of heat from this mechanisms.
- Prematures like all neonates do not shiver and do not have significant large body motion.
- Prematures do not have much brown fat as it is laid down mainly in the third trimester.

Mechanisms of Heat Conservation - Insulation

- White Fat lines the dermis providing insulation.
- Neurological control of the blood vessels connecting the superficial and deep venous plexuses (on opposite sides of the fat) in the skin determine how much blood reaches the cool areas peripheral to the white fat.
  - In order to raise body temperature these vessels are closed and blood does not reach the periphery. (The body appears modeled, blue and feels cold.)
  - In order to lower the body temperature these vessels are opened and blood reaches the skin surface. (The body is flushed, red and feels warm)

Prematures and Insulation

- Prematures do not have much white fat as it is laid down mainly in the last trimester.
- Prematures can not control vasodilatation and vasoconstriction adequately to control flow from the deep and superficial venous plexuses.

Mechanisms of Heat Loss
-These are all physical processes

- Conduction – solid to solid contact transfer of heat.
  - This is dependent upon the surface area in contact.
  - Smaller newborns and prematures tend to have larger percentages of their total body surface area in contact with the mattress.
- Convection – solid to gas transfer.
  - The transfer of heat by convection increases with the radius of curvature of the surface. Prematures and neonates have more loss per square inch of surface than older children and adults due to their smaller body parts.
- Radiation – solid to solid at a distance transfer of heat.
  - Loss or gain of heat is related to the solid angle which is made to the surface to which radiation occurs. Thus we are colder when we are close to a window rather than further from it.
- Evaporation – Liquid to gas transfer. Babies are born wet and tiny prematures leak fluid through the skin making this more of a problem.

Temperature in the Neonate

- A very important concept is that temperature control becomes more problematic as the mass to surface area ratio decreases. Heat generation is proportional to mass. All heat loss mechanisms are proportional to body surface area.
  - This ratio shows the following:
  - ADULT > Child >> Term Baby >>> Premature

The Neutral Thermal Environment

- The NTE is defined as the temperature range in which a particular infant uses the least amount of energy for temperature regulation. Infants use more energy below this range to raise their temperature and use more energy above this range trying to cool off.
- NTEs are different for infants of different gestational ages AND for infants of different chronological ages.
- NTEs were determined experimentally on growing infants in steady state. They may not be valid for unstable infants, on IV alimentation and ventilators.

Examples of NTE Ranges

RECOMMENDED RANGES FOR INCUBATOR TEMPERATURES

RANGE OF OPTIMAL INCUBATOR TEMPERATURES (°C) Birth Weight Group					
Age	< 1000 gm	1000 – 1500 gm	1500 – 2000 gm	2000 – 2500 gm	2500 gm + 36 weeks
0 – 6 hr	36.7 – 36.2	36.2 – 35.4	35.7 – 34.2	34.8 – 33.6	34.8 – 32.7
6 – 12 hr	36.7 – 36.0	36.2 – 35.4	35.7 – 34.1	34.8 – 33.0	34.8 – 32.0
12 – 36 hr	36.6 – 35.9	36.0 – 35.2	35.6 – 34.1	34.7 – 32.5	34.7 – 31.6
24 – 36 hr	36.5 – 35.9	35.9 – 35.1	35.5 – 34.0	34.7 – 32.3	34.4 – 31.2
36 – 48 hr	36.5 – 35.9	35.9 – 35.0	35.4 – 33.9	34.6 – 32.0	34.2 – 31.0
48 – 72 hr	36.4 – 35.8	35.9 – 34.8	35.2 – 33.6	34.4 – 31.8	34.1 – 30.6
72 – 96 hr	36.3 – 35.7	35.8 – 34.7	35.1 – 33.5	34.2 – 31.7	33.6 – 30.2
4 – 5 days	36.3 – 35.6	35.7 – 34.4	35.0 – 33.3	34.1 – 31.6	33.4 – 29.9
5 – 6 days	36.2 – 35.5	35.6 – 34.3	34.9 – 33.2	33.9 – 31.6	33.1 – 29.8
6 – 8 days	36.0 – 35.2	35.5 – 34.1	34.8 – 33.0	33.8 – 31.6	32.5 – 29.3
8 – 10 days	35.9 – 35.1	35.2 – 34.0	34.6 – 32.8	33.5 – 31.6	32.5 – 29.3
10 – 12 days	35.8 – 34.9	35.0 – 33.9	34.4 – 32.7	33.4 – 31.6	32.0 – 29.3
12 – 14 days	35.7 – 34.7	35.0 – 33.4	34.3 – 32.6	33.3 – 31.6	31.4 – 29.3
2 – 3 weeks	35.6 – 34.1	35.0 – 33.0	34.2 – 32.4	33.2 – 31.0	–
3 – 4 weeks	35.2 – 33.6	34.6 – 32.3	34.1 – 32.0	33.0 – 30.4	–
4 – 5 weeks	34.7 – 33.3	33.9 – 31.8	33.9 – 31.5	32.6 – 29.9	–
5 – 6 weeks	–	33.1 – 31.0	–	31.8 – 29.3	–

NOTE: No single temperature is a full statement of the thermal environment of the baby.

Temperature Control – NTE vs. Servo

- Using NTE for temperature control in newborns is like setting the temperature in a room. Since we can not ask the newborn whether it is too cold or too hot we use the NTE. We make the assumption the incubator or radiant warmer maintains the NTE (something you must check) and then monitor the infant temperature for hypothermia or fever.
- Using Servo for temperature we set the temperature that we want the skin to be held at (usually 36.5 C). We then monitor any changes to the environmental temperature required to keep this skin temperature. If the environmental temperature goes up, the infant is hypothermic. If it goes down, the infant has fever.

Temperature Control – NTE vs. Servo

- It is critical to know which mode of temperature control is being used on your infant.
  - We generally use servo on tiny prematures and very unstable newborns.
  - We always use NTE when weaning from the isolette.
  - The mode is illuminated on the isolette.
  - The servo mode requires a wire probe on the skin
- In both cases it is necessary to know both the stability of the infants skin temperature and the stability of the environmental temperature.
  - When using NTE, the environmental is supposed to be fixed – if it is not there is no point worrying about the skin temperature as the isolette is broken.
  - In Servo mode the skin temperature is supposed to be fixed. If it is not, the system is not working.

How do we assist Neonates with Temperature Control?

- We can only assist with heat loss control. We can do nothing for heat generation or insulation.
- Radiant Warmers and Isolettes are used. Both have positive and negative features.

Isolette vs. Radiant Warmer

These only control heat loss. They have no effect on Heat Generation or Insulation.

- Isolette
  - Conduction – no advantage of either system
  - Convection – convective losses well controlled. Air flow in an isolette follows a flow plan which minimizes heat loss of infant.
  - Evaporation – can control humidity well
  - Radiation – heat loss by this mechanism is well controlled especially in double walled isolettes.

- Radiant Warmer
  - Conduction – no advantage of either system
  - Convection – no control over convective heat losses.
  - Evaporation – no ability to control humidity – huge disadvantage
  - Radiation – different in each direction – a problem for little prematures.

Isolette vs.. Radiant Warmer

- Isolettes are generally better in all aspects of temperature control than Radiant Warmers.
- Access is much better with Radiant Warmers – thus their use at admission to nurseries (when more procedures are done) and in larger infants.

Review Questions

- Why is the mass to surface area ratio important for temperature control in neonates.
- What is Uncoupling protein 1? Why is it important in brown fat?
- Do Isolettes and Radiant Warmers help with heat generation? If not what do they do?
- Why is brown fat so important for infants?
- Explain how the infant insulates itself? Why do prematures have less ability to do this?
- What is NTE?
- How are NTE and Servo used in the NICU? Why must the environmental temperature and the skin temperature be monitored with both?
- Explain the advantages of Isolettes vs. Radiant Warmers.