




• Ether Day, 1846 •

A close-up of Elsa from Disney's Frozen, looking slightly to the right with a determined expression. She has her signature blonde braid and is wearing her light blue, shimmering ice dress. Her right hand is extended forward, palm up, as if she is about to cast a spell or is in the middle of one. The background is a deep blue with a subtle, crystalline texture.

**“ The cold never  
bother me anymore ”**

**R2 Wariya Vongchaiudomchoke & R2 Pichchaporn Praserdvigai**

**Supervisor: Aj. Aphichat Suphathamwit**

Is that really true?



y-cold

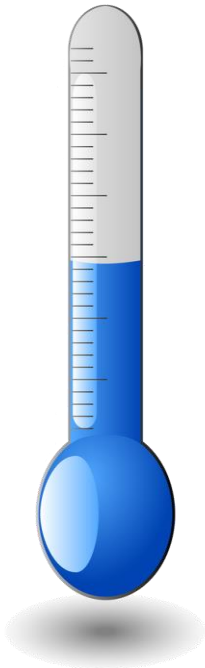
- ❑ Definition and classification
- ❑ Effect of hypothermia
- ❑ Physiology
- ❑ Hypothermia prevention
- ❑ Guidelines



y-cold

# Definition and classification

- Core temperature less than 36.0°C (96.8°F).
- Severity of hypothermia (core temperature )



Mild: 35.0 -35.9°C



Moderate: 34.0 - 34.9°C



Severe  $\leq$  33.9°C.

# Effect of hypothermia

**Table 3: Adverse effects of hypothermia**

Temperature (°C)	Effect
30-35	Physiological attempts to increase temperature, generation of heat: Shivering, peripheral vasoconstriction
≤36->35	Tachycardia
≤35	Bradycardia, low platelet count, impaired platelet function, impaired coagulation cascade, altered clearance of various medications
≤33	ECG changes: Increased PR-interval, widening of QRS-complex, increased QT interval
≤32	Mild arrhythmias
≤30-31	Depressed consciousness, lethargy, coma
≤30	“Hibernation:” Shivering ceases, marked decrease in rate of metabolism
≤28-30	Increased risk of tachyarrhythmias, beginning with atrial fibrillation

**Bleeding**

**EKG**

**Coma**

*ECG=Electrocardiography*

*The Effects of Mild Perioperative Hypothermia on **Blood Loss** and **Transfusion Requirement***

Suman Rajagopalan, M.D.,\* Edward Mascha, Ph.D.,† Jie Na, M.S.,‡ Daniel I. Sessler, M.D.§

(36.6°C)

**Normothermia**

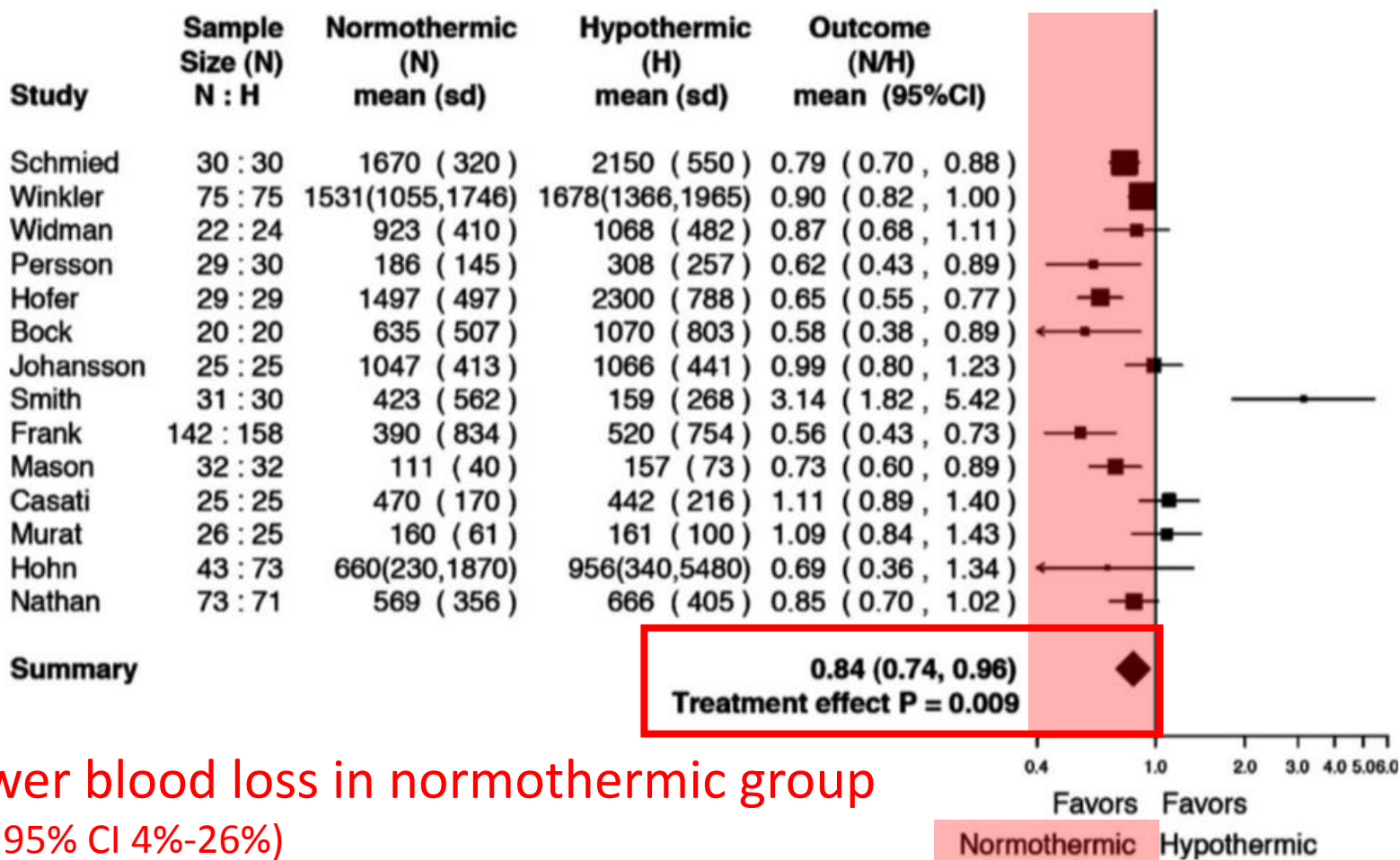
vs

(35.6°C)

**Mild hypothermia**

Cardiac and non-cardiac surgery

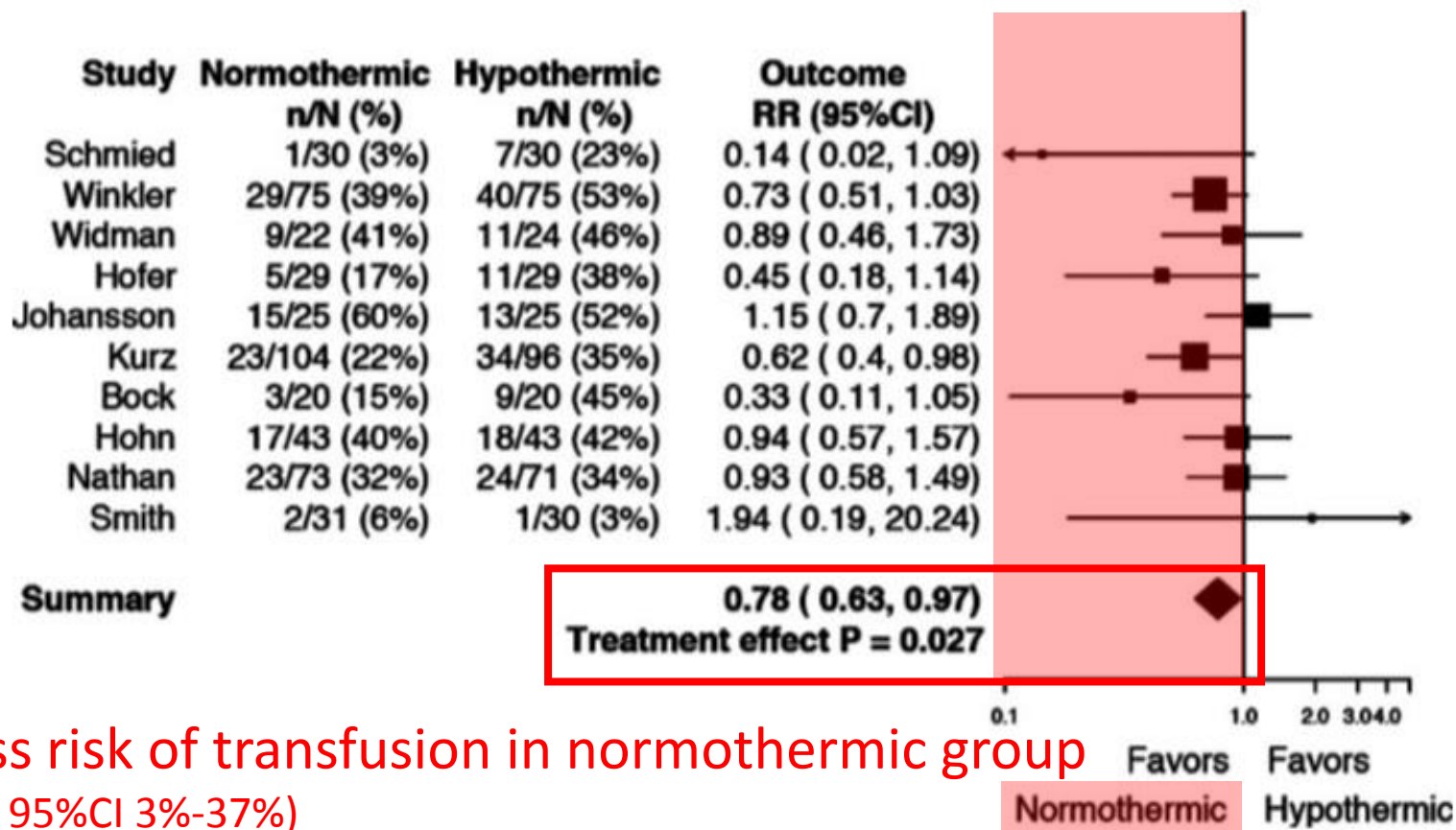
# Effect of hypothermia: **blood loss**



**16% lower blood loss in normothermic group**  
(p=0.009, 95% CI 4%-26%)



# Effect of hypothermia: transfusion



22% less risk of transfusion in normothermic group  
(p=0.027, 95%CI 3%-37%)

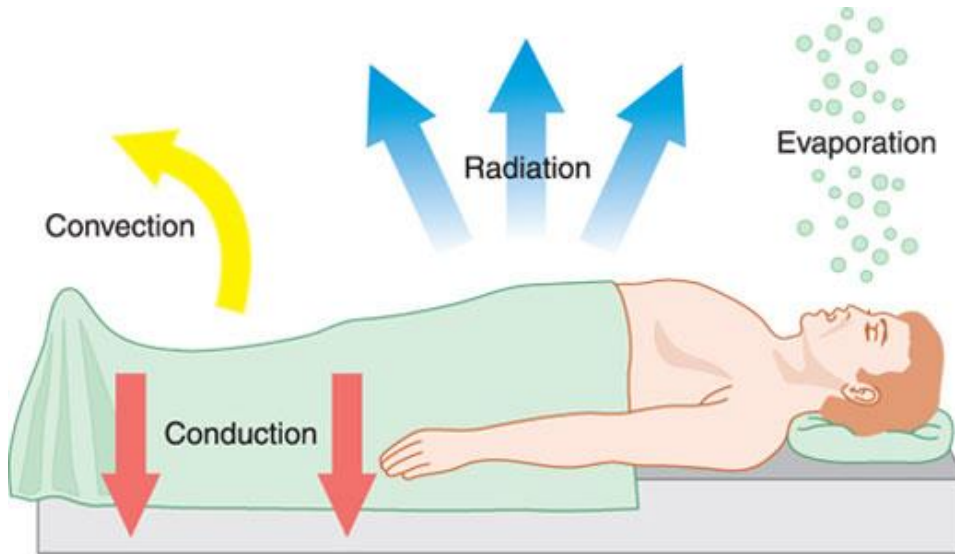
# Effects of hypothermia

- Delayed drug clearance
- ↑ wound infection
- Thermal discomfort and shivering
- Myocardial damage

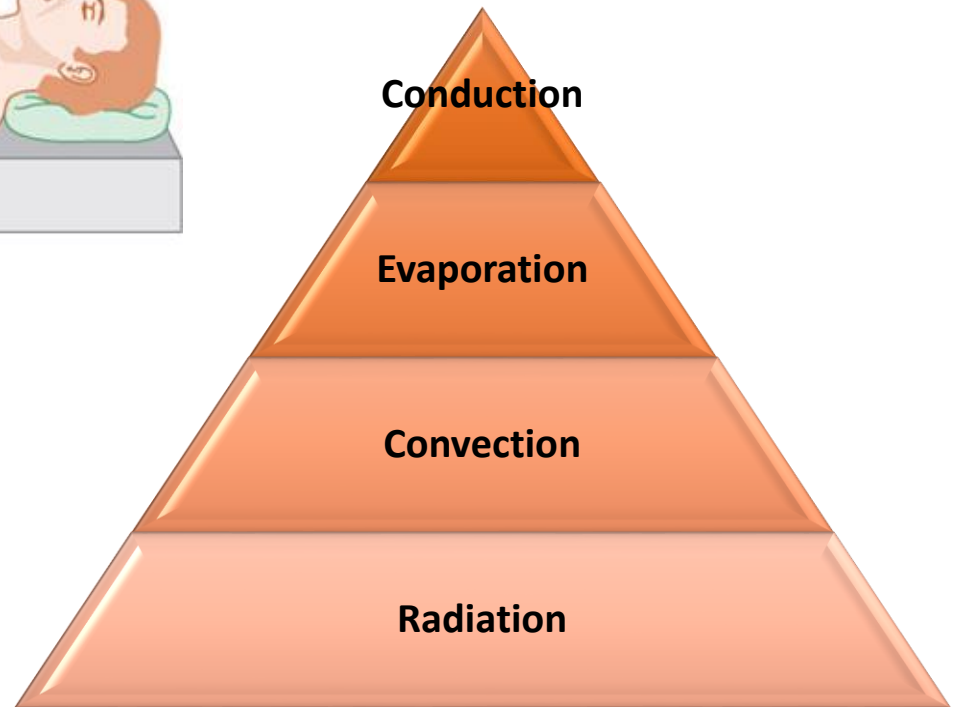
A person is shown in profile, wearing a dark hooded jacket and a blue scarf. They are standing in a snowy environment with falling snow. The background is a bright, overcast sky.

# Why? and How?

# Hypothermia under anesthesia



Source: D.E. Longnecker, S.C. Mackey, M.F. Newman, W.S. Sandberg, W.M. Zapol: Anesthesiology, Third Edition Copyright © McGraw-Hill Education. All rights reserved.



# Physiology

## Hypothalamus



Receptor

Effector

### Thermal receptor

- hypothalamus
- other parts of brains
- spinal cord
- deep thorax, abdomen
- skin surface

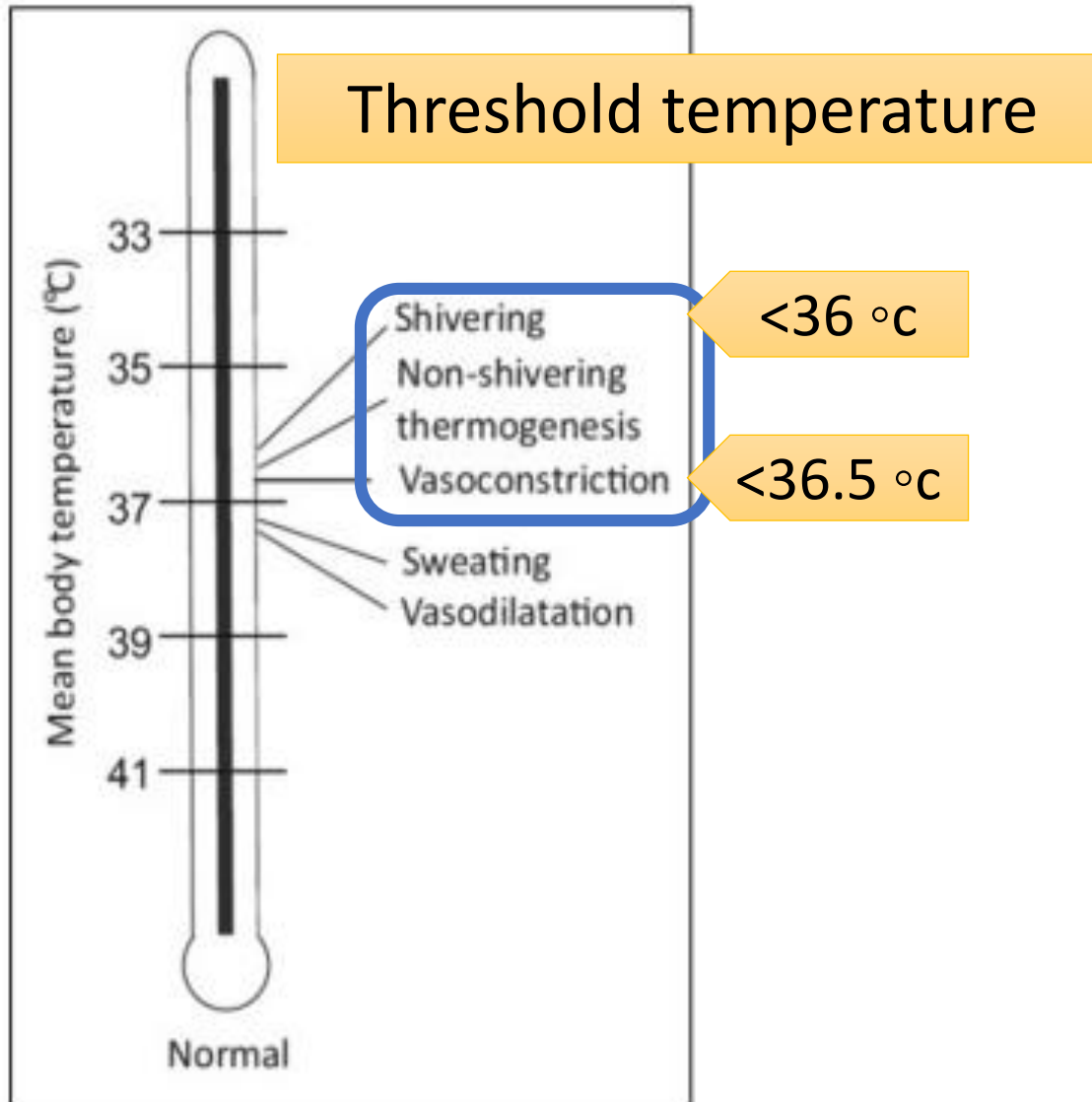
~~Behavioral regulation~~

Autonomic regulation

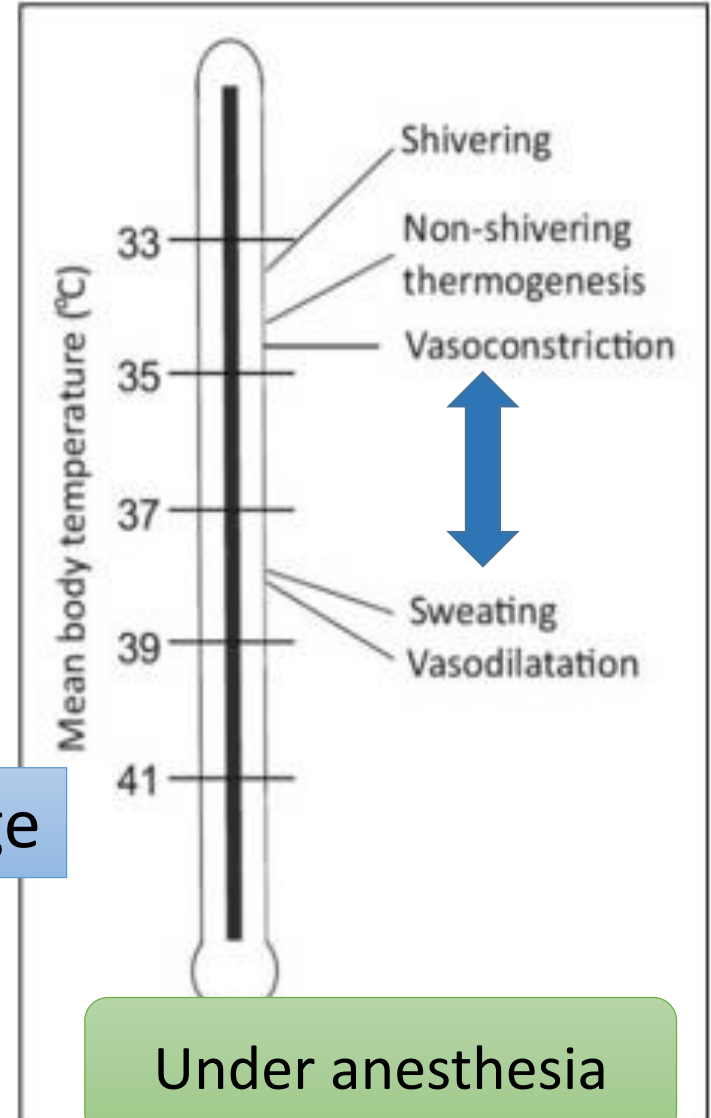
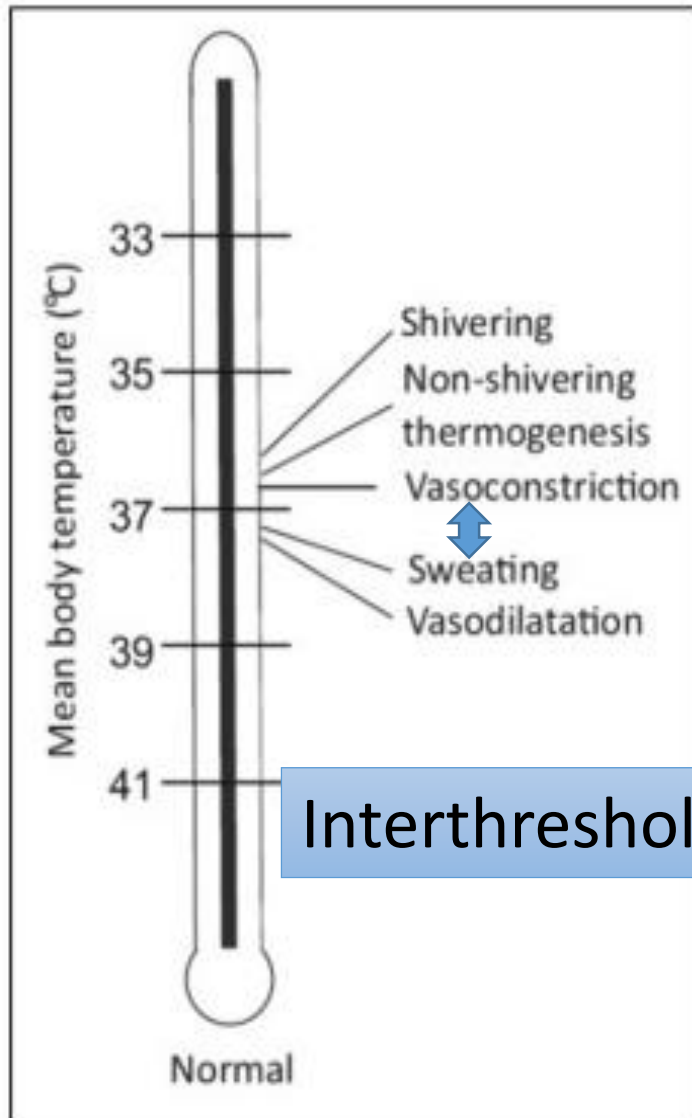
Temperature Homeostasis

Imbalance

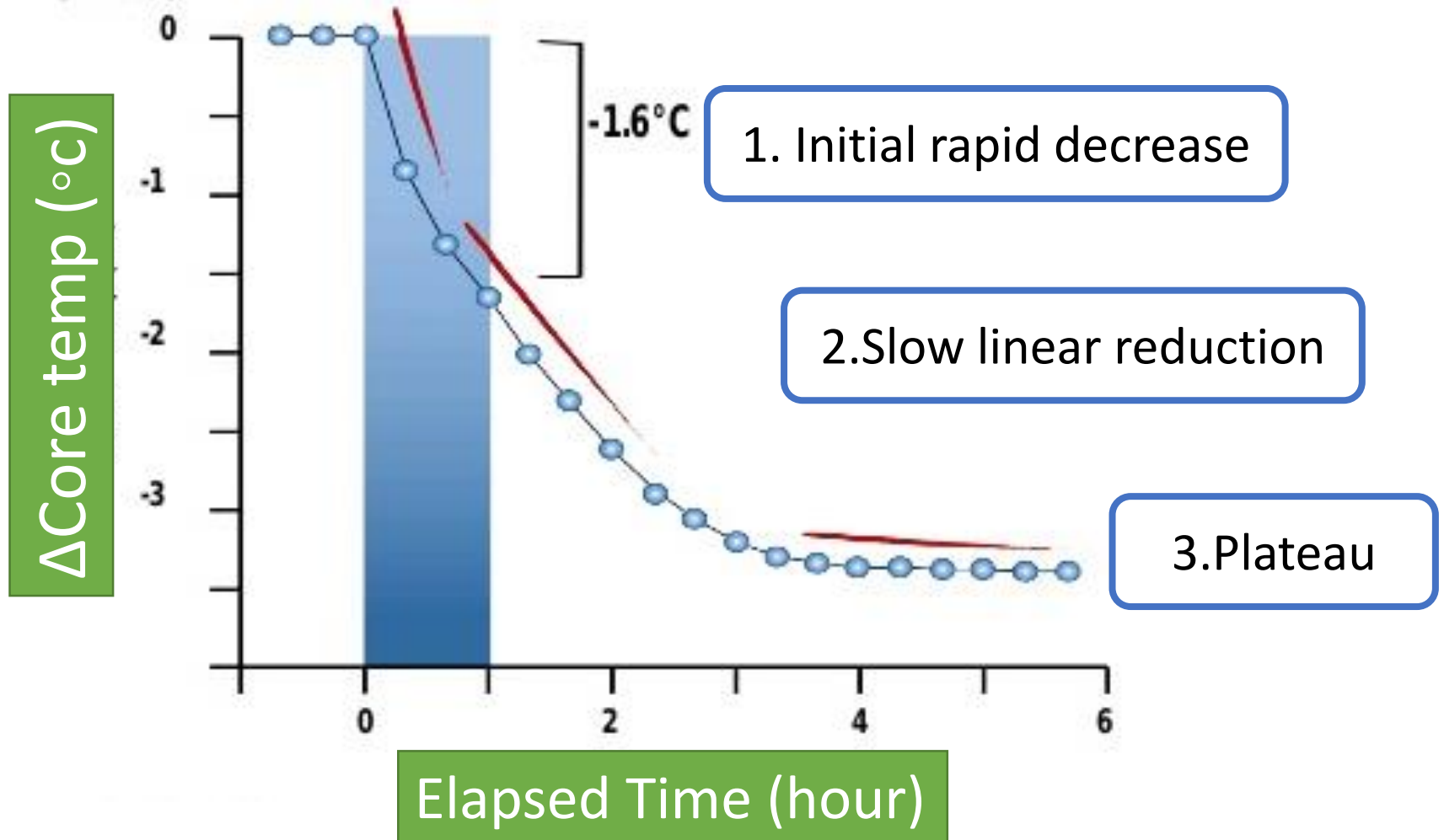
# Autonomic Thermoregulation



# Autonomic Thermoregulation



# Hypothermia under anesthesia





# Prevention



# Hypothermia prevention

Maintenance of body temperature in a **normothermic range** is recommended for **most procedures** other than during periods in which mild hypothermia is intended to provide organ protection (Class I, Level B)

*American Society of Anesthesiologists, 2015*

# Hypothermia prevention

Temp.  
Monitoring

Preoperative  
warming

Theatre suite  
temp.

Fluid  
warming

Cutaneous  
warming

Postoperative  
warming

# ASA **Standard II** Body temperature

**Every patient** receiving anesthesia should have  
**temperature monitoring**

when clinically significant changes  
in BT are intended, anticipated, suspected

*American Society of Anesthesiologists*



Hands up!!

# Temperature monitoring

Eur J Anaesthesiol. 2007 Aug;24(8):668-75. Epub 2007 Apr 11.

## **Survey on intraoperative temperature management in Europe.**

Torossian A<sup>1</sup>; TEMMP (Thermoregulation in Europe Monitoring and Managing Patient Temperature) Study Group.

- 801 surgical procedures, 17 European countries
- Temperature monitoring is done in **19.4%**

# Temperature monitoring

- None of the existing guideline specify the best tools
- Electronic thermometers are accurate & inexpensive
- **The site and device selection** depend on physicians, type of surgery, and accessibility of monitoring site
- **The least invasive** modalities with **a reliable assessment** are preferred

# Temperature monitoring

Core body temperature should be measured

- GA longer than 30 min
- RA when changes in body temperature are intended, anticipated, suspected

*NICE pathway on inadvertent perioperative hypothermia*



# Sites for temperature monitoring

## Core

- Pulmonary artery
- Distal esophagus
- Tympanic membrane
- Nasopharynx

## Intermediate

- Oral
- Rectum
- Bladder

## Skin

- may reflect core temperature

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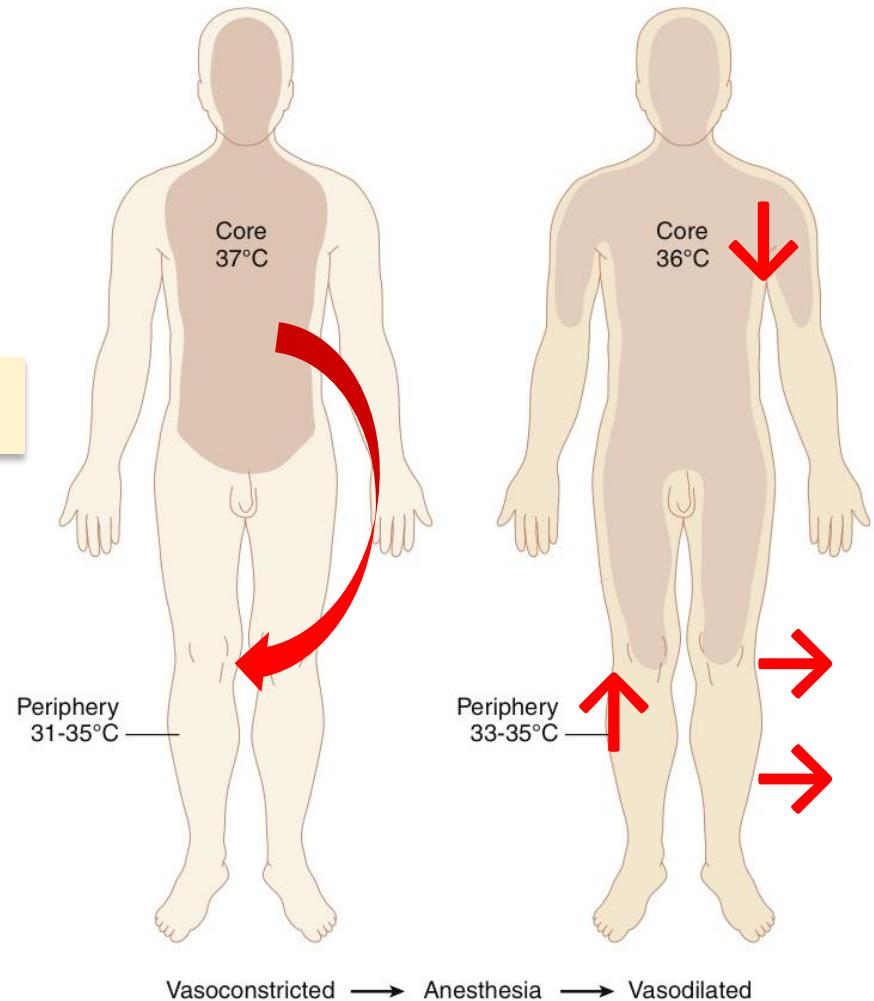
Postoperative  
warming

# Preoperative warming

↑ peripheral heat content

↓ redistribution hypothermia

Higher core temperature



# Preoperative warming

Author	Year	Method	N	Setting	Intervention	Result
Fossum	2001	RCT	100	OPD GA for 1-3 hr	FAW 38±3°C > 45 min Cotton blanket	↑ pre-op core T <span style="color: red;">P=0.02</span> <b>Better maintain peri-op T</b> Similar shivering
Wong	2007	RCT	103	Major abd Sx	On/off warming mattresses 2 hr	<span style="color: red;">P&lt;0.001</span> <b>Higher intra-op core T</b> Same core T after 2 hr Less blood loss in prewarm
Andrzejowski	2008	RCT	68	Spine Sx	FAW 38°C x 1 hr Linen gown	<span style="color: red;">P&lt;0.05</span> <b>Smaller ↓ core T intra-op</b> More pt maintain core T > 36°C
Horn	2012	RCT	200	GA 30-90 min	FAW 44°C x 10, 20, 30 min Insulation	<span style="color: red;">P&lt;0.00001</span> <b>Higher intra-op core T</b> Same core T in all FAW groups More pt maintain core T > 36°C Lower shivering in all FAW gr

FAW: Forced air warmer



REPORTS OF ORIGINAL INVESTIGATIONS

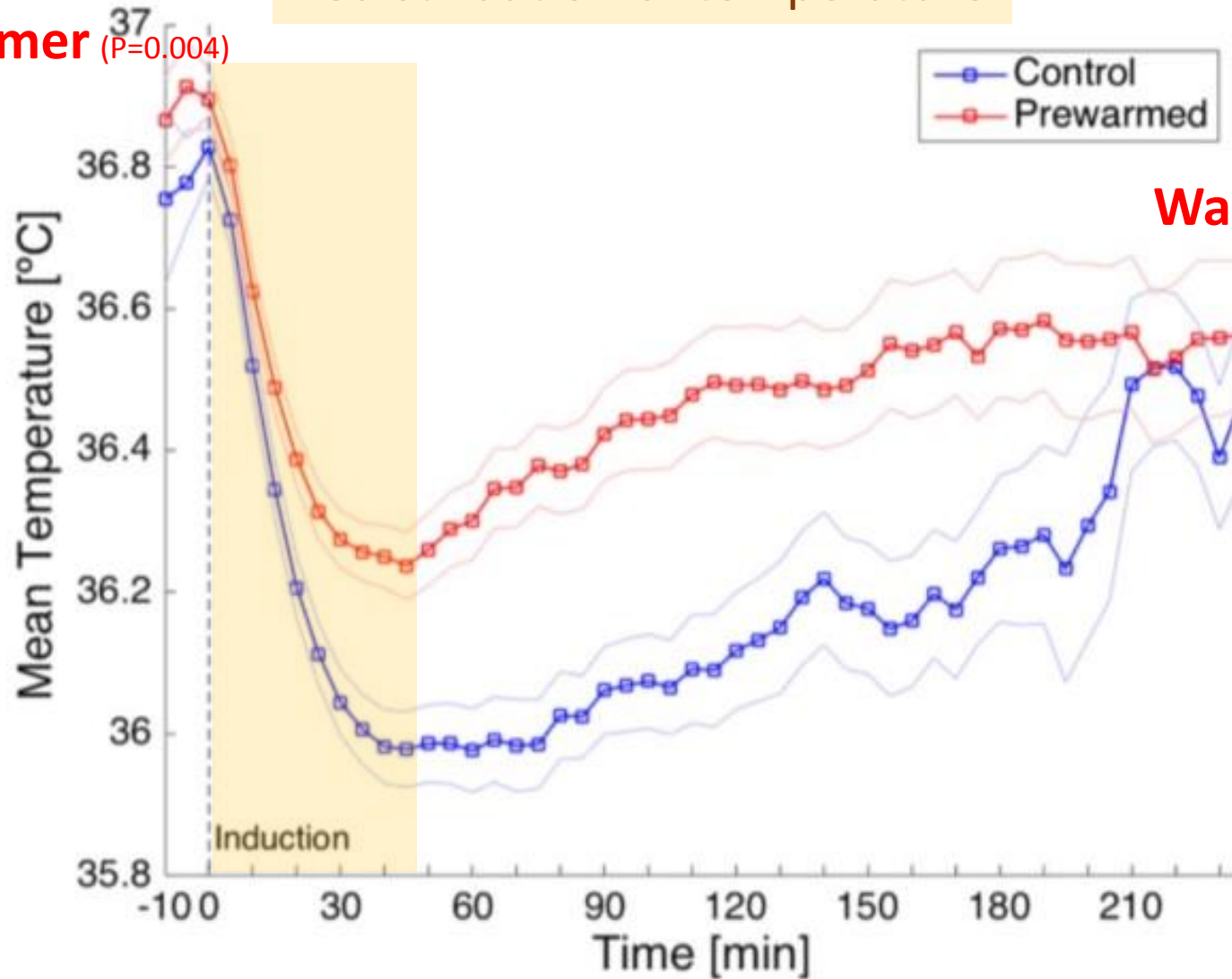
## Effect of preoperative warming on intraoperative hypothermia: a randomized-controlled trial

Aaron Lau, MD, BSc · Nasim Lowlaavar, MD, MPH · Erin M. Cooke, BSc ·  
Nicholas West, MSc · Alexandra German, BA, BSc · Dan J. Morse, MSc ·  
Matthias Görge, PhD · Richard N. Merchant, MD, FRCPC

- Adult, ASA I-III, **non-cardiac** surgery under **GA** 1-6 hr  
n = 200
- **FAW**  $\geq 41^{\circ}\text{C}$  and  $\geq 30$  min vs warmed blanket on request
- Intraoperative hypothermic **magnitude** (AUC for  $T < 36^{\circ}\text{C}$ )

## Redistribution of temperature

**Warmer** ( $P=0.004$ )



**Warmer** ( $P<0.001$ )

- **Pre-warming time > 30 min**  
**NO** further effect on magnitude of hypothermia  
(P = 0.39)
- **Every minute of delay** between the end of the pre-warming period and initiation of intraoperative warming **increased the magnitude of hypothermia**  
(P<0.001)

# Preoperative warming

- Active prewarming **30 min** likely prevents considerable redistribution\*
- Prevent the sudden decrease in core temperature during the **first hour**
- Effect on post-op shivering is **controversy**
- **Minimize gap** between pre-warming period and intraoperative warming

\* Sessler DI, Schroeder M, Merrifield B, Matsukawa T, Cheng C. Optimal duration and temperature of prewarming. Anesthesiology: The Journal of the American Society of Anesthesiologists. 1995;82(3):674-81.



# Hypothermia prevention

Temp.  
Monitoring

Preoperative  
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Theatre suite  
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Fluid  
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Cutaneous  
warming

Postoperative  
warming

# Theatre suite temperature

- **At least 21°C**
- May reduce after active warming is established



NICE pathway on inadvertent perioperative hypothermia

# Hypothermia prevention

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warming

Postoperative  
warming

# Warm fluid before use: Warming cabinet



<https://www.alimed.com/pedigo-fluid-warming-cabinets.html>

# Warm fluid before use: Blood warmer



Plasmatherm

<https://www.marlinmedical.com.au>

Actively warm fluids while being administered: Dry heat technology



3M™ Ranger™ Blood/Fluid Warming Unit

Actively warm fluids while being administered: Hotline fluid warmer

S-line



# Warming intravenous fluid

- Intravenous fluids (500 ml or more) and blood products should be **warmed to 37°C**
- **No clinically difference** among fluid warmers
- Considered in trauma patients

**Keeping patient warm is more important than warming blood (WHO guideline)**



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Postoperative  
warming

# Cutaneous warming



**Passive insulation**

**Active warming**

# Passive cutaneous warming



De Jose Maria B. (2017) Local and Regional Anesthesia in Pediatrics. In: Finucane B., Tsui B. (eds) Complications of Regional Anesthesia. Springer, Cham

# Forced air warmer



# Circulating water mattress



# Cutaneous warming

- **Passive insulation alone is insufficient**
- Under-the-body warming is less effective
  - little heat loss from back
  - Poor perfusion + heat >> heat necrosis/burn
- **Forced air warmer is superior** to circulating water mattresses in maintaining normothermia

# Hypothermia prevention

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# Postoperative warming therapy

- Forced air blankets and radiant heater are most commonly used
- Low efficacy and takes long time
- **Intraoperative warming is ideal**



- ✓ Definition and classification
- ✓ Effect of hypothermia
- ✓ Physiology
- ✓ Hypothermia prevention
- Guidelines
- Take home messages



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## ASA, 2015

-

**2 or more** of the following

- ASA class II to V
- Preoperative BT < 36.0°C (and preoperative warming is not possible)
- Combined GA and RA
- Major or intermediate surgery
- At risk of cardiovascular complications

## NICE, 2017

**Preparation:** patient's temperature should be  $\geq 36^{\circ}\text{C}$  before transferred to OR

**Monitor temp:** when anesthesia > 30 min or Higher risk of inadvertent hypothermia

### **Record:**

Every 30 min intraoperative  
Every 15 min at RR

**Goal:** maintain BT  $\geq 36.5^{\circ}\text{C}$

### **Method:**

- FAW set at maximum and then adjusted
- If FAW is unsuitable
  - >> resistive heating mattress/blanket
- IV fluid & blood products: warm to  $37^{\circ}\text{C}$
- Irrigate fluid: warm to  $38-40^{\circ}\text{C}$

# Take home messages

- **Effect of hypothermia**

Alter drug metabolism, bleeding, wound infection, thermal discomfort, morbid myocardial outcome

- **Mechanism of heat loss**

Radiation > convection > evaporation > conduction

- **Temperature monitoring**

Standard II ASA monitoring // NICE recommendation

- **Active prewarming**

30 min before intra-op active cutaneous warming  
>> reduce hypothermia

# Take home messages

- **Set OR temperature**  $\geq 21^{\circ}\text{C}$
- **IV fluids and blood products** warmed to  $37^{\circ}\text{C}$
- **Forced air warmer is effective**  
even in patient undergoing large operation
- **Postoperative warming therapy**  
low efficacy and takes long time

**STOP HYPOTHERMIA**



**PREVENTION OF HEAT LOSS**

**KEEP PATIENTS WARM INTRAOPERATIVELY**



**“ The cold will never  
bother you and your  
patients anymore ”**