Targeted temperature management

- jak a čím pacienta chladit?

OA Dr. Stibor B.

ICU, Landesklinikum Baden bei Wien, Austria

no conflict of interest

OA Dr. Stibor B.

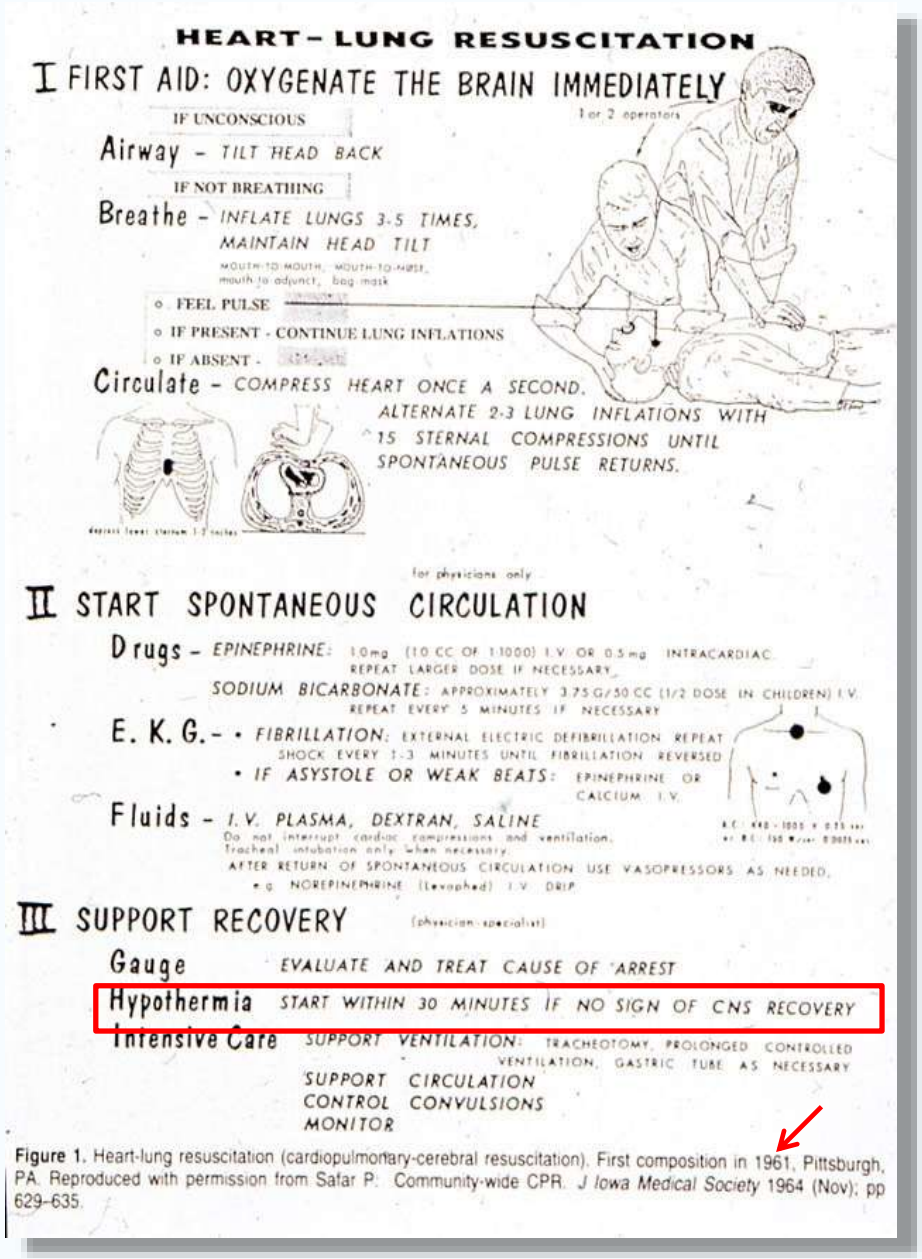
ICU, Landesklinikum Baden bei Wien, Austria

přehled

1. proč hypotermie
2. fyzikální principy
3. postup chlazení
4. chlazení studenou vodou
5. chlazení studeným vzduchem
6. intravenózní chlazení
7. intravaskulární chlazení
8. selektivní chlazení mozku
9. *shivering*
10. *fever control*

proč

hypotermie?



HEART-LUNG RESUSCITATION

I FIRST AID: OXYGENATE THE BRAIN IMMEDIATELY

IF UNCONSCIOUS

Airway - TILT HEAD BACK

IF NOT BREATHING

Breathe - INFLATE LUNGS 3-5 TIMES, MAINTAIN HEAD TILT

MOUTH-TO-MOUTH, MOUTH-TO-NOSE, mouth to adjunct, bag mask

- FEEL PULSE
- IF PRESENT - CONTINUE LUNG INFLATIONS
- IF ABSENT -

Circulate - COMPRESS HEART ONCE A SECOND. ALTERNATE 2-3 LUNG INFLATIONS WITH 15 STERNAL COMPRESSIONS UNTIL SPONTANEOUS PULSE RETURNS.

for physicians only

II START SPONTANEOUS CIRCULATION

Drugs - EPINEPHRINE: 1.0 mg (10 CC OF 1:1000) I.V. OR 0.5 mg INTRACARDIAC. REPEAT LARGER DOSE IF NECESSARY.

SODIUM BICARBONATE: APPROXIMATELY 3.75 G/50 CC (1/2 DOSE IN CHILDREN) I.V. REPEAT EVERY 5 MINUTES IF NECESSARY

E. K. G. - • FIBRILLATION: EXTERNAL ELECTRIC DEFIBRILLATION. REPEAT SHOCK EVERY 1-3 MINUTES UNTIL FIBRILLATION REVERSED

• IF ASYSTOLE OR WEAK BEATS: EPINEPHRINE OR CALCIUM I.V.

Fluids - I.V. PLASMA, DEXTRAN, SALINE

Do not interrupt cardiac compressions and ventilation. Tracheal intubation only when necessary.

AFTER RETURN OF SPONTANEOUS CIRCULATION USE VASOPRESSORS AS NEEDED, e.g. NOREPINEPHRINE (Levophed) I.V. DRIP

III SUPPORT RECOVERY (physician-specialist)

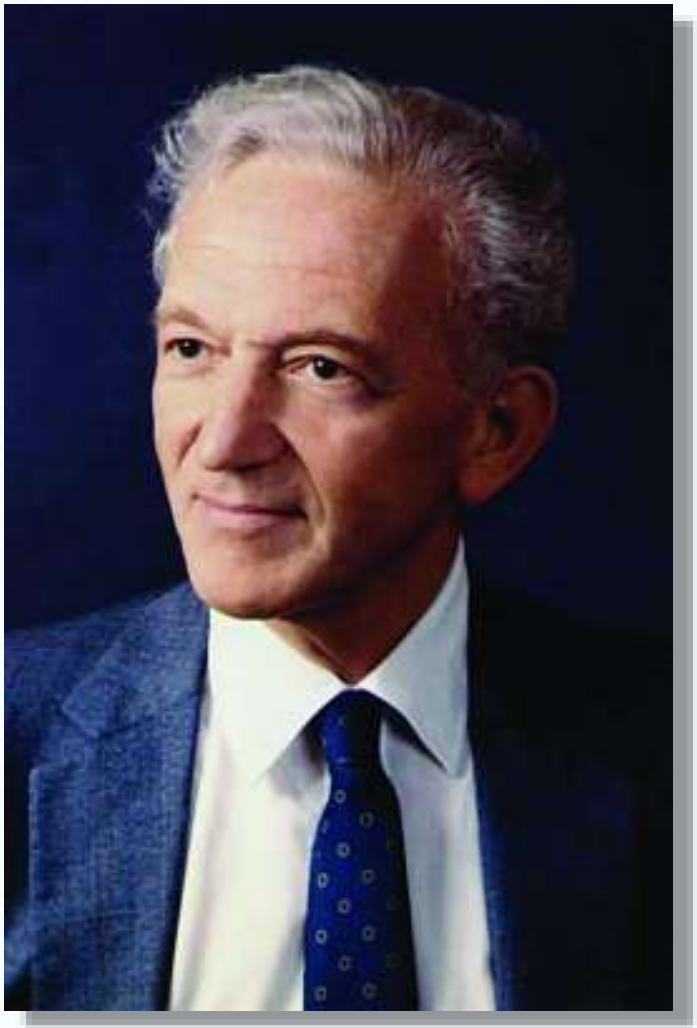
Gauge EVALUATE AND TREAT CAUSE OF ARREST

Hypothermia START WITHIN 30 MINUTES IF NO SIGN OF CNS RECOVERY

Intensive Care SUPPORT VENTILATION: TRACHEOTOMY, PROLONGED CONTROLLED VENTILATION, GASTRIC TUBE AS NECESSARY

SUPPORT CIRCULATION
CONTROL CONVULSIONS
MONITOR

Figure 1. Heart-lung resuscitation (cardiopulmonary-cerebral resuscitation). First composition in 1961, Pittsburgh, PA. Reproduced with permission from Safar P: Community-wide CPR. *J Iowa Medical Society* 1964 (Nov); pp 629–635.



†Dr. Peter Safar

fyzikální principy

Radiation

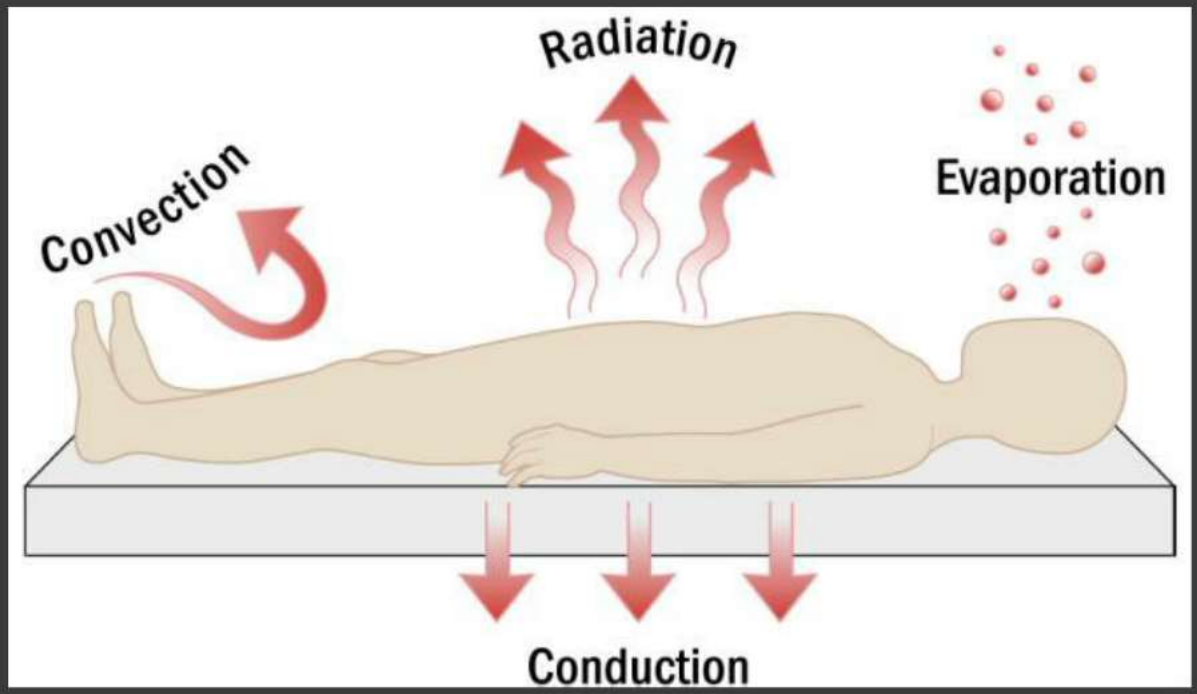
Transfer of heat between the separated surfaces of two objects via electromagnetic (infrared) radiation.

Accounts for 50–70% of heat loss in awake patients

Evaporation

Heat loss derived from the evaporation of water from skin & lungs

Accounts for ±15% of heat loss (5% from the skin, 10% from the lungs)



Convection

Transfer of heat from a surface to the surrounding air.

Accounts for 20–30% of heat loss

Conduction

Direct transfer of between surfaces

Amount of heat loss is closely related to contact surface

Increases in the sitting or lying position

postup chlazení

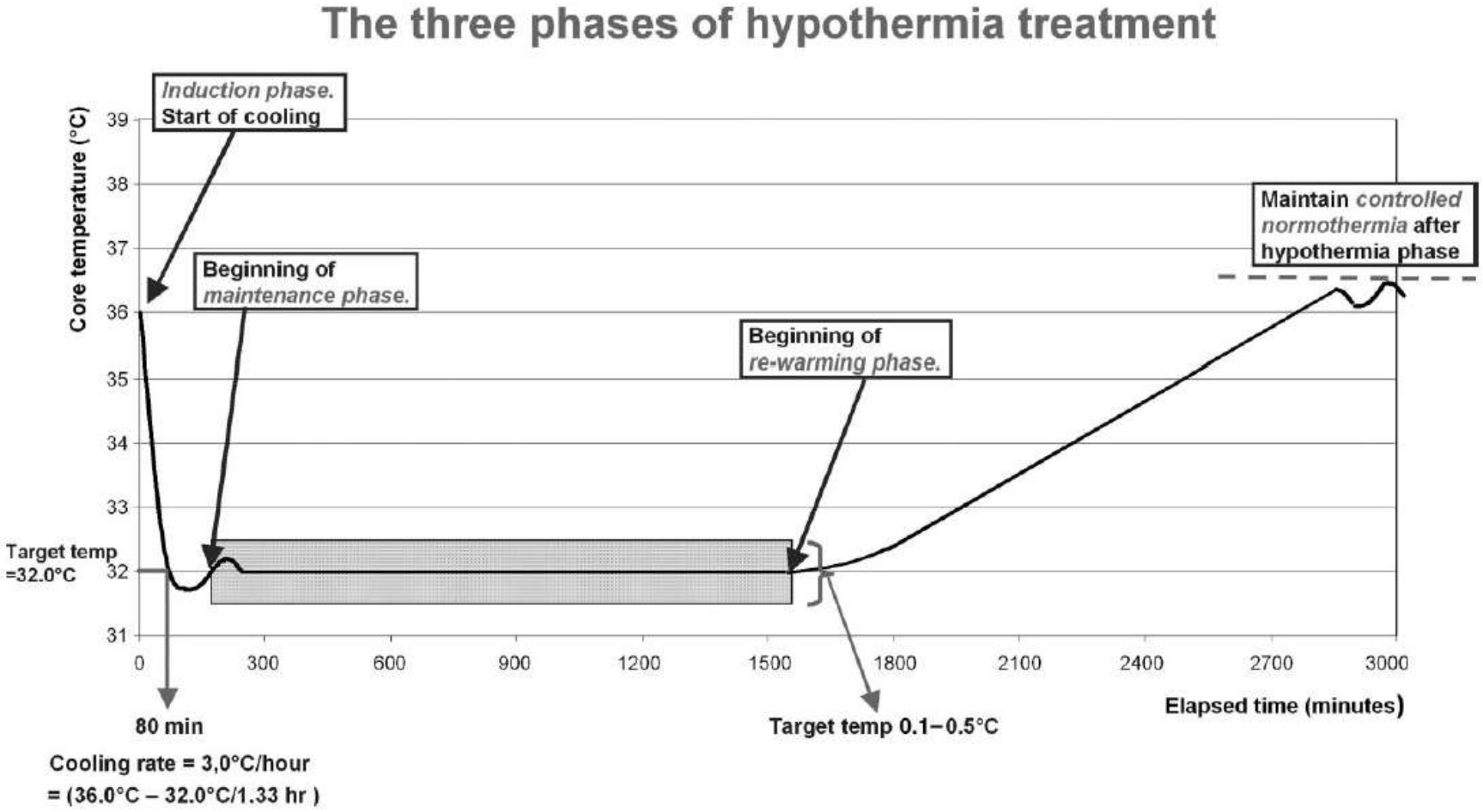


Figure 3. Graphic depiction of the three phases of hypothermia treatment. The induction phase should last between 30 and 120 mins; rapid cooling may lead to a small overshoot, which should be accepted provided it is no greater than 1°C. The maintenance phase usually lasts 24 hrs in cardiac arrest patients (may be longer for other indications) and should be characterized by no or minimal fluctuations in temperature. The rewarming phase should be slow and controlled, with rewarming rates of 0.2°C to 0.5°C in cardiac arrest patients and lower rewarming rates for other indications. Fever should be prevented after rewarming.

phases of hypothermia

1. induction phase

get to target temperature (34ºC?) as quickly as possible

(small overshoot acceptable provided temperature remains > 30 ºC)

2. maintenance phase

should be reliable, with no or minor fluctuations (max. 0,2-0,5 ºC)

3. re-warming phase

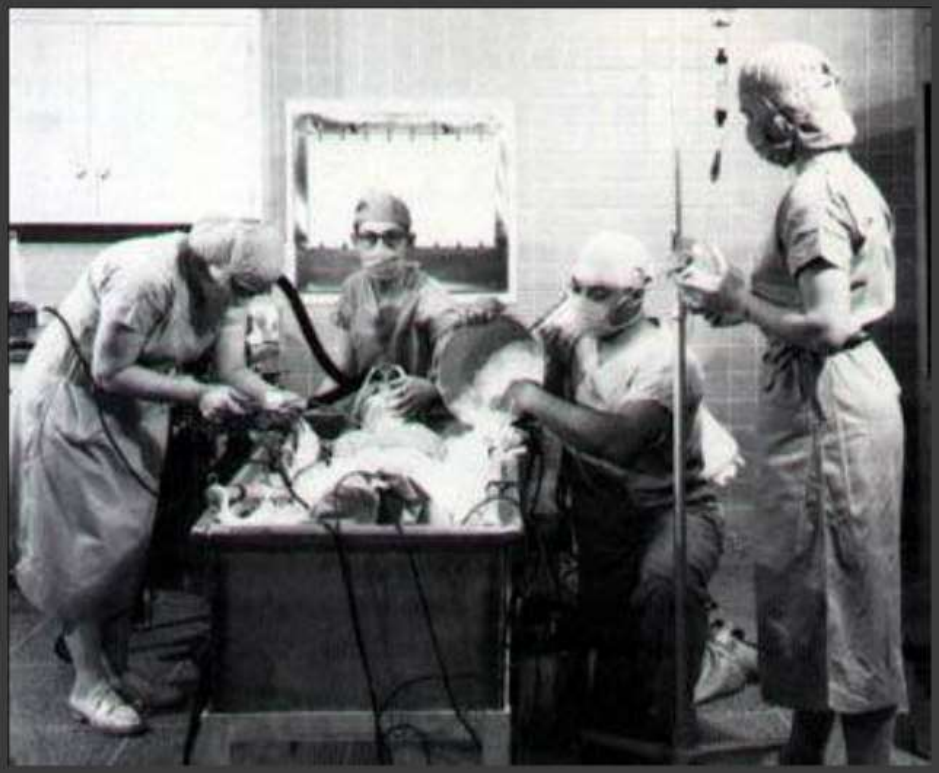
slow and controlled (max 0,2-0,5 ºC/h)

4. fever-control phase

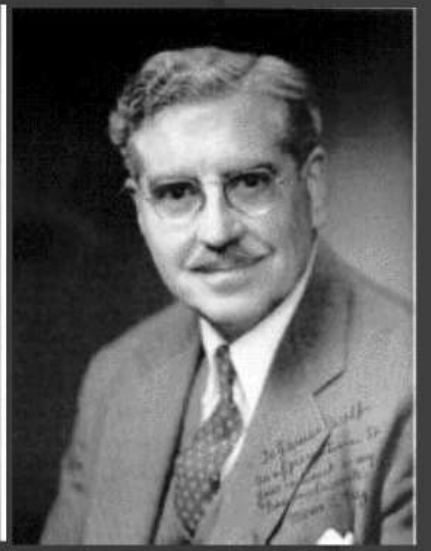
maintain controlled normothermia

metody chlazení

Historical hypothermia



Baltimore, 1955



Philadelphia, July 1936

metody chlazení

povrchové chlazení

- ledové obklady, polévání studenou vodou, alkoholem
- systémy s cirkulující vodou
- systémy s cirkulujícím vzduchem

intravenózní roztoky

intravaskulární chlazení

selektivní ochlazování mozku (RhinoChill)

povrchové chlazení

povrchové chlazení

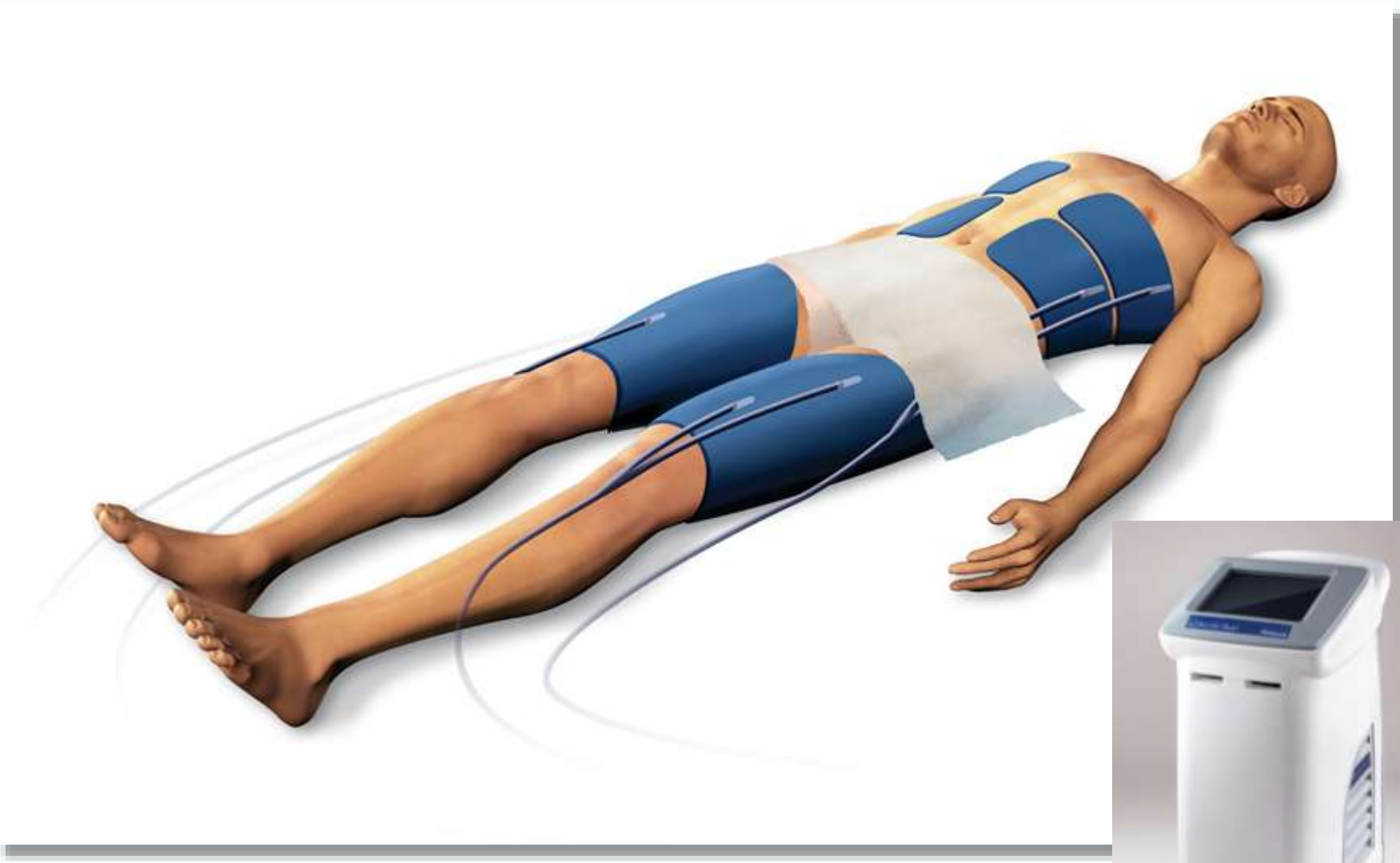
- vaky s ledem, polévání studenou vodou, alkoholem
- chlazení kondukcí
- špatná řiditelnost všech 3 (4) fází hypotermie, nekomfortní uživatelsky a ošetřovatelsky
- levné *(„poor-man´s method")*


10:32 AM

chlazení cirkulující vodou

chlazení cirkulující vodou

- chladí cirkulující studenou vodou
- v chladicím systému je podtlak
- velmi účinné, rychle se naloží na pacienta
- *cooling and re-warming profil*
- nutná sedace pacienta *(shivering)*



Arctic Sun® 5000, Colorado, USA

Blanketrol III®, Cincinnati Sub-Zero, USA

chlazení studeným vzduchem

chlazení studeným vzduchem

- chlazení konvekcí
- méně efektivní
- nastavuje se teplota vzduchu na 32 ºC
- náročné ošetřovatelsky
- nutná sedace pacienta

Bair Hugger® ,
Augustine Medical, USA

intravenózní chlazení

intravenózní chlazení

- ✓ cold fluids 4 ºC i.v. 30 ml/kg
- ✓ with pressure bag
- ✓ „as rapidly as possible“
- ✓ type of fluid: 0,9% NaCl, Ringer, Hartmann, Elo-Mel... (crystalloids)
- ✓ begin prehospital

External and/or internal cooling techniques can be used to initiate cooling. An infusion of ***30 ml/kg of 4 C saline or Hartmann's solution decreases core temperature by approximately 1.5 C.***

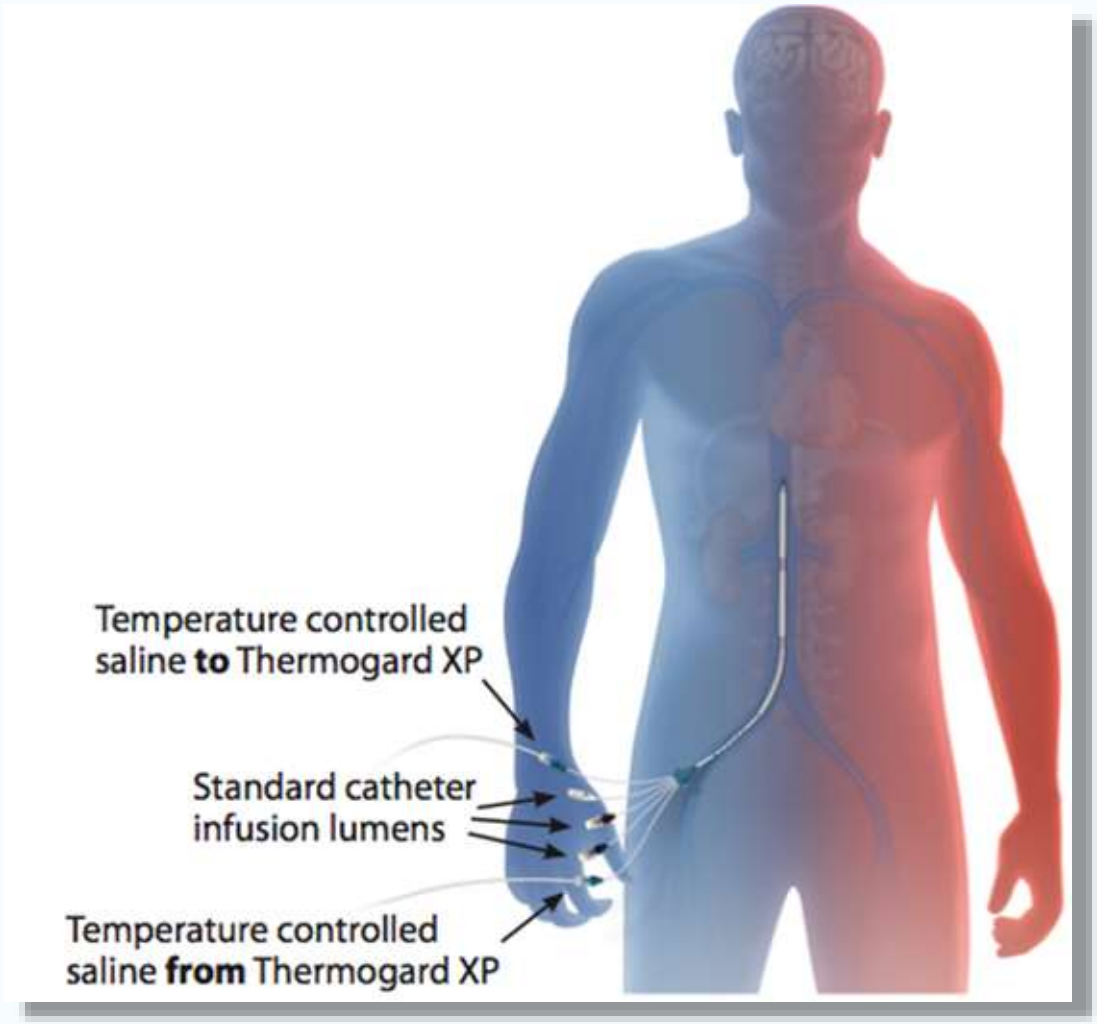
ERC, 2010

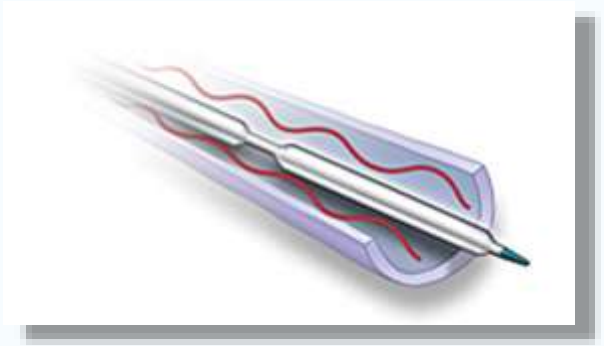
$$T_{ges} = \frac{m_1 \times T_1 + m_2 \times T_2}{m_1 - m_2}$$

intravaskulární chlazení

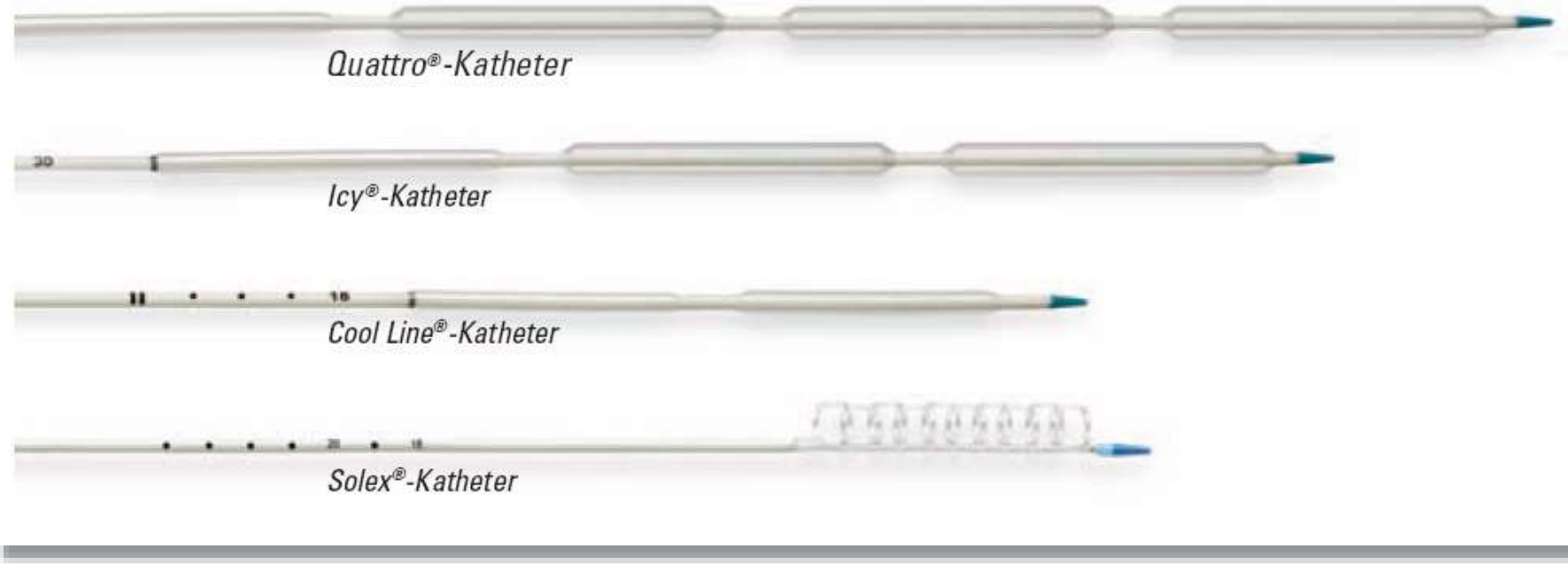
intravaskulární chlazení

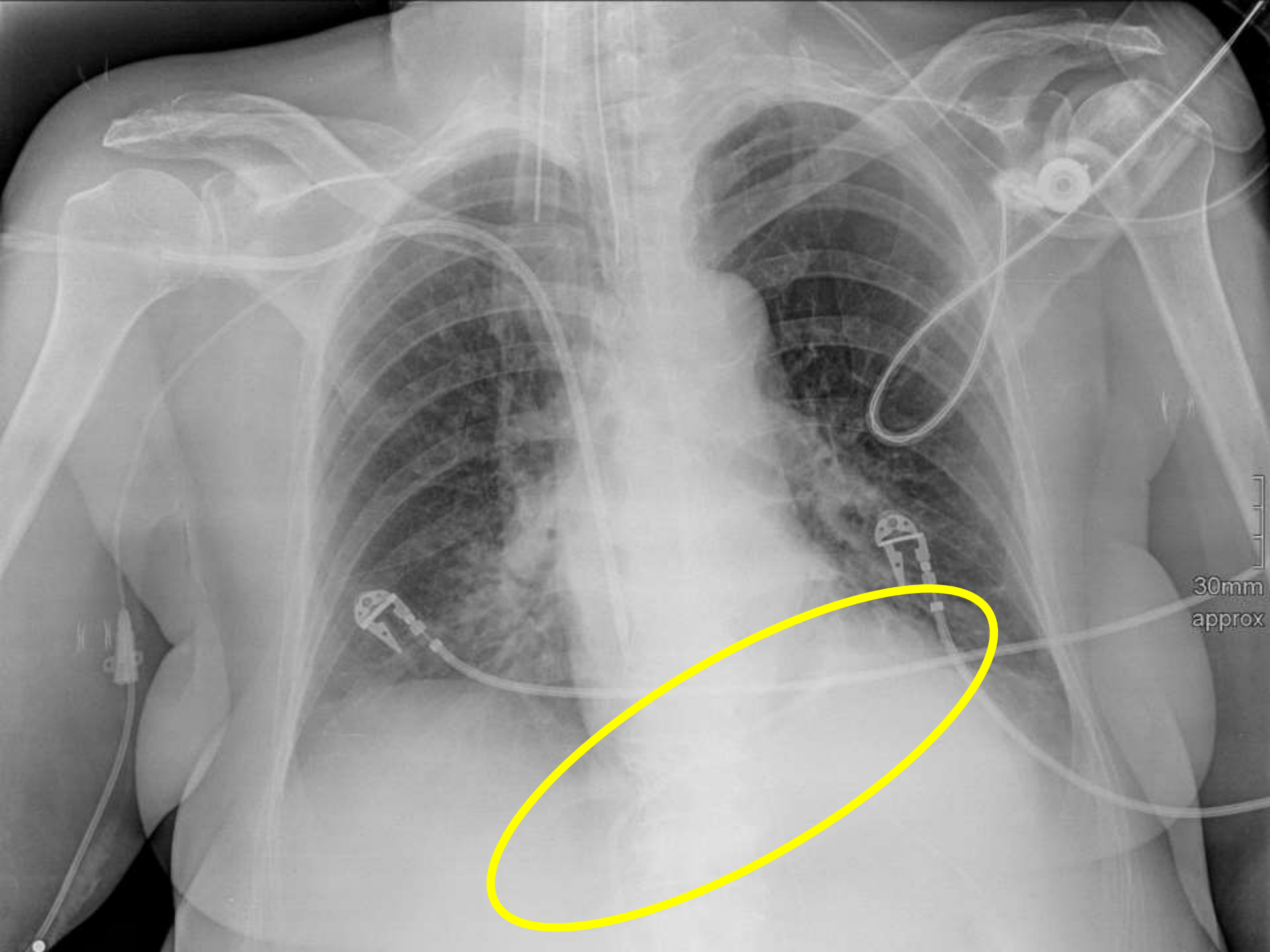
- intravenózně zavedený katetr (v. femoralis)
- cirkulující chladný roztok 0,9 % NaCl
- „invazivní“, proveditelná pouze nemocničně
- velmi rychlé dosažení cílové teploty
- nejlépe se udržuje nastavená teplota TTM („autopilot“)





ThermoGard XP®, Alsius, USA


Quattro®-Katheter
Icy®-Katheter
Cool Line®-Katheter
Solex®-Katheter


30mm
approx


R


kasettenfehler

RhinoChill

- ✓ transnazální evaporativní ochlazování
- ✓ certfikován pro EU, doporučen ERC
- ✓ minimálně invazivní metoda
- ✓ pro přednemocniční fázi
- ✓ cíleně ochlazuje mozek

Konduktionskühlung

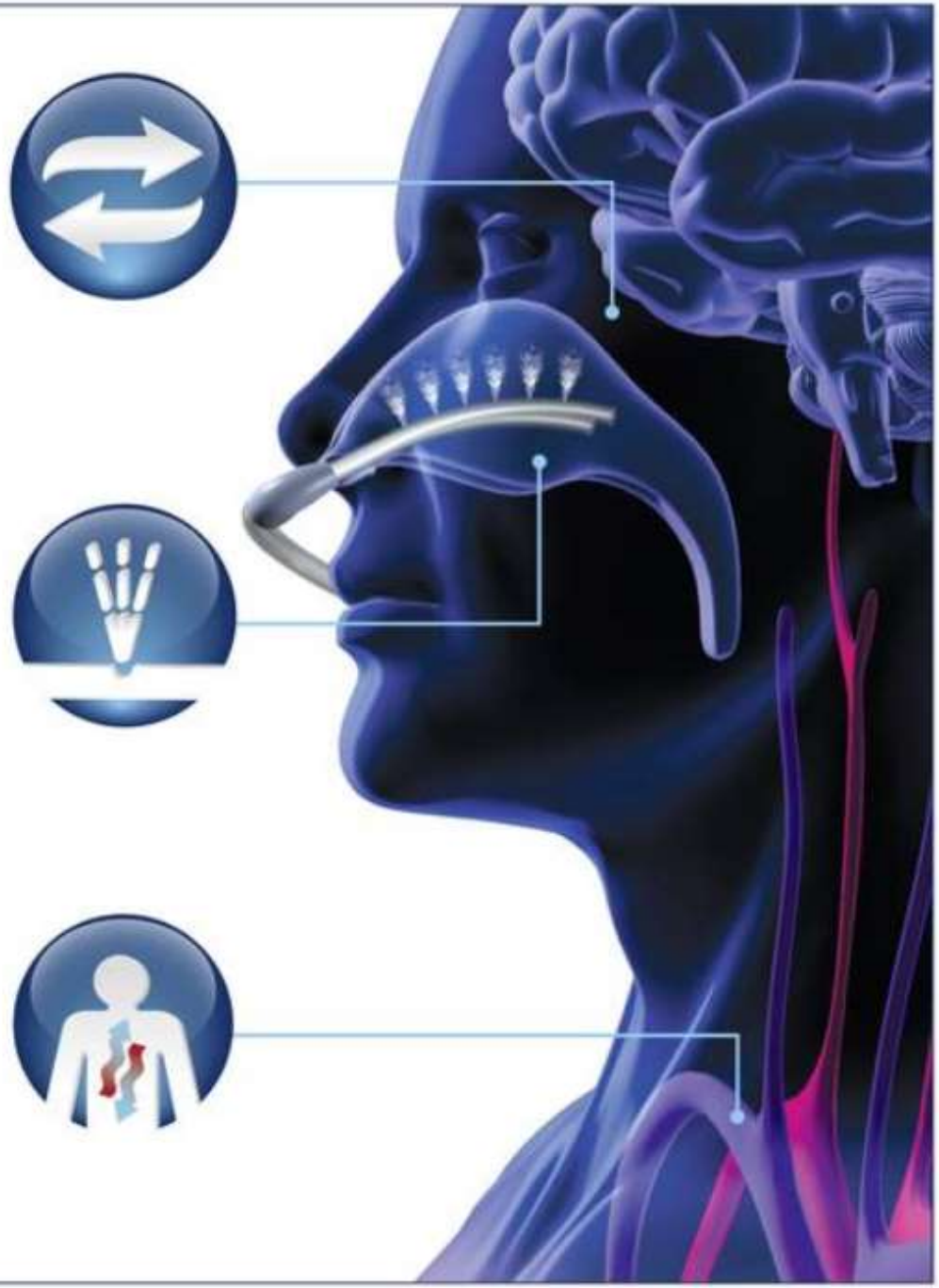
Die dünne Lamina cribrosa, die das Gehirn vom Nasenrachenraum trennt, ermöglicht eine effiziente Diffusion der thermalen Energie zur Kühlung des Gehirns.

Kühlung durch Evaporation

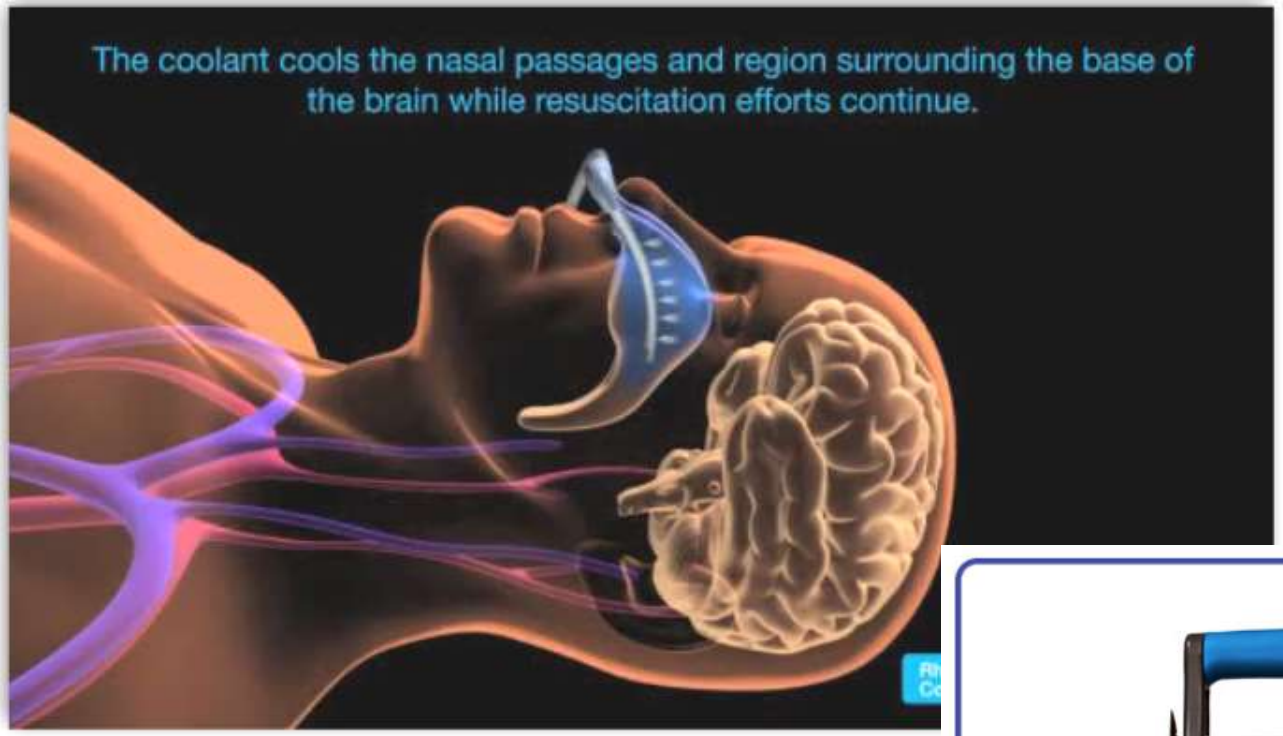
Das zerstäubte Kühlmittel vaporisiert innerhalb des Nasenrachenraumes und sorgt so für eine schnelle Kühlung.

Konvektionskühlung

Das Blut, welchen vom Gehirn zum Herzen das durch das Gehirn zurück zum Herzen fließt wird dadurch gekühlt, da es dabei die Umgebung des Nasenrachenraum passiert. Durch das Blut wird daraufhin ebenfalls Gehirn und der restliche Körper abgekühlt.

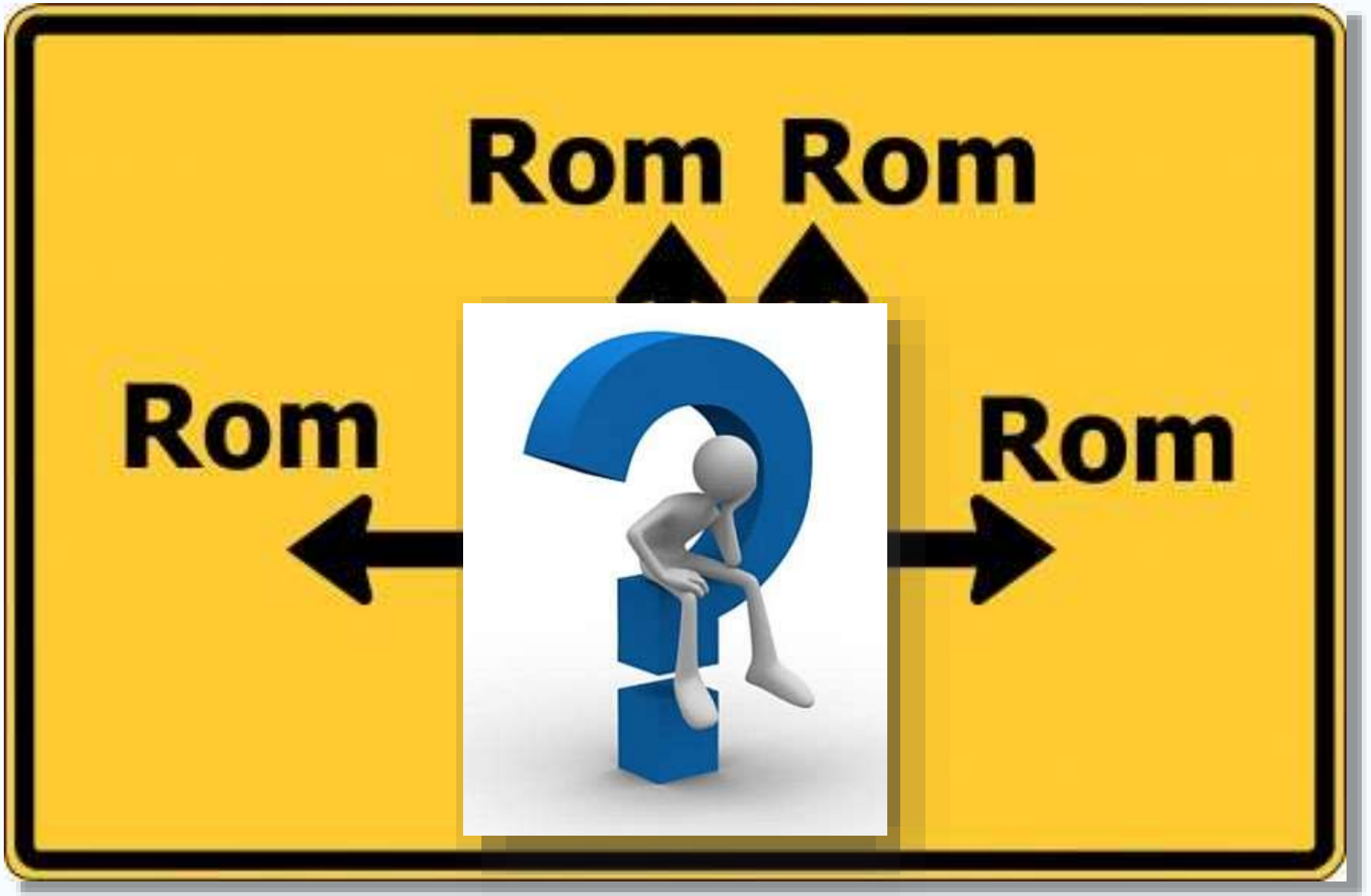


- perfluorohexan vstřikován do oblasti nazofaryngu
- rychlým odpařováním se ↓ teplota sliznice na 2-4°C
- mozek se ochlazuje kondukcí a perfúzí
- CAVE: perfluorohexan se sráží v nasofaryngu a zatéká do žaludku


The coolant cools the nasal passages and region surrounding the base of the brain while resuscitation efforts continue.


RhinoChill

srovnání metod


Rom Rom
Rom
Rom

Devices: Cooling safety

Endovascular:

Benefits:

- excellent temperature modulation
- cooling speed
- feedback loop

Risks:

- Infection, thrombosis, bleeding
- positioning issues / comfort
- shivering

Surface:

Benefits:

- safe and easy to use
- good temperature modulation
- feedback loop

Risks:

- slower cooling
- mild temperature flux
- shivering

Abb.3 Kühltechniken zur Indikation einer therapeutischen Hypothermie[16]

Kühltechnik	**Kühlrate °C/h**
Eispacks	0,9
Kaltluft	0,4-0,8
Kältematten	0,9
Infusion kalter Flüssigkeiten	3,2
Endovaskulärer Kühlkatheder	0,8-4,7
Venovenös (z.B. Hämofilter)	3,5
Extrakorporale Zirkulation	12

Research

Open Access

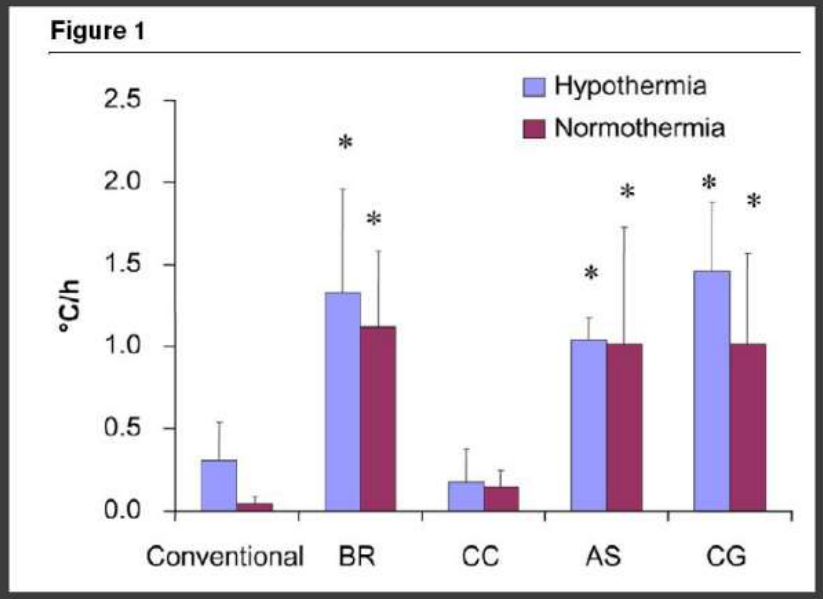
Comparison of cooling methods to induce and maintain normo- and hypothermia in intensive care unit patients: a prospective intervention study

Cornelia W Hoedemaekers, Mustapha Ezzahti, Aico Gerritsen and Johannes G van der Hoeven

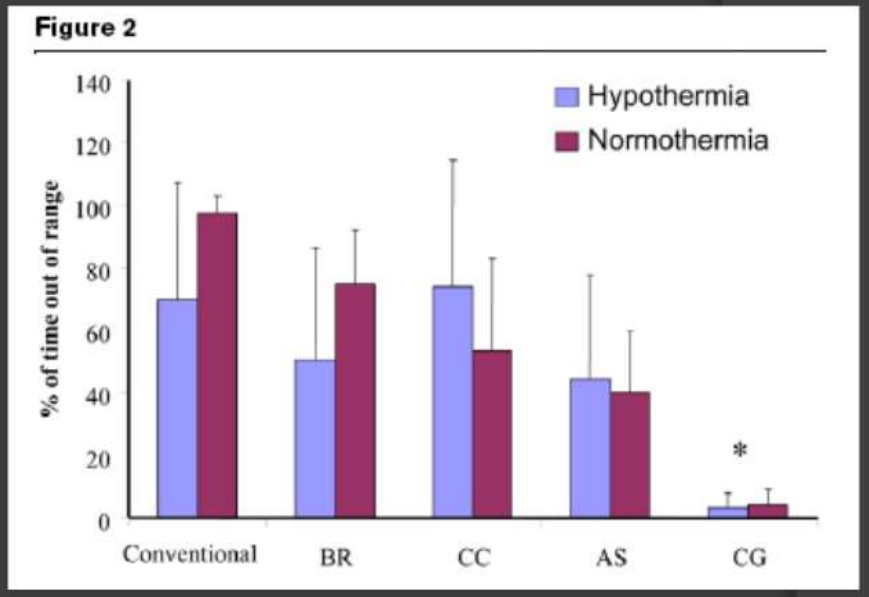
- 50 patients
  - Indications for mild hypothermia or strict euthermia
  - Randomized to 5 groups
    - "Conventional" = 30cc/kg cold IVF + ice/cold packs
    - Water circulating blankets (Blanketrol II, Cincinnati Subzero)
    - Air circulating blankets
    - Arctic Sun
    - Intravascular balloon device
  - Endpoints: speed of cooling, % time above or below temperature range

Crit Care 2007;11:R91

Cooling efficacy



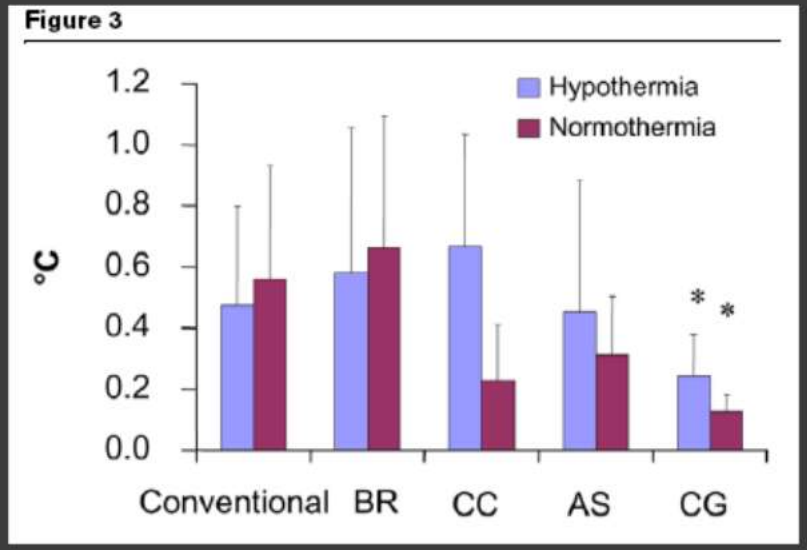
Induction of hypo- and normothermia. Pace of cooling expressed as ℃/h



Maintenance of target temperature. Depicted as the percentage of time the patient's temperature was 0.2 ℃ below or above the target temperature.

Crit Care 2007;11:R91

Cooling efficacy



Mean temperature deviation from target temperature.

- Water-circulating blankets, gel-coated water circulating pads and intravascular cooling were equally efficient in inducing hypothermia and normothermia
- Intravascular cooling with heat-exchange balloons was the most effective way to maintain goal temperature

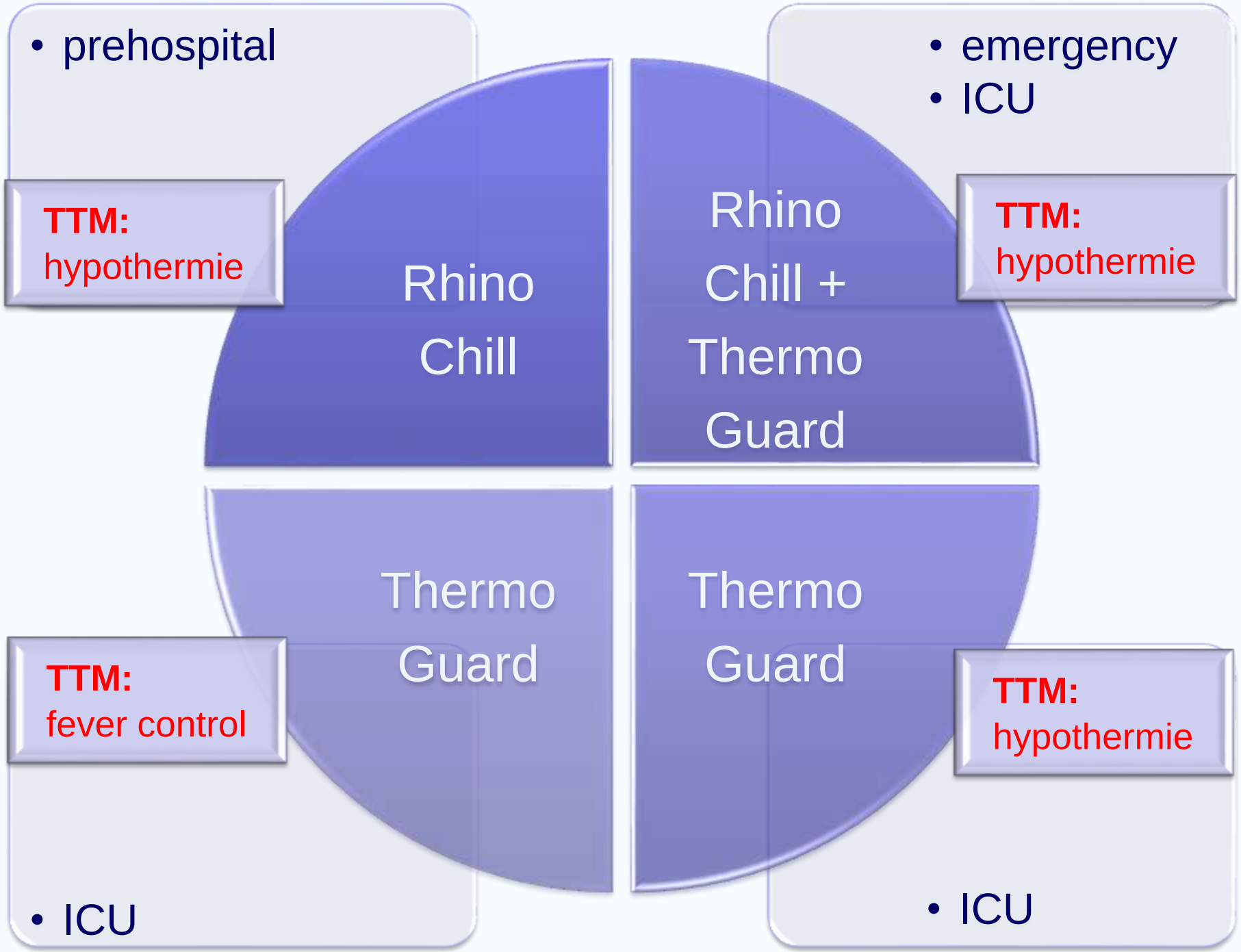
Crit Care 2007;11:R91

Landesklinikum Baden bei Wien

NAW

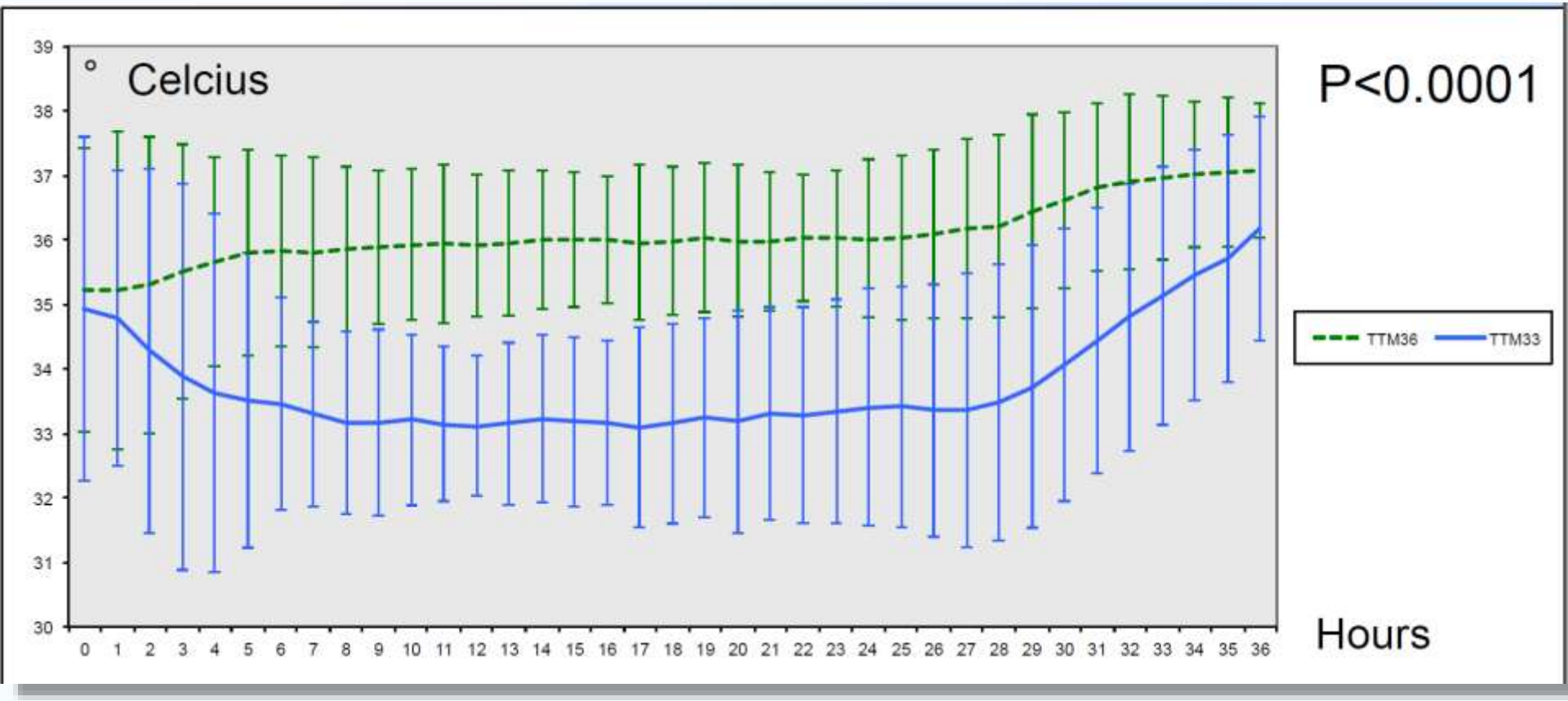
ER

ICU


• prehospital
TTM:
hypothermie
Rhino
Chill
Rhino
Chill +
Thermo
Guard
• emergency
• ICU
TTM:
hypothermie
TTM:
fever control
Thermo
Guard
Thermo
Guard
TTM:
hypothermie
• ICU
• ICU

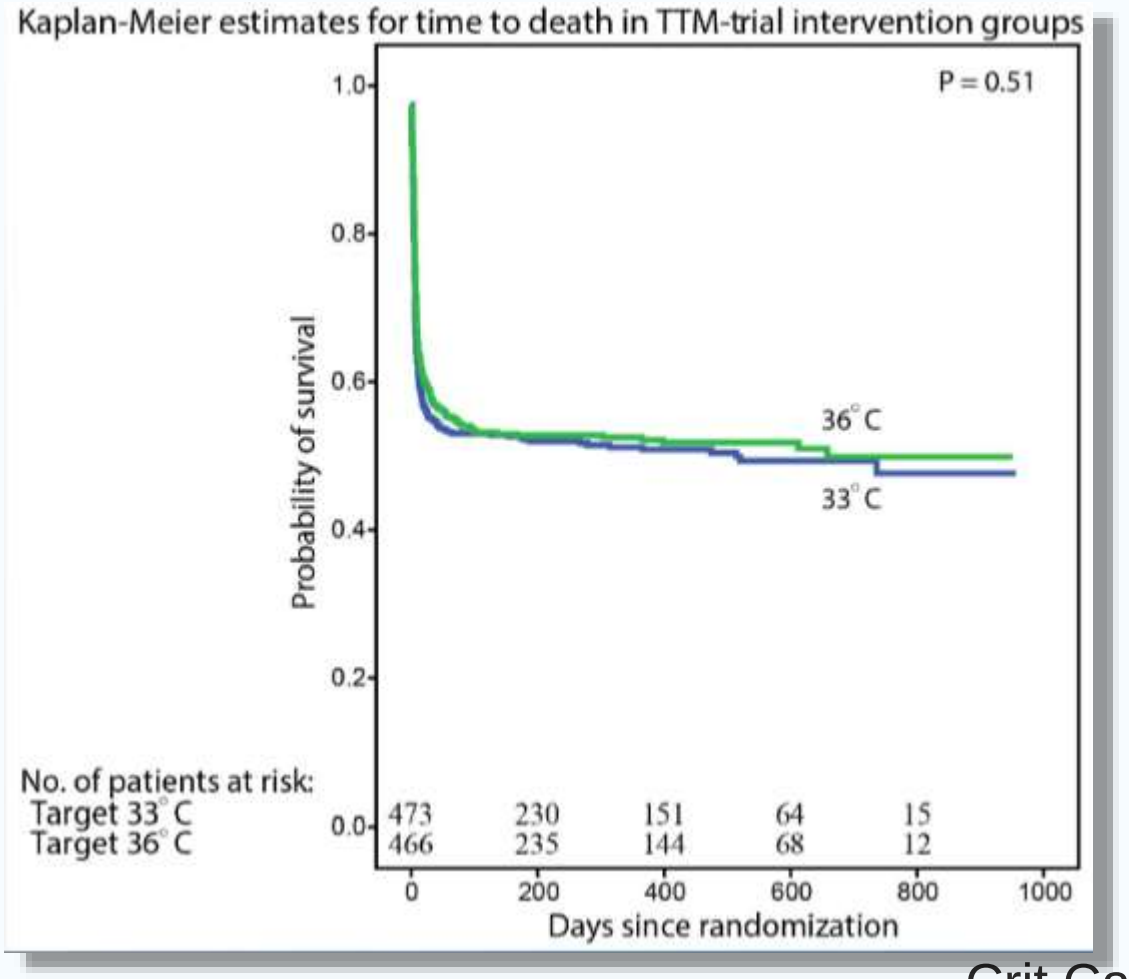
fever control

33 ºC vs 36 ºC



Crit Care Med. 2013;*41:99-115*.

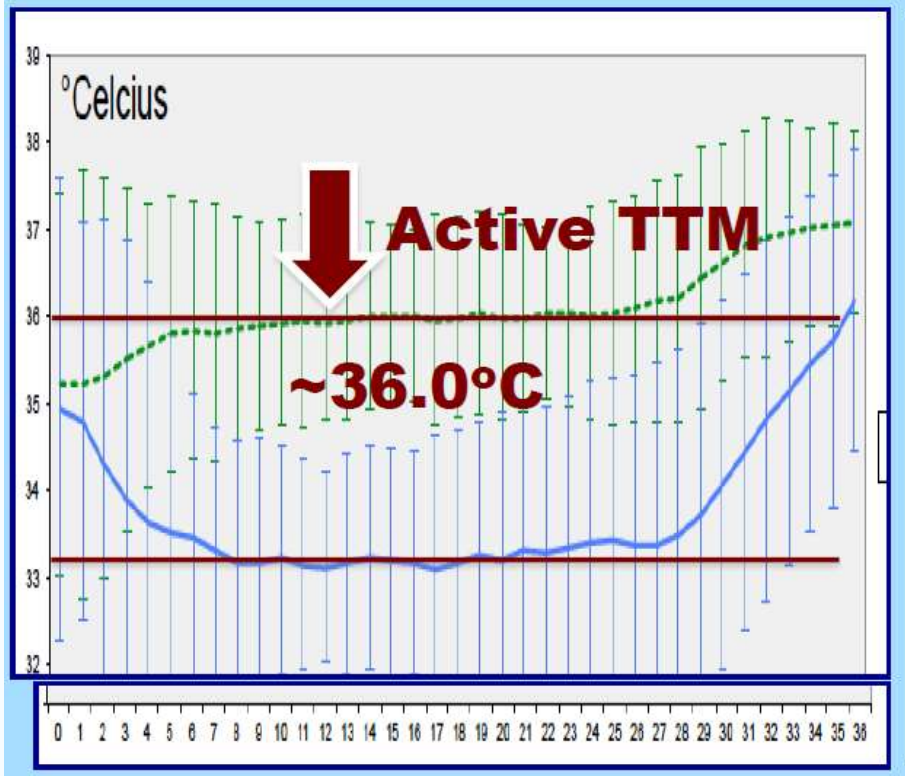
33 ºC vs 36 ºC



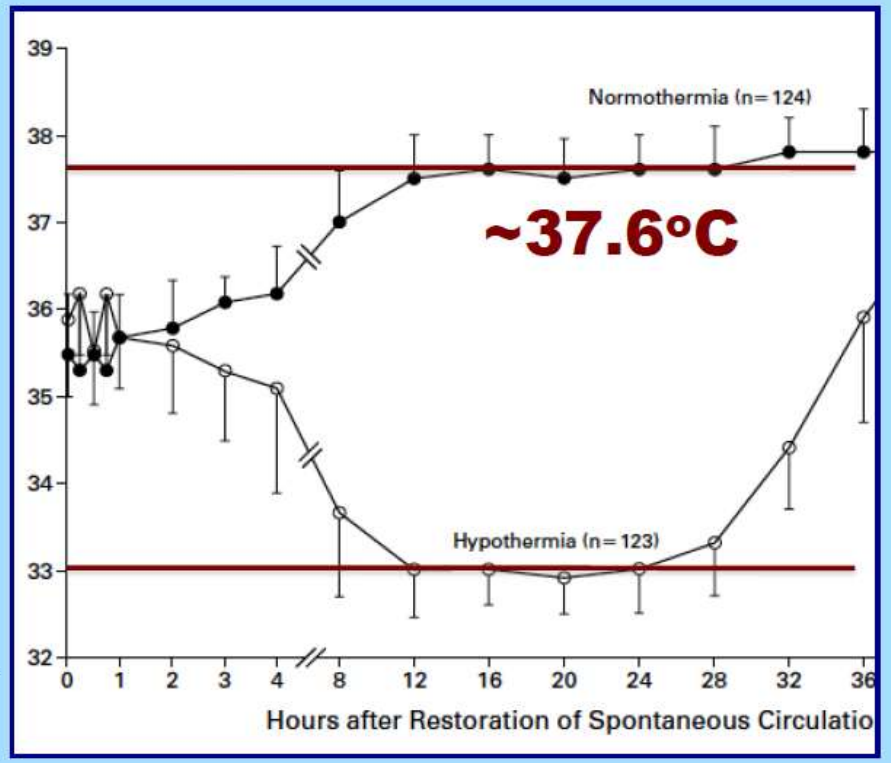
Crit Care Med. 2013;*41:99-115*.

Marked differences in “control” group

Nielsen et al



HACA study



Bernard et al: ~37.3°C

Large difference in maintenance temperatures

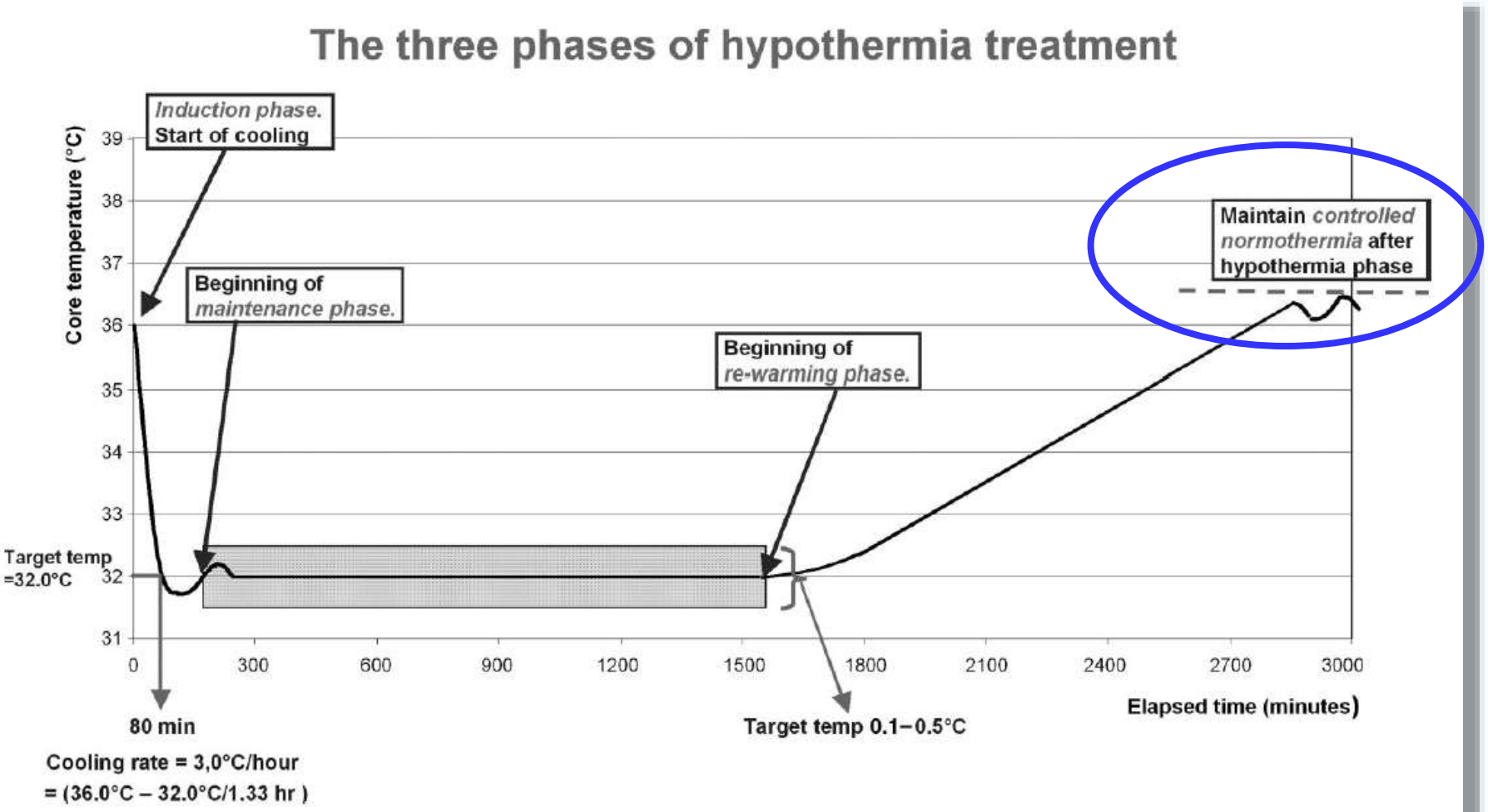


Figure 3. Graphic depiction of the three phases of hypothermia treatment. The induction phase should last between 30 and 120 mins; rapid cooling may lead to a small overshoot, which should be accepted provided it is no greater than 1°C. The maintenance phase usually lasts 24 hrs in cardiac arrest patients (may be longer for other indications) and should be characterized by no or minimal fluctuations in temperature. The rewarming phase should be slow and controlled, with rewarming rates of 0.2°C to 0.5°C in cardiac arrest patients and lower rewarming rates for other indications. Fever should be prevented after rewarming.

- ✓ intravaskulární chlazení je nejlepší na udržení hypotermie a prevenci horečky
- ✓ použitelné i u bdělých (extubovaných) pacientů !!!

TTM

- ✓ intravaskulární chlazení je nejlepší na udržení hypotermie a prevenci horečky
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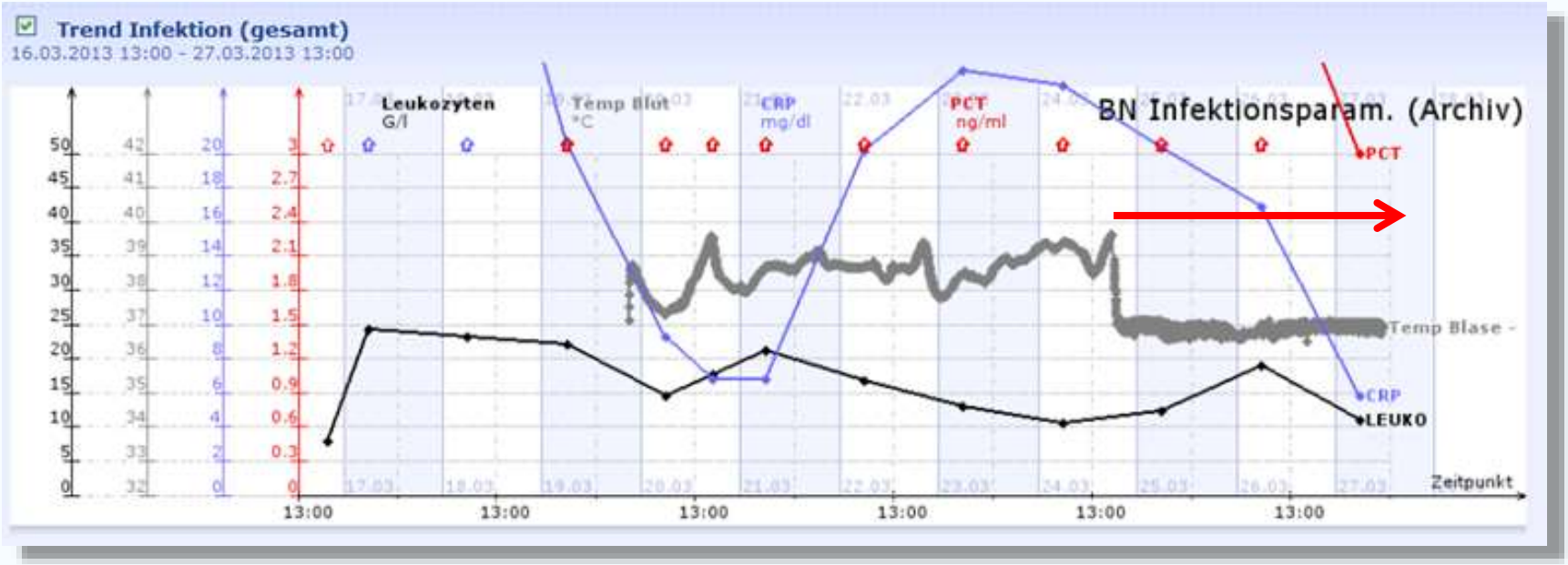
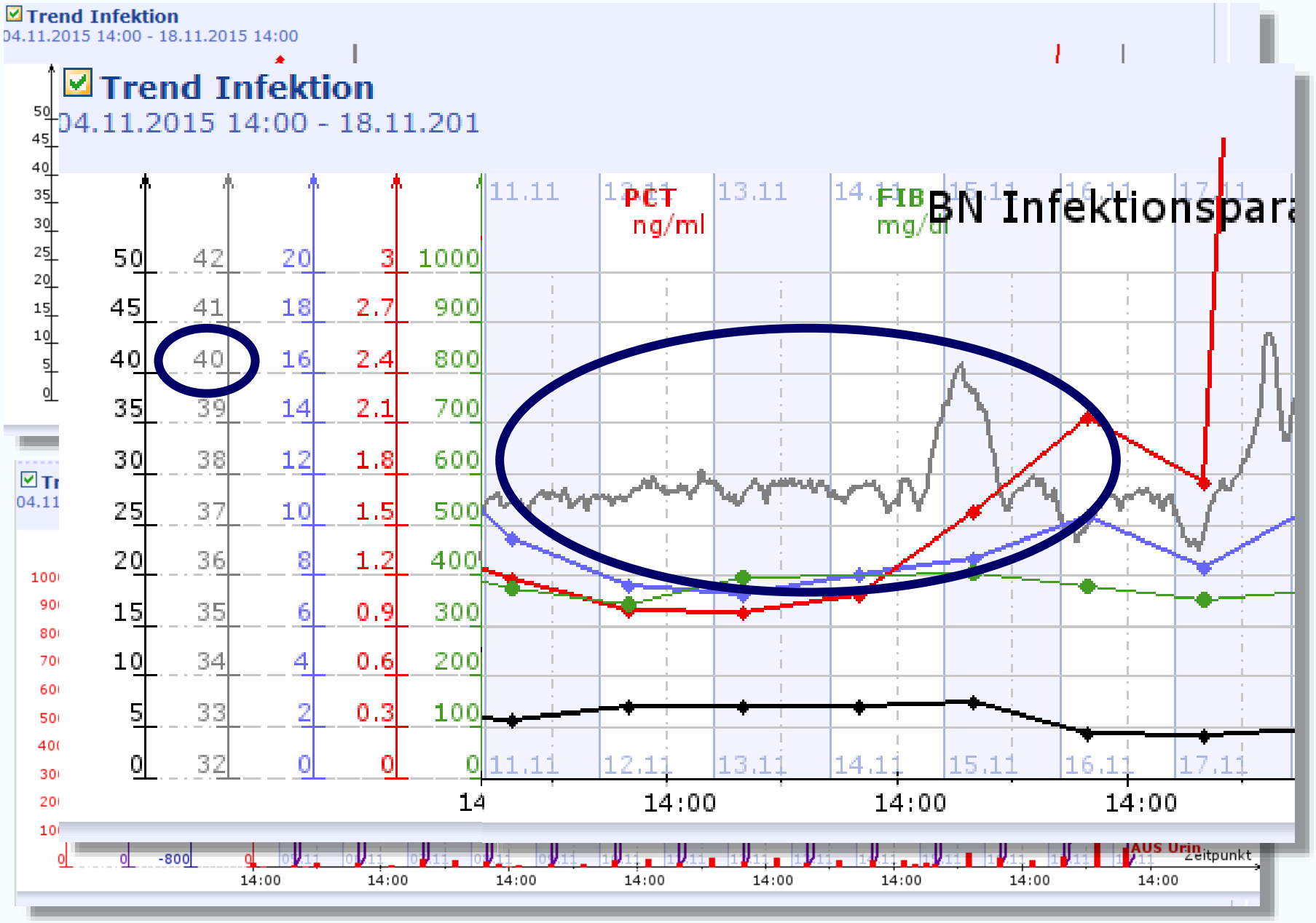
fever control



chlazení

CRRT?


Trend Infektion
04.11.2015 14:00 - 18.11.2015 14:00
PCT
ng/ml
FIB
mg/dl
BN Infektionspara
11.11
12.11
13.11
14.11
15.11
16.11
17.11
14:00
Zeitpunkt

shivering

shivering

35,9 - 33,5 °C

maximum shivering (peak at 35,5 °C)

33,5 - 31,0 °C

much decreased shivering response

< 30,0 °C

shivering stops completely

Dr. K. Polderman

physiology of temperature control

temperature control

- about 90% of information regarding temperature comes from skin
- 10% comes from the core
- so... in theory (and, as the evidence suggests, in practice) we can FOOL the body and circumvent its' thermoregulatory defense mechanisms
- skin counterwarming can be a highly effective anti-shivering strategy...

Crit Care Med. 2009;*37:1893-7*.

Dr. K. Polderman

cooling awake patients


77
99

BADEN
PATIENTEN-TEMPERATUR
34.2°C
36.5°C
0.20°/h

jkm Medizintechnik e.K.
Hamburg
Tragbarer Lufterwärmer
Modell: E
Ein
Power
Aus
40
°C

…děkuji Vám za pozornost