Hypotermi:

- Prehospitalt – Perioperativt- Postoperativt
- Hvorfor er hypotermi farlig og tema for trygg kirurgi?
- Hva kan vi gjøre for å forebygge og behandle?

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Avd for Anestesiologi
Oslo Universitetssykehus – Ullevål

E-post: johan.rader@medisin.uio.no

- Normal temp ≈ 37° ± 0.2°

Kjernetemperatur !!

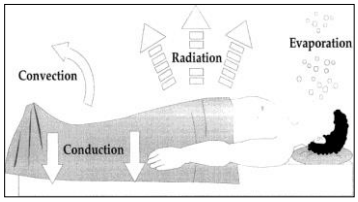
(nasopharynx, distal øsofagus, trommehinne, lungeart, urinblære, panne*)

Forbrenning + varme utenfra
(normal metabolisme + evt ”brunt” fett):
- 50-100 watt

vs

- Varmetap til omgivelser

Fig. 5

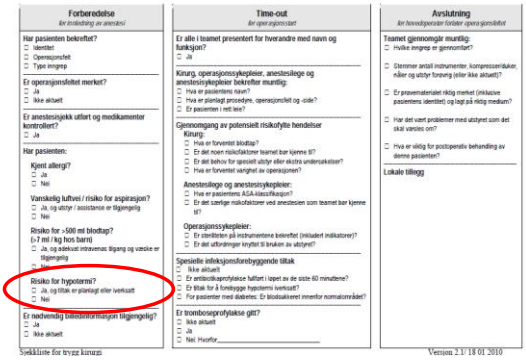


Perioperative Heat Balance.
Sessler, Daniel; Todd, Michael

Anesthesiology. 92(2):578, February 2000.

Fig. 5. The linear second phase of the hypothermia curve. The second phase of the hypothermia curve results from heat loss exceeding metabolic heat production. Typical heat production is approximately 1 kcal [middle dot] kg-1 [middle dot] h-1. At steady state, heat loss must equal this amount. During anesthesia and surgery, however, heat loss is often far greater. The major cause of loss is radiation, accounting for roughly 60% of the total. Radiative loss is proportional to the difference of the fourth powers of room wall (i.e., ambient) and skin temperatures. The remaining loss is largely convective, which is proportional to the difference between skin and air temperatures multiplied by the square root of air speed. Respiratory evaporative loss contributes only approximately 10% to the total and cutaneous evaporative loss remains relatively small except during sweating. However, evaporative loss from within surgical incisions can be substantial. Conductive loss is unimportant during anesthesia.

Varmetap:
-Stråling (infra rød)
-Konduksjon (ledning – kontakt)
-Konveksjon (luft bevegelse)
-Fordamping (hud – ekspirasjonsluft)
-Kroppsvæsker
-Svette



Advances in Surgery 45 (2011) 249–263
ADVANCES IN SURGERY

Perioperative Normothermia During Major Surgery: Is It Important?

Nestor F. Esnaola, MD, MPH, MBA*, David J. Cole, MD
Division of Surgical Oncology, Department of Surgery, Medical University of South Carolina, 25 Courtenay Drive Suite 7018, Charleston, SC 29425, USA

Perioperative Maintenance of Normothermia Reduces the Inci of Morbid Cardiac Events

A Randomized Clinical Trial

Steven M. Frank, MD; Lee A. Fleisher, MD; Michael J. Breslow, MD; Michael S. Higgins, MD; Krista F. Olson; Susan Kelly, BSN; Charles Beattie, MD

JAMA. 1997;277:1127-1134

300 high-risk patients undergoing thoracic, abdominal, or peripheral vascular surgery were randomized to receive:
A) warmed intravenous (IV) fluids alone → **temp=35.4 C**
Or
B) warmed IV fluids and intraoperative/postoperative active warming via warm forced-air devices. → **temp = 36.7 C**

Table 3.—Intraoperative and Postoperative Cardiac Outcomes

	No. (%)		
	Hypothermic (n=158)	Normothermic (n=142)	*P*
Intraoperative Cardiac Outcomes			
Electrocardiographic event*	15 (10)	13 (9)	.76
Myocardial ischemia	8 (6)	7 (6)	.99
Ventricular tachycardia	7 (5)	6 (5)	.95
Postoperative Cardiac Outcomes†			
Electrocardiographic event*	23 (16)	9 (7)	.02
Myocardial ischemia‡	12 (9)	6 (5)	.17
Ventricular tachycardia§	11 (8)	3 (2)	.04
Morbid cardiac event‖	10 (6)	2 (1)	.02
Unstable angina/ischemia	7 (4)	2 (1)	
Cardiac arrest	2 (1)	0 (0)	
Myocardial infarction	1 (1)	0 (0)	
Electrocardiographic or morbid cardiac event	33 (21)	11 (8)	.001

*Myocardial ischemia or ventricular tachycardia.
†Postoperative outcomes include those events that occurred in the first 24 postoperative hours.
‡Includes 140 patients in the hypothermic group and 123 patients in the normothermic group with interpretable Holter monitor data.
§Includes 143 patients in the hypothermic group and 127 patients in the normothermic group with interpretable Holter monitor data.
‖Unstable angina/ischemia, cardiac arrest, or myocardial infarction.

The Effects of Intraoperative Hypothermia on Surgical Site Infection

An Analysis of 524 Trauma Laparotomies

Mark J. Seamon, MD, Jessica Wobb, BS,† John P. Gaughan, PhD,‡ Heather Kulp, MPH,† Ihab Kamel, MD,§ and Daniel T. Dempsey, MD†*

Annals of Surgery • Volume 255, Number 4, April 2012

→ Intraoperative temperature measurement less than **35◦C** increased the site infection risk **221%** per degree below 35◦C
(OR: 2.21; 95% CI: 1.24–3.92, P = 0.007).

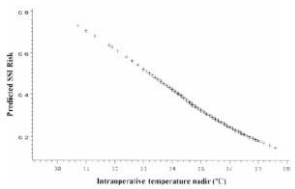


FIGURE 3. The predicted risk of surgical site infection correlated with the intraoperative temperature nadir depth.

Anesthesiology 2008; 108:71–7

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.§*

Anesthesiology 2008; 108:71–7

Conclusion: (14 studies – 1219 patients)
→ Even mild hypothermia (<1°C)
→ Significantly in-creases blood loss by approximately 16% (4–26%)
→ Increases the relative risk for transfusion by approximately 22%(3–37%).

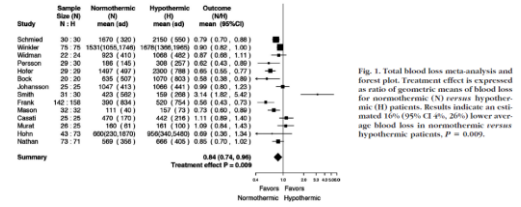


Fig. 1. Total blood loss meta-analysis and forest plot. Treatment effect is expressed as ratio of geometric means of blood loss for normothermic (N) *versus* hypothermic (H) patients. Results indicate an estimated 16% (95% CI 4%, 26%) lower average blood loss in normothermic *versus* hypothermic patients, $P = 0.009$.

Peri-operativ hypotermi

- Farer:
  - Mer hjerte-kar komplikasjoner
  - Mer sårinfeksjoner (sepsis?)
  - Økt blodtap – redusert hemostase
  - Hjertearytmier (28-32°), hjertestans (<20-25°)
  - Elektrolyttforstyrrelser (hyperkalemi → hypokalemi)

  - Lengre virketid for medikamenter
  - Økt potens av hypnotika/anestetika
- Fordeler:
  - Lavere metabolisme = lavere O2 behov
    - CNS, hjerte, (ischemisk vev)

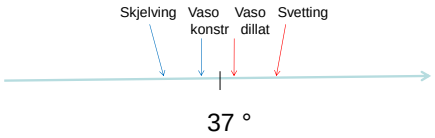
Hypertermi?

- Farer:
  - Økt generell metabolisme:
    - Økt O2 behov, økt cardiovaskulær og pulmonal belastning
    - Økt intrakranielt trykk
    - Svetting; væske – elektrolyttap
    - Cerebrale skader – kramper – mors
    - Malign hypertermi – sjelden, arvelig, gass+suxamethonium
- Fordeler:
  - Bedre immunforsvar
  - Vasodilatasjon – bedre perifer perfusjon

Temperatur regulering

Termostat:
-Hypothalamus
-Ryggmarg
-Hjerne
-Hud
-Dypt vev

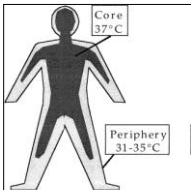
a) Autonom



37 °

b) Adaptiv adferd

Fig. 2



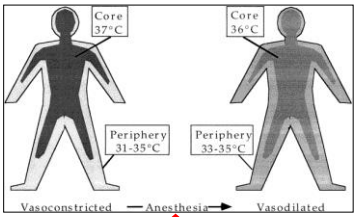
Perioperative Heat Balance.
Sessler, Daniel; Todd, Michael

Anesthesiology. 92(2):578, February 2000.

Hypotermi v/ gen anestesi:

- Varmen i kroppen ”omfordeles”
- Termostaten slår inn mye senere
  - Dsv: større avvik fra 37° før ”noe” skjer
- Varmeproduksjon er redusert
  - Lite muskelaktivitet – redusert metabolisme
- Varmetap kan være økt:
  - Lite tildekning, kraftig rom ventilasjon
  - Tørr ventilatorluft
  - Fordamping fra sår, spritvasket/anken hud
- Pasienten er fratatt ”egenomsorg”

Fig. 2



Perioperative Heat Balance.
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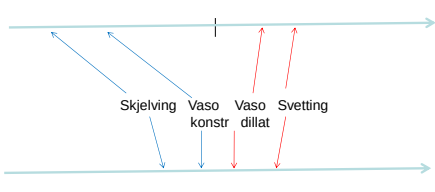
Anesthesiology. 92(2):578, February 2000.

Fig. 2. Cartoon showing redistribution hypothermia after induction of general anesthesia. Body heat content is not normally distributed evenly. Instead, tonic thermoregulatory vasoconstriction maintains a core-to-peripheral temperature gradient. Induction of general anesthesia inhibits vasoconstriction, allowing a core-to-peripheral redistribution of body heat. Reprinted with permission from Sessler DI: Temperature monitoring, Anesthesia, 4th edition. Edited by Miller RD. New York, Churchill Livingstone, 1994, pp 1363-82.

«Automatisk» straks-<u>omfordeling</u> av varme ved start av generell anestesi

Temperatur regulering

Generell Anestesi



Normal

37 °

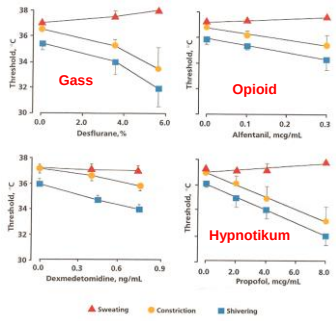


Figure 1: *The major autonomic thermoregulatory response thresholds in volunteers given desflurane, alfentanil, isoflurane or propofol. All the anesthetics slightly increase the sweating threshold (triggering core temperature), while markedly and synchronously decreasing the vasoconstriction and shivering thresholds. Used with permission.*[2,3]

Hypotermi v/ gen anestesi:

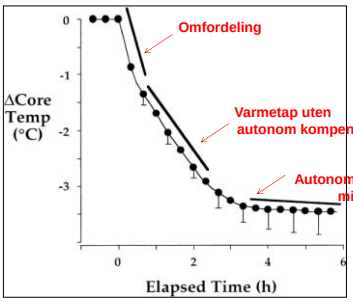
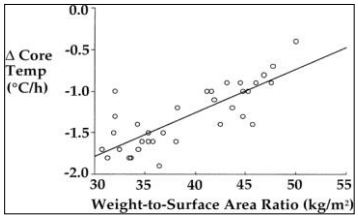


Fig. 4



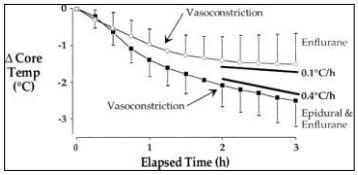
Perioperative Heat Balance.
Sessler, Daniel; Todd, Michael

Anesthesiology. 92(2):578, February 2000.

Fig. 4 . The influence of body morphology on redistribution hypothermia. The amount of redistribution hypothermia (reduction in core temperature during the first hour of anesthesia was inversely proportional to the weight-to-surface area ratio: [DELTA] core temp = 0.0524 [middle dot] W/SA - 3.35; R2 = 0.66. The 95% confidence interval for the slope was 0.040-0.065[degrees]C [middle dot] h-1 [middle dot] kg-1 [middle dot] m2. Reduced redistribution hypothermia in obese patients apparently results because the major thermoregulatory problem in these well-insulated patients is dissipation of metabolic heat. Consequently, they spend much of their time vasodilated, which differs from the constricted state most patients maintain in a hospital environment. The result is that peripheral tissue temperature in obese patients is higher than normal, which reduces core-to-peripheral redistribution of heat after induction of anesthesia. Reprinted with permission from Kurz et al.56

→ Mer redistribusjon av varme og større temperaturfall initialt hos tynne pasienter

Fig. 9

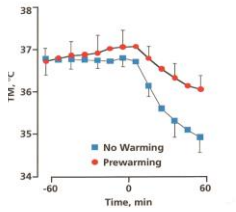


Perioperative Heat Balance.
Sessler, Daniel; Todd, Michael

Anesthesiology. 92(2):578, February 2000.

Fig. 9 . Pronounced hypothermia during combined epidural-general anesthesia. Patients undergoing colorectal surgery were randomly assigned to combined epidural-enflurane anesthesia or enflurane alone. In appropriate patients, epidural anesthesia was maintained by an infusion of bupivacaine. Arteriovenous shunt vasoconstriction was observed nearly 1 h later in the patients administered combined epidural-general anesthesia, which is consistent with the established centrally mediated thermoregulatory impairment produced by neuraxial anesthesia. There was a distinct core temperature plateau after 2 h in the patients administered general anesthesia alone; in contrast, core temperature continued to decrease at a rate of 0.4[degrees]C/h in the patients who were also administered epidural anesthesia. Reprinted with permission from Joris et al.77

Mer varmetap og mindre vasokonstriksjon med epidural + generell anestesi



Mindre redistribusjon av varme
→Mindre fall i kjernetemperatur

hvis:

Huden er varm før anestesistart! *

*** Generell anestesi eller epidural/spinal**

Peri-operativ hypotermi: *Hva kan vi gjøre?*

- Omfordeling:
  - Varm hud på forhånd
- (Produksjon) vs **varmetap:**
  - Varmt i rommet
  - Varme væsker/gasser (+ fukte)
  - Dekke til hud
  - Varme tepper/kontaktflater
  - Varmluftstepper
  - Varmeveksling via hud (pads, pulserende vann)
  - Intern blodbanevarming (Cool-guard, H-Lmaskin

British Journal of Anaesthesia 98 (3): 331–6 (2007)
doi:10.1093/bja/ael369 Advance Access publication January 26, 2007

BJA

CLINICAL PRACTICE

Hypothermia during laparotomy can be prevented by locally applied warm water and pulsating negative pressure

E. B. Rein[1] *†, M. Filtvedt[2†], L. Walloe[1] and J. C. Ræder[2]

[1]Department of Physiology, Institute of Basic Medical Sciences, University of Oslo, N-0317 Oslo, Norway.
[2]Department of Anaesthesiology, Ullevål University Hospital, University of Oslo, N-0407 Oslo, Norway
*Corresponding author: E-mail: e.b.rein@medisin.uio.no

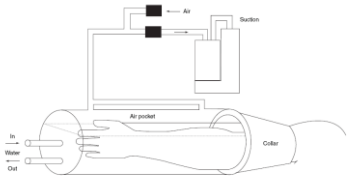


Fig 1 Cylindrical transparent Plexiglass chamber (50×16 cm), sealed to the upper arm by a neoprene collar attached to an adapter (10×16 cm). An elastic rubber sleeve ran from the proximal neoprene collar to the Plexiglass cylinder making the tube watertight.

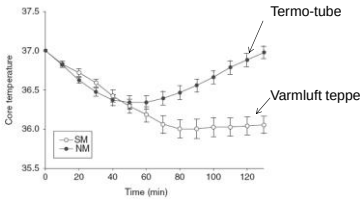


Fig 3 Averaged normalized tympanic temperatures from both groups. The graphs are normalized by adding, making all experiments start at 37.0°C. Induction of anaesthesia is at 0 min. Error bars are plus and minus one standard error.

Varmluftsteppe:
- **Effektivt**
- **Tilfører mye varme**

- **Hvirvler opp støv**
- **Litt støy**
- **Plasskrevende**
- **Elektrisitet**
- **Investeringer**
- **Engangsutstyr**

Effects of preinduction and intraoperative warming during major laparotomy

• 2 x 20 patients, laparotomy

Test group:

Warm air 30 min preoperative + peroperative

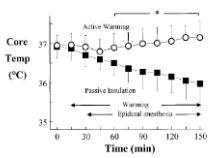
Control group:

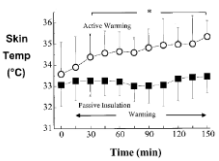
No pre-warming, warm per-op mattress

•No preoperative drugs, 22°C in room
•General anaesthesia: propofol and N2O
•Epidural

References
Bock M et al. British journal of anaesthesia.1998;80:159-63

Effects of preinduction and intraoperative warming during major laparotomy





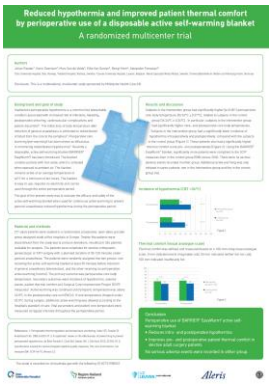
References
Bock M et al. British journal of anaesthesia.1998;80:159-63

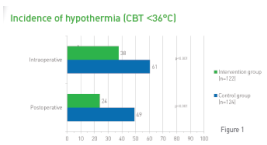
Effects of preinduction and intraoperative warming during major laparotomy

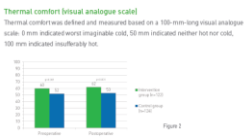
Pre and per operative forced air warming:

- Less drop in core temperature
- Less blood-loss (635 vs 1070 ml)
- Less transfusion (1 pat vs 6 pat)
- Less need of recovery room stay (94 vs 217min)
- 24% reduction in total anaesthetic costs (408 vs 534 £)

References
Bock M et al. British journal of anaesthesia.1998;80:159-63







Conclusion

Perioperative use of BARRIER® EasyWarm® active self-warming blanket:

- Reduces intra- and postoperative hypothermia
- Improves pre- and postoperative patient thermal comfort in elective adult surgery patients

No serious adverse events were recorded in either group.

Ny studie

- Varmeteppe: 30 min preop + per/post

Versus

- Varmluft teppe: per-operativt

- Elektiv kirurgi, generell anestesi, 1-2 timers varighet

Peri-operativ hypotermi: *Hva kan vi gjøre?*

- **Omfordeling – «varmelager»:**
  - Varm hud på forhånd
- **(Produksjon) vs varmetap:**
  - Varmt i rommet
  - Varme væsker/gasser (+ fukte)
  - Dekke til hud
  - Varme tepper/kontaktflater
  - Varmluftstepper
  - Varmeveksling via hud (pads, pulserende vann)
  - Intern blodbanevarming (Cool-guard, H-Lmaskin

Takk !

Post til:

johan.rader@medisin.uio.no