







# Hypothermia in avalanche: outstanding issues

## **Outstanding issues**

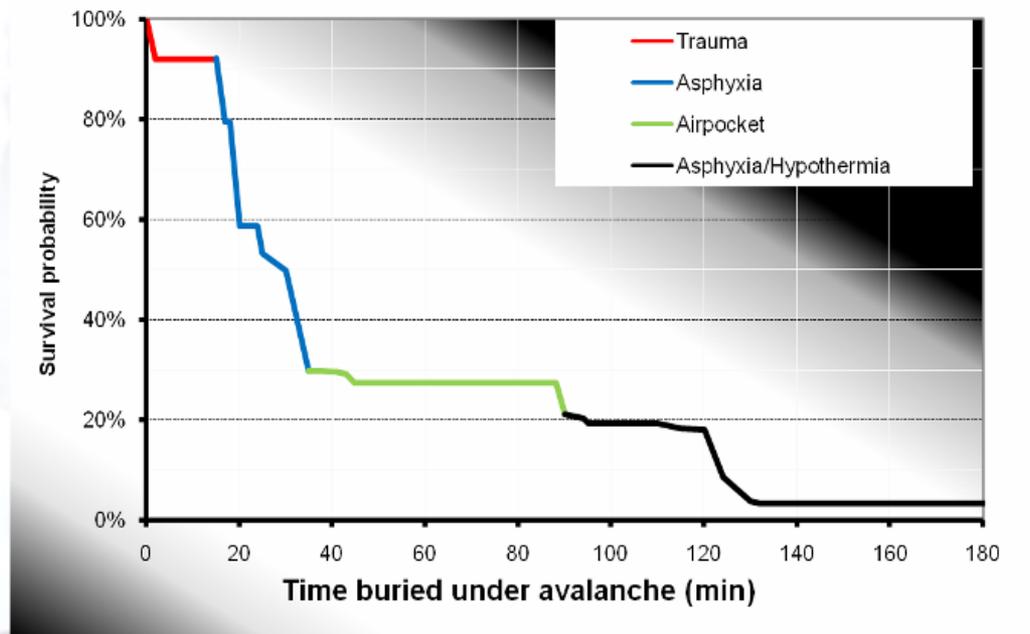
- a) Incidence of hypothermia in avalanche**
- b) Cooling rates during & after burial**
- c) On-site core temperature reading**
- d) Ideal rewarming of non-arrested victims**

# *Outstanding issues: incidence of hypothermia*

## **a) Incidence of hypothermia**

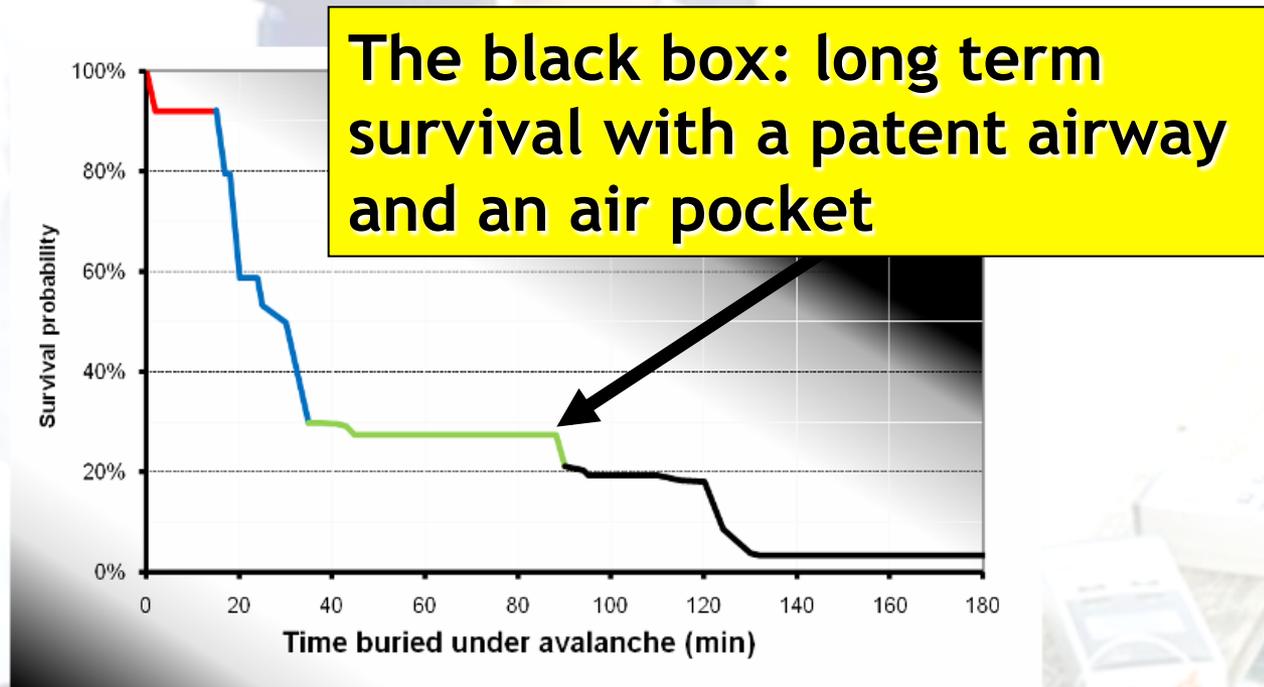


# Outstanding issues: incidence of hypothermia



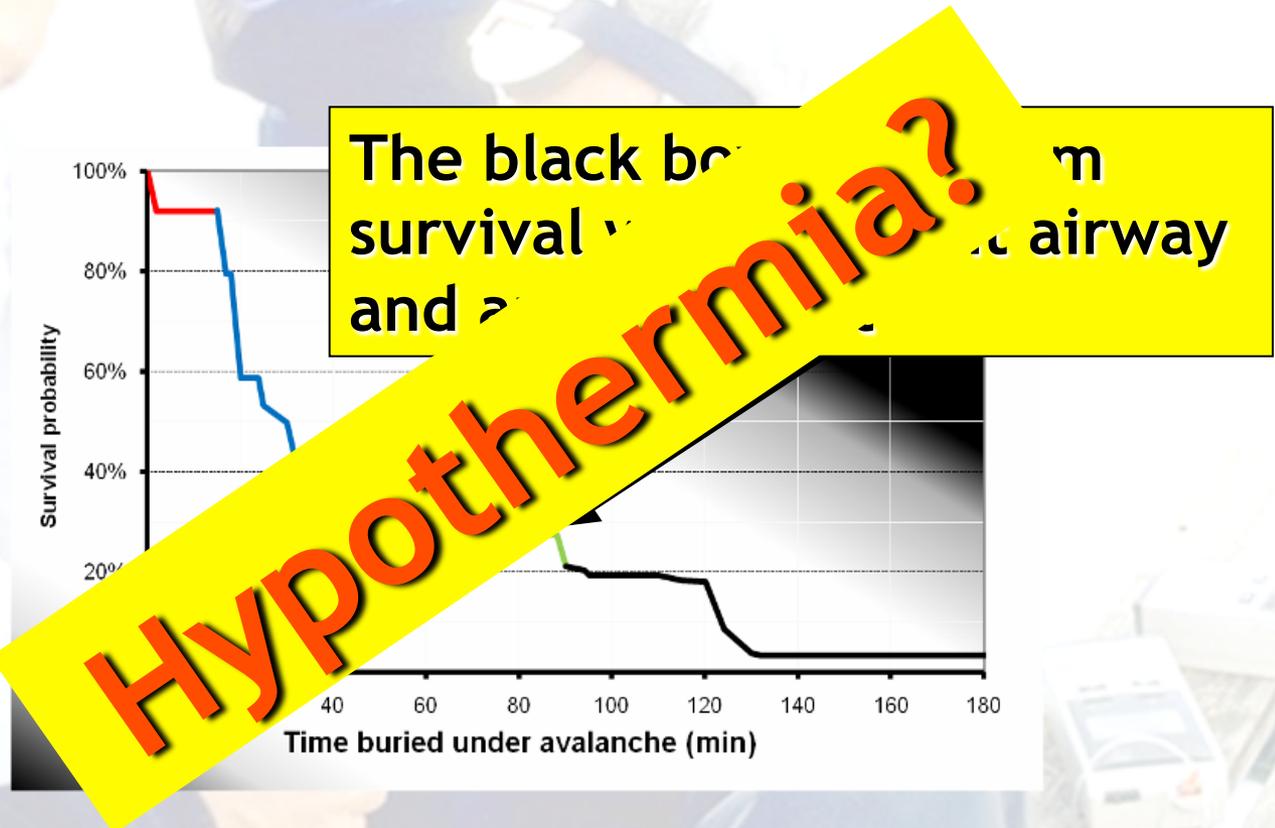
Falk M et al Nature 1994. Brugger H et al Resuscitation 2001

# Outstanding issues: incidence of hypothermia



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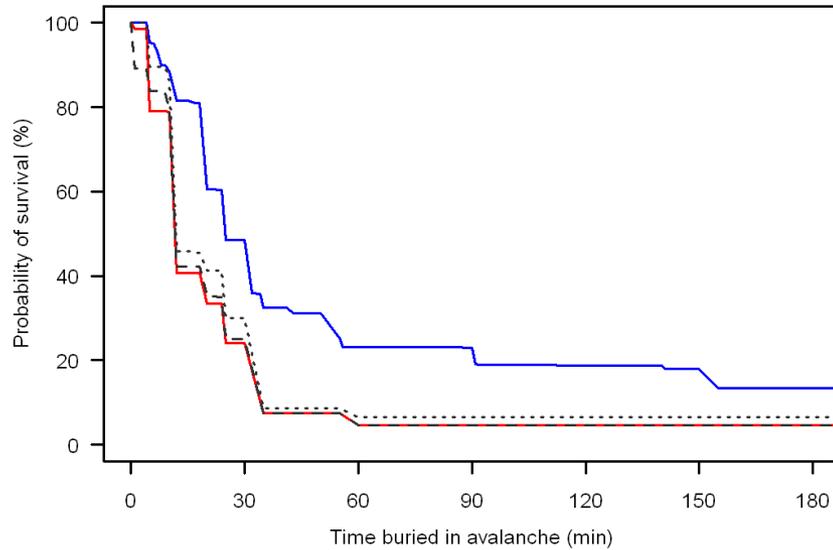
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## Avalanche survival patterns Canada vs Switzerland

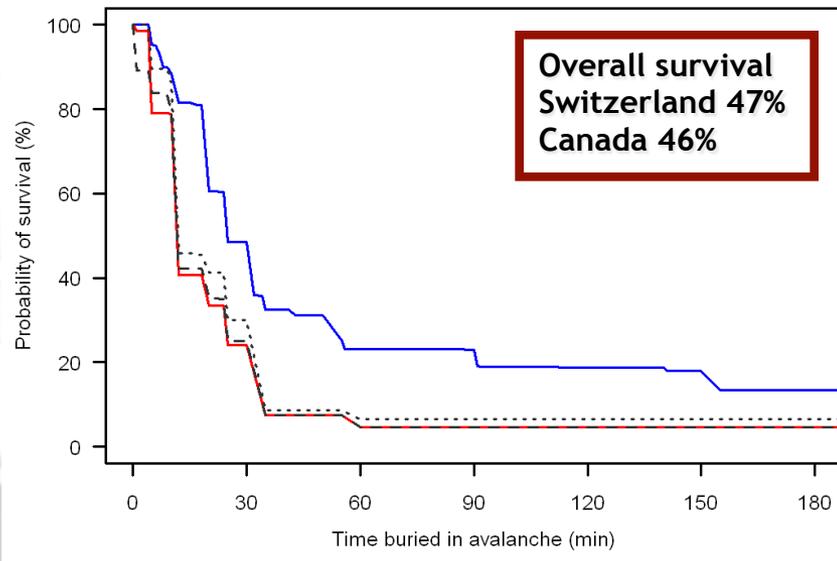


Comparison of survival curves. Swiss survival curve (blue; n=946) and Canadian survival curve (red; n=301). The black dotted survival curve is based on the Canadian dataset without trauma fatalities (n=255). The black dashed survival curve is calculated with the Canadian dataset where the extraction times for severe trauma fatalities was replaced with an estimated time of death of 1 minute after burial (n=301).

Haegeli P, Falk M, Boyd J, Etter HJ, Brugger H, CMAJ 2010, in press

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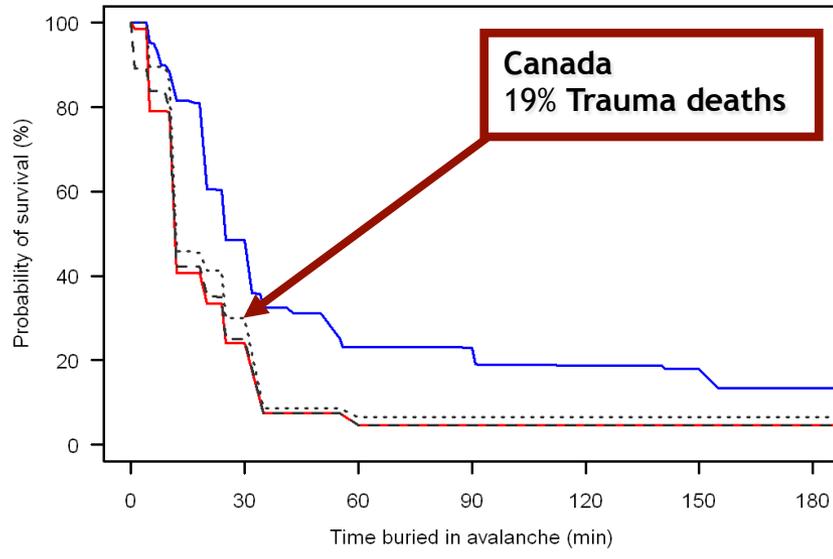


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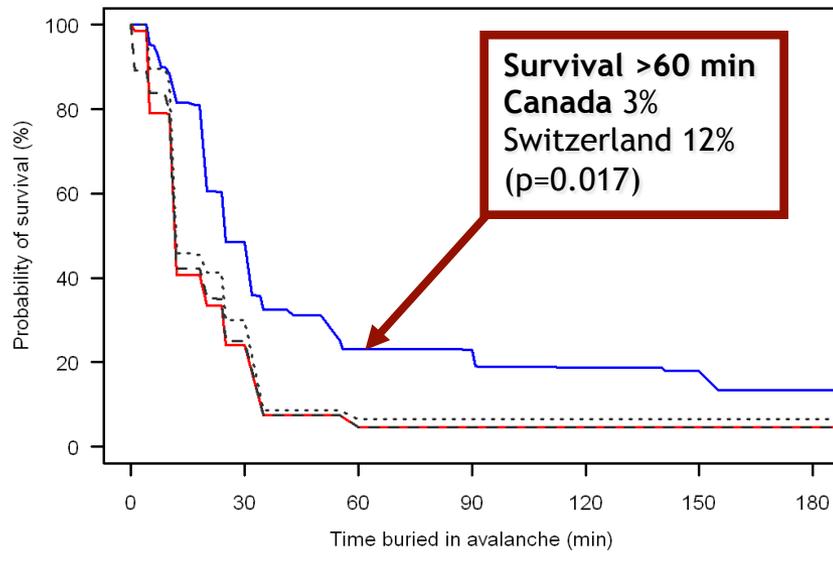


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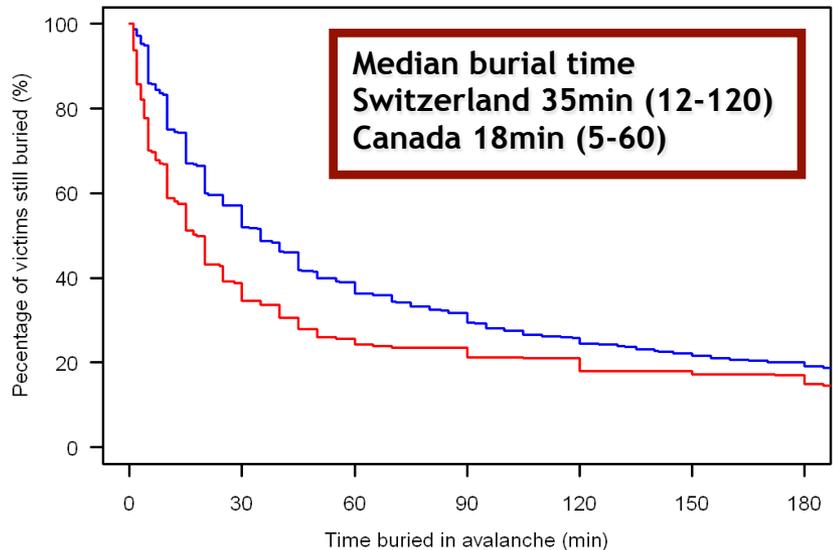


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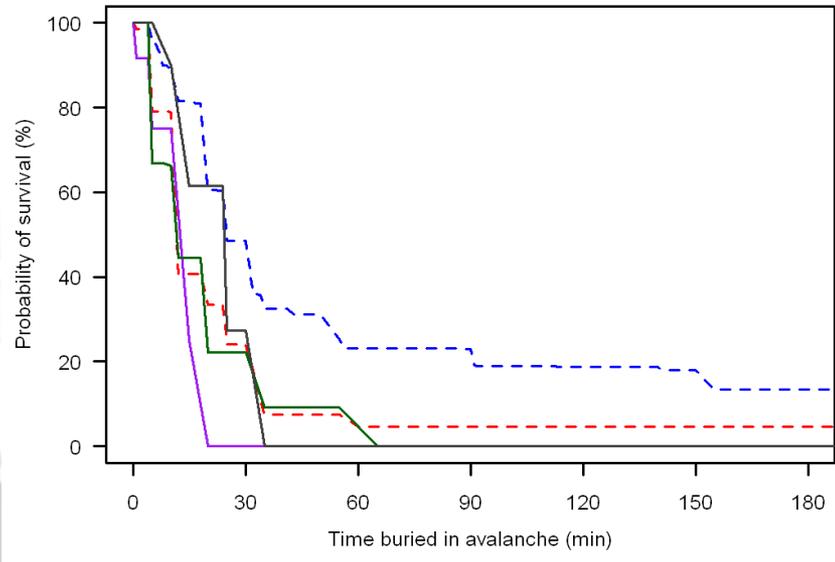


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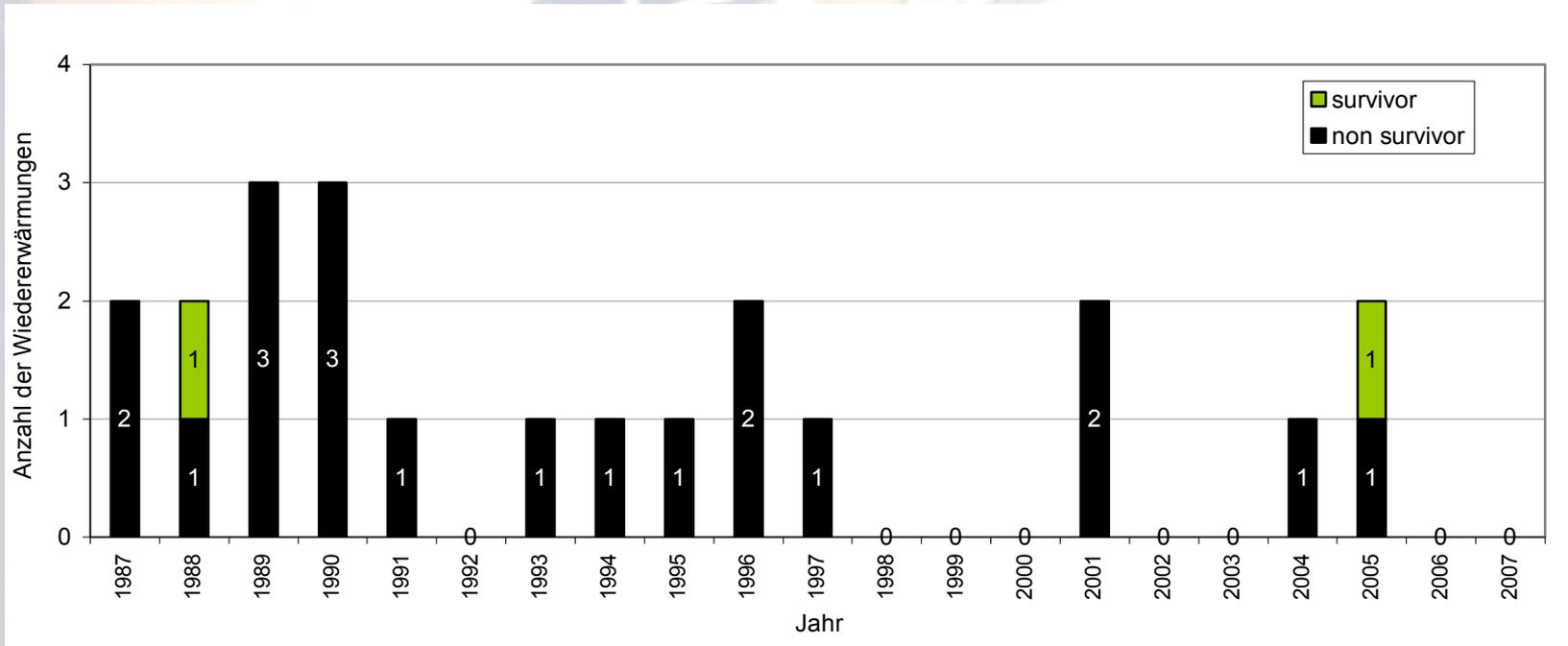
Factors determining poorer survival beyond 60 minutes in Canada

1. Delay of organized rescue
2. Limited medical support upon extrication and during transport
3. Higher snow density

Haegeli P, Falk M, Boyd J, Etter HJ, Brugger H, CMAJ 2010, in press

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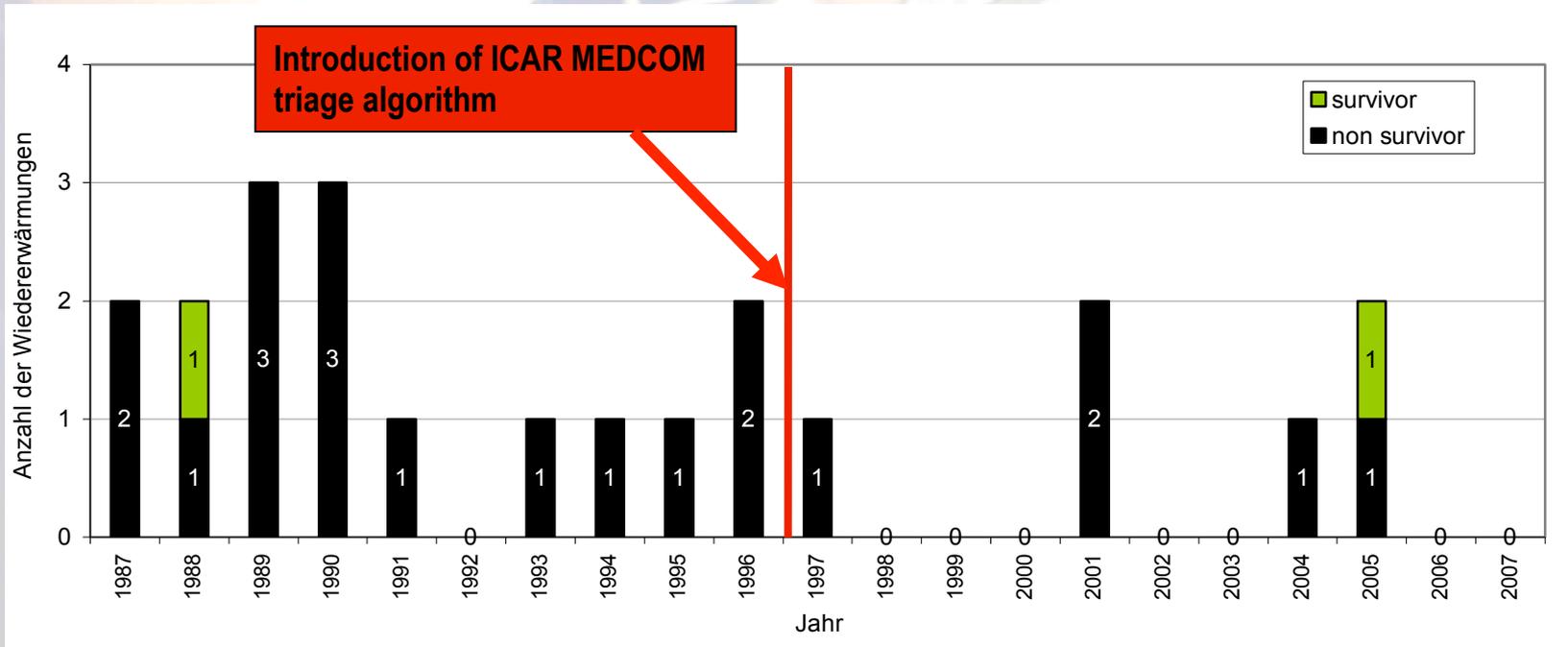
## Incidence of hypothermic avalanche victims rewarmed with ECC at the Innsbruck University Hospital 1987-2007



Plankensteiner J. Alpine Notfallmedizin am Beispiel des Lawinenunfalls. Medical University Innsbruck 2009

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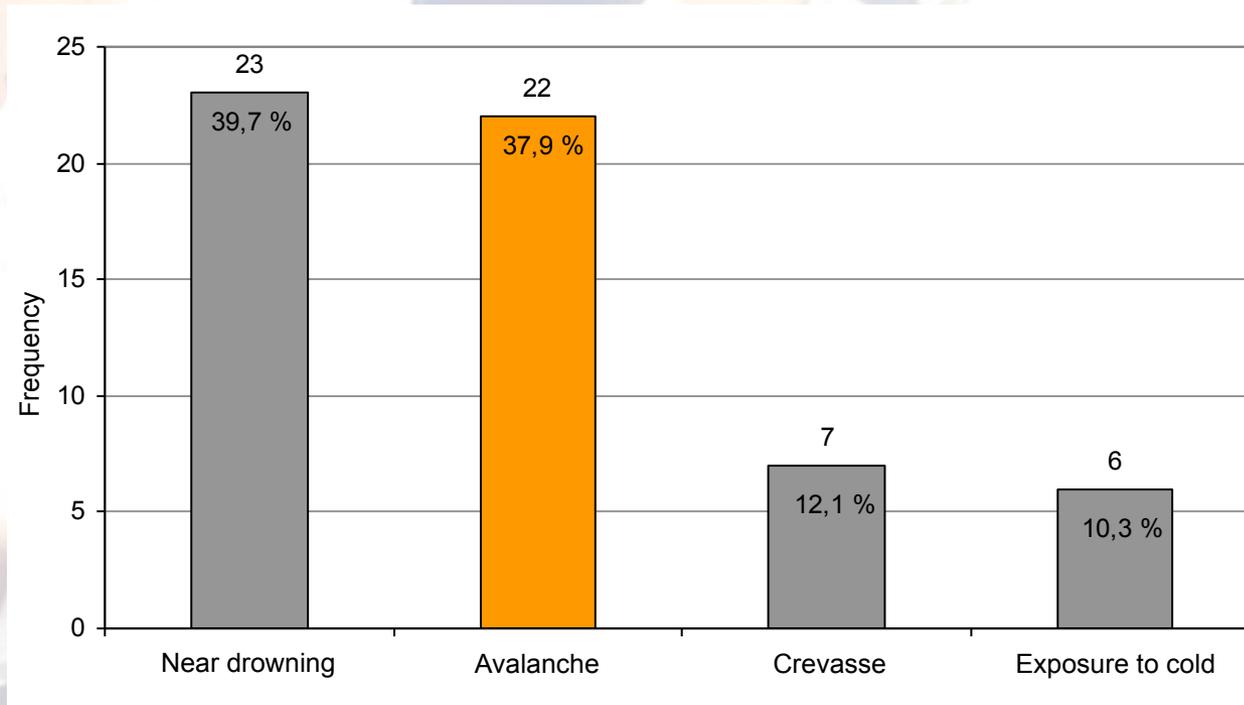
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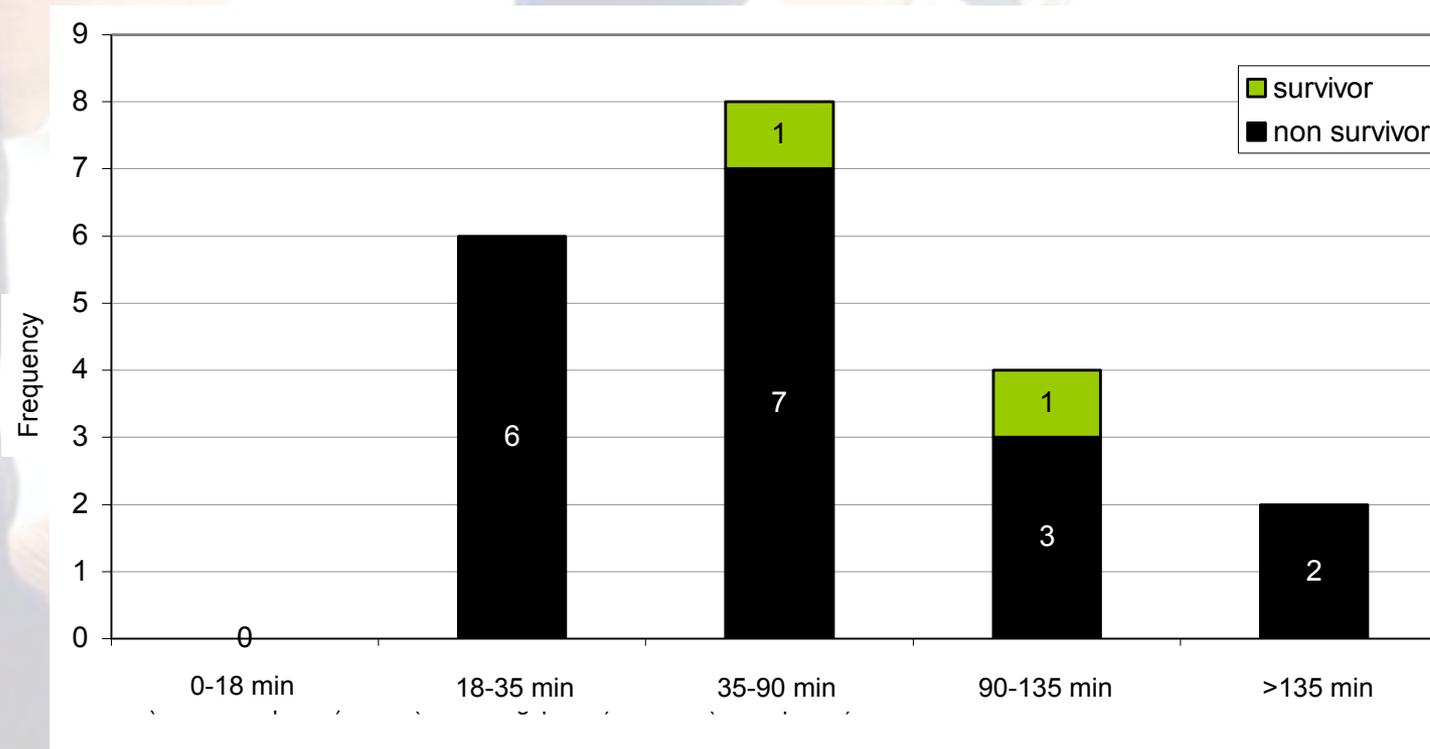
## Origin of hypothermic avalanche victims rewarmed with ECC at the Innsbruck University Hospital 1987-2007



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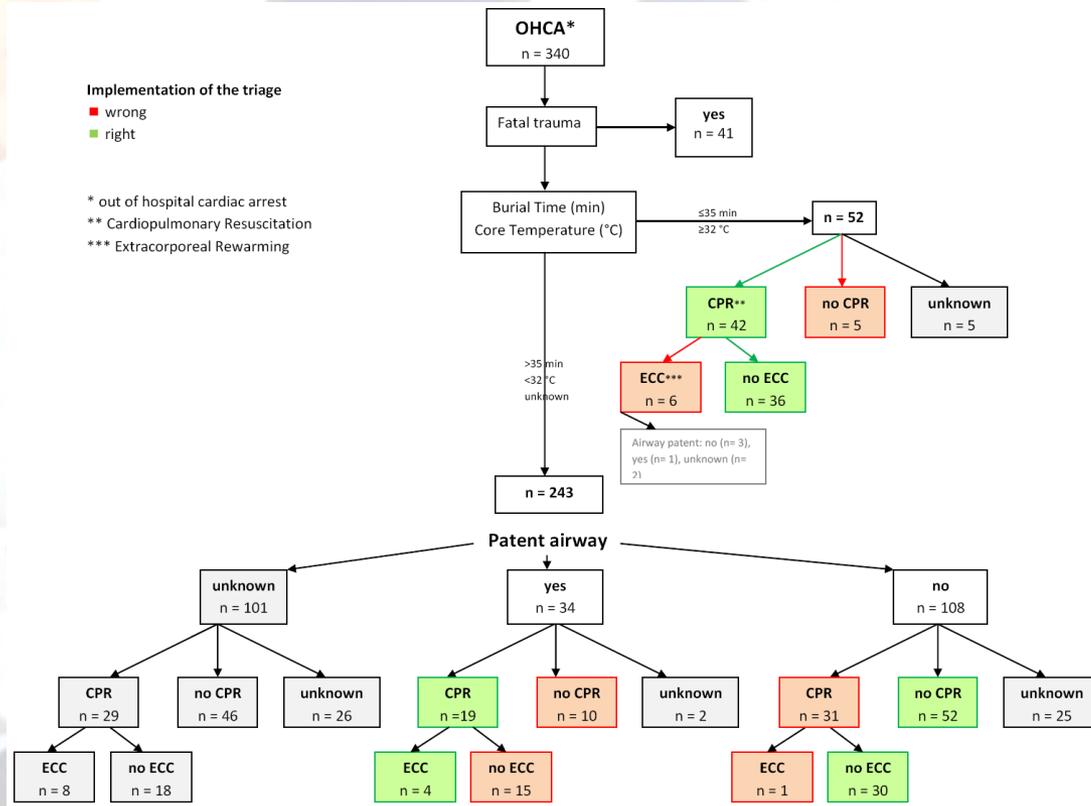
# Outstanding issues: incidence of hypothermia

**Frequency and outcome of hypothermic avalanche victims rewarmed with EC in relation to burial time at the Innsbruck University Hospital 1987-2007**



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# Outstanding issues: incidence of hypothermia



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# Outstanding issues: incidence of hypothermia

## Causes of deaths from avalanche (autopsy or documented external post-mortem examination)

	Trauma	Asphyxia	Hypothermia	Total
Tough 1993 <sup>1</sup>	1 (6.7%)	14 (93.3%)	0 (0%)	15 (100%)
McIntosh 2007 <sup>2</sup>	3 (5.4%)	53 (94.6%)	0 (0%)	56 (100%)
Hohlrieder 2007 <sup>3</sup>	2 (5.5%)	33 (91.7%)	1 (2.8%)	36 (100%)
Boyd <sup>4</sup> 2009	48 (24%)	154 (75%)	2 (1%)	204 (100%)
<b>Total</b>	<b>54 (17.3%)</b>	<b>254 (81.7%)</b>	<b>3 (1.0%)</b>	<b>311 (100%)</b>

<sup>1</sup> Tough SC, Butt JC. A review of 19 fatal injuries associated with backcountry skiing. *Am J Forensic Pathol.* 1993;14:17-21.

<sup>2</sup> McIntosh SE, Grissom CK, Olivares CR, et al. Cause of death in avalanche fatalities. *Wilderness Environ Med.* 2007;18:293-297.

<sup>3</sup> Hohlrieder M, Brugger H, Schubert H, et al. Pattern and severity of injury in avalanche victims. *High Alt Med Biol.* 2007;8:56-61.

<sup>4</sup> Boyd J, Haegeli P, Abu-Laban R, et al. Avalanche fatalities in Western Canada: A 21 year review. *CMAJ* 2009;180(5):507-12

HT = Hypothermia

# *Outstanding issues: incidence of hypothermia*

Questionable whether **hypothermia**, associated with hypoxia and hypercapnia (“slow asphyxia”), is **detectable solely by external examination or autopsy** without clinical data.

# *Outstanding issues: incidence of hypothermia*

We can say that **hypothermia can develop only if the buried person is able to breathe longer than 35 minutes**, but we cannot say how many victims are still breathing under the avalanche after this time.

# *Outstanding issues: incidence of hypothermia*

Further investigation needed to clarify the significance of hypothermia as a cause of death, paying attention to **body temperature** and the **presence of free airway on extrication**.

# Outstanding issues: incidence of hypothermia

The **varying incidence of trauma** fatalities is inversely correlated to the rate of hypothermia and lowers the survival curve (24% in Western Canada<sup>1</sup> vs. 6% in Europe<sup>2</sup>)

<sup>1</sup> Boyd J, Haegeli P, Abu-Laban R, et al. Avalanche fatalities in Western Canada: A 21 year review. *CMAJ* 2009;180(5):507-12

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# *Outstanding issues: cooling rate during & after burial*

## **b) Cooling rate during & after burial**



# Outstanding issues: cooling rate during & after burial

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Significant **variability of cooling rate** during burial

Locher and Walpoth 1996<sup>1</sup> 3°C max. 9°C per hour

Grissom et al 2004<sup>2</sup> 0.7-1.2°C per hour

Oberhammer et al 2008<sup>3</sup> 9°C per hour

<sup>1</sup> Locher T, Walpoth BH. Schweizerische Rundschau für Medizin 1996;85:1275-1282.

<sup>2</sup> Grissom CK, et al J Appl Physiol 2004;96:1365-70.

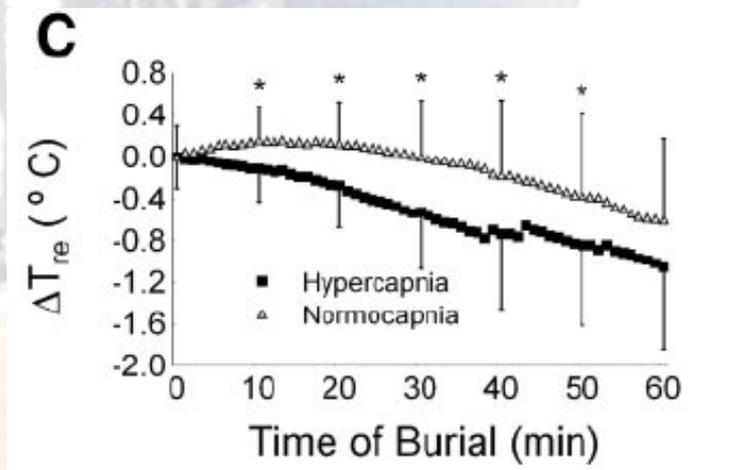
<sup>3</sup> Oberhammer et al Resuscitation 2008;76/3:474-480.

# Outstanding issues: cooling rate during & after burial

## b) Cooling rate during & after burial

Factors impact on **cooling rate** during burial

- Hypercapnia



Grissom CK et al. , J Appl Phys 2004

# *Outstanding issues: cooling rate during & after burial*

## **b) Cooling rate during & after burial**

Factors impact on **cooling rate** during burial

- Energy depletion
- Impaired consciousness
- Associated injuries
- Clothing

# *Outstanding issues: cooling rate during & after burial*

## **b) Cooling rate during & after burial**

**Full-body insulation and the avoidance of unnecessary movements prevent after drop**

**Locher and Walpoth 1996<sup>1</sup>**

**Althaus et al 1982<sup>2</sup>**

**Oberhammer et al 2008<sup>3</sup>**

<sup>1</sup> Locher T, Walpoth BH. Schweizerische Rundschau für Medizin 1996;85:1275-1282.

<sup>2</sup> Althaus U et al. Ann Surg 1982;195:492-5.

<sup>3</sup> Oberhammer et al. Resuscitation 2008;76/3:474-480.

# *Outstanding issues: cooling rate during & after burial*

## **b) Cooling rate during & after burial**

**The Triple  
H Study  
2010**



# Outstanding issues: cooling rate during & after burial

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The Triple  
H Study  
2010

Med Univ IBK

**EURAC**

Institute of Mountain  
Emergency Medicine

Charitè Berlin



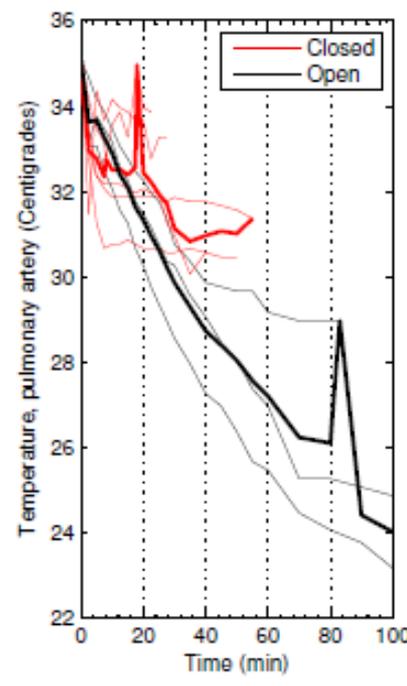
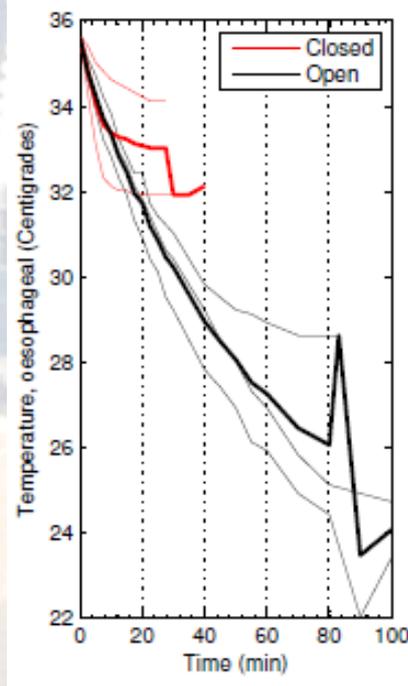
Univ Tromsø

Mayo Clinic US

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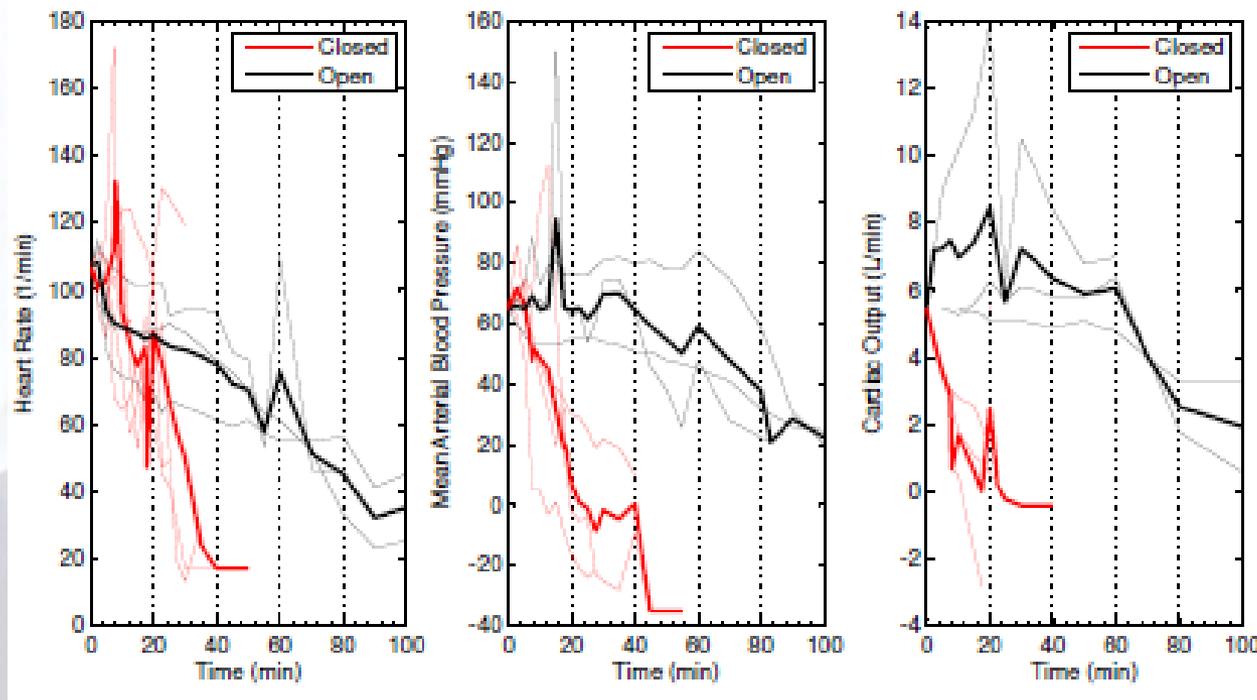
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## b) Cooling rate during & after burial

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## **b) Cooling rate during & after burial**

**The Triple  
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2010**

The case series supports the hypothesis that acute hypothermia, associated with hypoxia and hypercapnia, does occur and may protect avalanche victims from death during burial if oxygen support is sufficient to maintain cardiac function

# *Outstanding issues: on-site core temperature reading*

## **c) On-site core temperature reading**



# *Outstanding issues: on-site core temperature reading*

## **c) On-site core temperature reading**

**Epitympanic vs oesophageal measurement**

**Only thermistor-based ear thermometer  
correlate well with oesophageal temperature  
measurements in a cold environment**

<sup>1</sup> Walpoth B et al. J Clin Monit. 1994 Mar;10(2):91-6.

<sup>2</sup> Locher T et al. International Congress of Mountain Medicine Francois-Xavier Bagnoud. Interlaken (Switzerland) 1997, p 56.

# *Outstanding issues: on-site core temperature reading*

## **c) On-site core temperature reading**

**Epitympanic measurement** for the non-intubated patient

**Oesophageal measurement** for the intubated patient

# Outstanding issues: on-site core temperature reading

## c) On-site core temperature reading

The „double sensor“  
for non-invasive measurement



# *Outstanding issues: rewarming of non-arrested victims*

## **d) Rewarming of non-arrested victims**



# *Outstanding issues: rewarming of non-arrested victims*

## **d) Rewarming of non-arrested victims**

### **Invasive vs. non-invasive techniques**

**What re-warming technique is practicable, safe and efficient for a non-arrested hypothermic patient in a tertiary hospital?**

# *Outstanding issues: rewarming of non-arrested victims*

## **d) Rewarming of non-arrested victims**



# *Hypothermia in avalanche: further research*

## **Further research needed on**

- **Incidence of hypothermia**
- **Cooling rates of avalanche victims**

# *Hypothermia in avalanche: acceptable solutions*

## **Acceptable solutions needed for**

- **On-site core temperature reading**
- **Rewarming of non-arrested victims**

# *Hypothermia in avalanche: acceptable solutions*

**International Hypothermia Registry**  
<https://www.hypothermia-registry.org>





**Thank you for your attention**