Patient pre-warming helps to impede hypothermic consequences.

Perioperative hypothermia can lead to severe complications

A guide about hypothermia, risks and better patient warming practice

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Perioperative hypothermia

Normal core body temperature (normothermia) is 37.0°C (+/- 0.5°C). If core body temperature drops, vasoconstriction and shivering are triggered at particular temperature thresholds to generate heat. In addition, if the temperature becomes elevated/rises, the cooling mechanisms, vasodilation and sweating, are also triggered at threshold levels[1].

During anaesthesia, the effects of the anaesthetic drugs/pharmaceuticals coupled with the effects of the anaesthesia coupled with a reduction in metabolic heat production means patients are at an increased risk of hypothermia, which is defined as a core body temperature below 36°C. This can be aggravated by a cold environment.

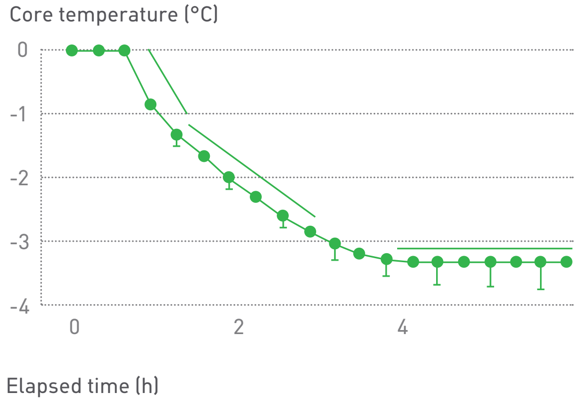
Unwarmed patients typically become hypothermic, experiencing a loss in core body temperature of up to 1-1.5°C in the first hour after induction of anaesthesia[3].

Causes of hypothermia

Hypothermia during anaesthesia

Anaesthesia impairs thermoregulation by lowering the thresholds at which the body's own warming mechanisms start to work. Studies[2] have shown that the thresholds at which shivering and vasoconstriction are triggered decrease with increased medication levels/ concentrations.

Unwarmed patients typically experience a drop in core body temperature of up to 1.0-1.5°C in the first hour and 3°C in the first three hours[3].

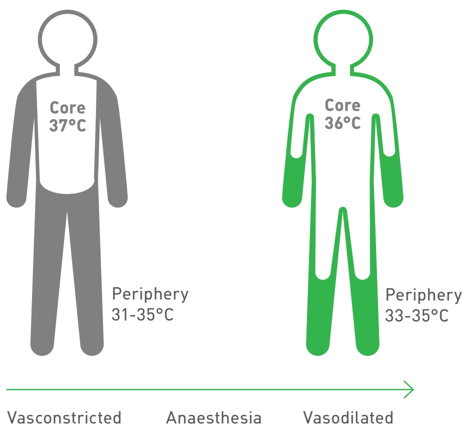


Typical pattern of hypothermia during general anaesthesia[4]

Redistribution hypothermia

During the first hour of anaesthesia, heat is redistributed from the core to the periphery of the body through vasodilation. This lowers the core body temperature, while increasing temperature at the periphery. As a result, patients typically become hypothermic.

More than 80 percent of the temperature drop in the first hour is caused by redistribution hypothermia[5].

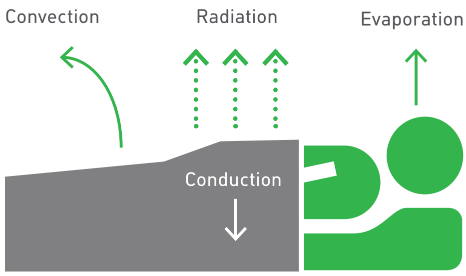


Illustrations of redistribution hypothermia[6]

Intraoperative heat transfer

Heat loss due to a reduction in metabolic heat production and a cold environment also reduce core body temperature intraoperatively. Heat loss is greater if the operating room is cold.

Serious operations, involving large open wounds, can also cause a loss of core body temperature.



Other contributing factors causing hypothermia[7]

Even with active intraoperative warming, patients typically experience an initial temperature drop in the first hour of surgery.

The consequences of perioperative hypothermia

In the operating room, the effects of the anaesthesia, coupled with a reduction in metabolic heat production, means patients are more at risk of hypothermia. This can result in a wide range of consequences, from serious health risks through to increased costs.

Consequences associated with perioperative hypothermia

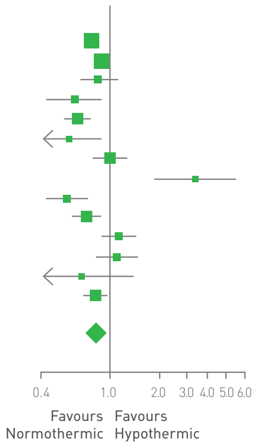
Greater blood loss and transfusion requirement

Even mild to moderate perioperative hypothermia (core body temperature: 34°C - 36°C) reportedly impairs platelet function and enzymes needed for blood coagulation which result in both greater blood loss and transfusion requirements[8].

A meta-analysis of randomised controlled trials demonstrated these adverse effects of hypothermia[8]. Patients having their core body temperature in the normal range lose 16% less blood and have 22% less risk of transfusion on average compared to hypothermic patients[8].

Results indicate an estimated 16% (95% CI 4%, 26%) lower average blood loss in normothermic versus hypothermic patients, P=0.009[1]

Study	Sample size (N) N : H	Normotheric (N) mean (sd)	Hypothermic (H) mean (sd)	Outcome (N/H) mean (95%CI)
Schmied	30 : 30	1670 (320)	2150 (550)	0.79 (0.70,0.88)
Winkler	75 : 75	1531 (1055,1746)	1678 (1366,1965)	0.90 (0.82, 1.00)
Wildman	22 : 24	923 (410)	1068 (482)	0.87 (0.68,1.11)
Persson	29 : 30	188 (145)	308 (257)	0.62 (0.43, 0.89)
Hofer	29 : 29	1497 (497)	2300 (788)	0.65 (0.55, 0.77)
Bock	20 : 20	635 (507)	1070 (803)	0.58 (0.38, 0.89)
Johansson	25 : 25	1047 (413)	1066 (441)	0.99 (0.80, 1.23)
Smith	31 : 30	423 (562)	159 (268)	3.14 (1.82, 5.42)
Frank	142 : 158	390 (834)	520 (754)	0.56 (0.43, 0.73)
Mason	32 : 32	111 (40)	157 (73)	0.73 (0.60, 0.89)
Casati	25 : 25	470 (170)	442 (216)	1.11 (0.89, 1.40)
Murat	26 : 25	160 (61)	161 (100)	1.09 (0.84, 1.43)
Hohn	43 : 73	660 (230,1870)	956 (340,5480)	0.69 (0.38, 1.34)
Nathan	73 : 71	569 (358)	666 (405)	0.85 (0.70, 1.02)
Summary				0.84 (0.74, 0.96)



Total blood loss meta-analysis and forest plot[8]

Perioperative hypothermia is an established risk factor for developing surgical site infections. The clinical guidance on the management of IPH in adults reports that hypothermic patients have four times higher risk of developing SSIs compared to normothermic patients[9].

Morbid cardiac events

Morbid cardiac events such as myocardial infarction, cardiac arrest and myocardial ishemia are significant inadvertent perioperative hypothermia (IPH). IPH is an independent predictor of morbid cardiac events. Patients with mild perioperative hypothermia are 2.2 times more likely to experience a morbid cardiac event perioperatively compared to normothermic patients. This indicates a 55% risk reduction when normothermia is maintained[10].

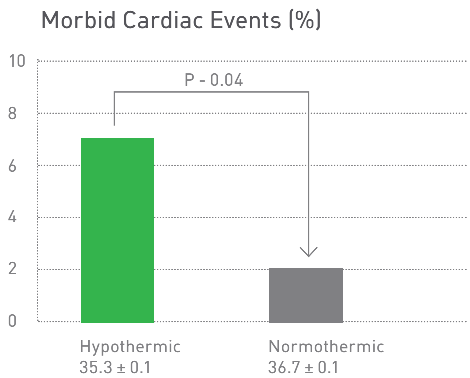
Prolonged recovery time

Hypothermia prolongs both the stay in the post-anaesthesia care unit (PACU) and the overall in-hospital stay. In one study it has been found that hypothermia affected patients' fitness for discharge. Time in the recovery room increased by an average of 40 minutes for patients with around 2°C hypothermia[11].

Increased costs

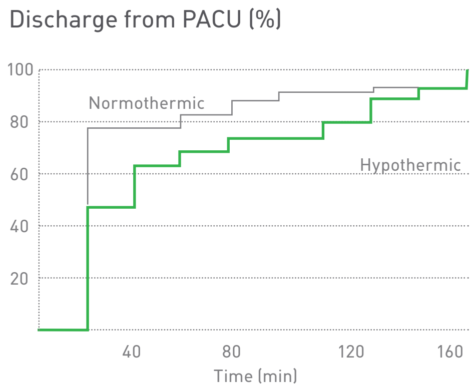
IPH have significant cost implications for the healthcare provider due to the numerous adverse consequences it is associated with. A patient experiencing inadvertent hypothermia perioperatively consumes significantly more healthcare resources compared to a normothermic patient.

- Inadvertent perioperative hypothermia (IPH) leads to both poorer clinical outcomes for the patient and increased financial cost to the healthcare provider.
- Blood loss and transfusion requirement: Many studies have shown that even mild hypothermia impairs both platelet function and the enzymes needed for coagulation, leading to greater blood loss and significantly increased transfusion requirements[8].
- Surgical site infections (SSIs):
  Patients with mild hypothermia can triple the risk of developing surgical site infections due to different mechanisms[14].
  – vasoconstriction decrease blood flow and thereby decreases the number of immune system cells and the oxygen levels in the wound.
  – impaired immune cell function.
- Morbid cardiac events: Heart attacks are a leading cause of unexpected mortality after surgery. A study found that patients with 1 to 2°c of hypothermia are three times more likely to experience morbid cardiac events (such as myocardial infraction, cardiac arrest and unstable angina) than patients with normal body temperature[10].
- Prolonged recovery time: IPH can increase the length of stay in hospital, and by consequence overall in the hospital increased costs[9].



Core body temperature (°C) N=300 patients

Hypothermic patients experience more morbid cardiac events than normothermic patients[10]



N=150 patients

Hypothermia prolongs recovery time after surgery[11]

Keeping patients warm

To ensure that your patients do not become hypothermic, monitor their core body temperature regularly and keep them warm before, during and after surgery.

Existing warming techniques

A considerable number of patient-warming strategies exist, which aim to reduce intraoperative heat loss.

Passive warming

Passive warming aims to reduce heat loss without additional heat being added to the body. Techniques to reduce intraoperative heat loss include:

- Informing patients on the risks of hypothermia and advise them to keep as warm as possible before surgery.
- Maintaining the highest possible temperature in the operating room.
- Placing warmed cotton blankets over patients.

While passive warming techniques are beneficial, they are not fully effective in preventing inadvertent perioperative hypothermia[15].

Active warming

Active warming is a transfer of heat from an external source to the body. Patients who undergo active warming have significantly higher core body temperatures after surgery than patients who undergo passive or no warming techniques[16.17.18].

Active intraoperative warming techniques include:

- Active warming blankets and mattresses.
- Forced air warming.
- Fluid warming.

Challenges with intraoperative warming

Active warming techniques used intraoperatively are usually started after redistribution hypothermia has already occurred. This means that patients could potentially be exposed to hypothermia before active warming techniques are initiated.

Measuring core temperature

The patient's core body temperature should be measured and documented before induction of anaesthesia and then every 30 minutes until the end of surgery.

Monitoring core body temperature will aid in maintaining normothermia a growing body of evidence suggests that temperature monitoring and pre-warming activities help this process[9].

Preferred methods for measuring the core body temperature include:

- Esophageal probe.
- Urinary bladder catheter thermometer.
- Pulmonary artery catheter temperature reading.
- The temperature at non-invasive sites such as the nasopharynx, tympanum and temporal artery is close to core temperature, but unfortunately all these methods have limitations when used perioperatively[19].

Who benefits from patient warming?

Every surgical patient benefits from patient warming Certain groups at greater risk of hypothermia stand to benefit the most:

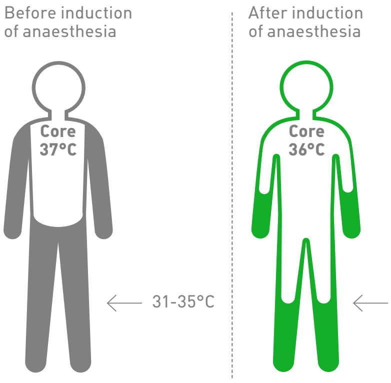
- The very young and the very old[20].
- Patients with medical conditions affecting thermoregulation such as stroke, Parkinson's disease, spinal cord injuries or burns[21].
- Trauma patients[21].

Pre-warming is key to prevention

Active pre-warming can be vital in preventing hypothermia by reducing the initial drop in core body temperature.

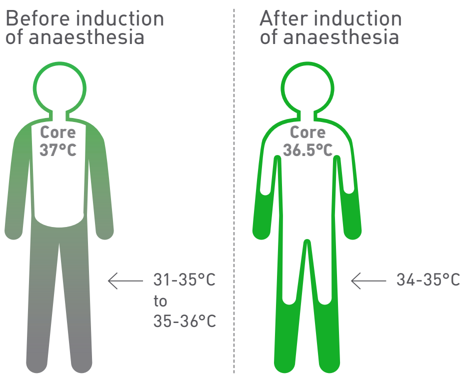
Without pre-warming

Without pre-warming, heat is redistributed from the core to the periphery of the body through asodilation. This lowers the core body temperature while increasing temperature in the periphery. The result is redistribution hypothermia.



With pre-warming

Patients with normal core body temperature of 37°C have a lower skin temperature of 31-35°C. Active pre-warming blankets can be used before surgery to prevent redistribution hypothermia. The blankets actively pre-warm mainly the periphery of the body. As a result, there is less heat redistribution from the core to the periphery of the body at the induction of anaesthesia.



Pre-warming reduces the drop of core body temperature caused by redistribution hypothermia[22]

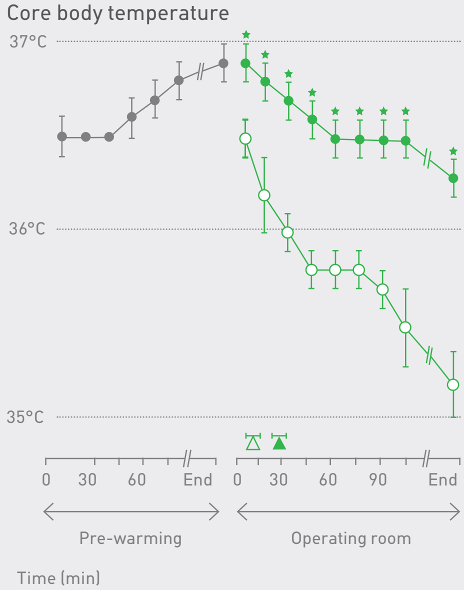
Evidence for pre-warming

A study showed that patients treated with pre-warming for a minimum of 90 minutes before surgery maintained a normothermic temperature (36.5°C) one hour after induction of anaesthesia[16].

The non pre-warmed control group became mildly hypothermic, losing 1.0-1.5°C in core body temperature.

At the end of surgery, the core body temperatures of the pre-warmed patients were stable and not hypothermic while those of the control group were just above 35°C. Other studies that have investigated the effects of pre-warming on perioperative core body temperature have found similar results[16,17,19].

Core body temperature



How patient temperature fluctuates with pre-warming and surgery[23]

Pre-warming

is an efficient way to avoid redistribution hypothermia

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