The elective re-warming of postoperative cardiac patients

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The elective re-warming of patients immediately after cardiac surgery is a core nursing procedure. Various methods can be used to perform the procedure including forced air-warming systems and radiant lights. This article discusses the evidence regarding the most efficacious method.

The elective re-warming of postoperative cardiac surgery patients is a simple core nursing procedure. It is undertaken immediately following an operation (Inwood, 2002) and it normally follows a designated protocol.

The current protocol in the cardiac intensive care unit at The Royal Wolverhampton NHS Trust dictates the use of a forced air-warming device. If a patient returns to the unit with a temperature of less than 35°C or 35–36°C with active bleeding, or complains of feeling cold, then this system is utilised. This aids re-warming through a convective heating system, creating a micro-environment around the patient by pumping air of varying temperatures into a specifically constructed blanket (Pathi et al, 1996).

The patient’s core temperature is monitored continually via a rectal probe and their peripheral temperature is monitored by a temperature probe attached to a big toe and by touch. Use of the forced air-warming system is discontinued when the patient’s core temperature reaches 36.5°C.

The protocol is simple but there is no rationale for its use or explanation of the most effective method of re-warming a patient. An investigation was therefore undertaken to establish best evidence for practice in re-warming postoperative cardiac patients.

Thermoregulation

Before evaluating the rationale for re-warming hypothermic patients, it is first necessary to review the body’s own heat producing mechanisms and how these affect normal physiology as well as the impact on the compromised cardiac patient (Fig 1).

The principal routes of heat loss include radiation, conduction, convection and evaporation. Radiation is the transfer of heat as infrared rays from a warmer object to a cooler one without physical contact. For example, the body loses heat to cooler objects such as ceilings, floors and walls. If these are at a higher temperature then the body absorbs the heat.

Conduction transfers body heat to a substance or object it is in contact with, such as a chair, clothing, air or water. At rest about three per cent of body heat is lost this way (Tortora and Grabowski, 1993). Convection is the transfer of heat by the movement of a liquid or gas between areas of differing temperature. When cool air makes contact with the body it becomes warmer and less dense. It is then carried away by convection currents as the less dense air rises. About 15 per cent of body heat is lost by convection and conduction. The contact of air or water with the body results in transfer of heat by both conduction and convection. The final route of heat loss from the body is evaporation, which under normal resting conditions accounts for approximately 22 per cent of heat loss (Tortora and Grabowski, 1993).

Surgery

Coronary artery bypass graft surgery is commonly performed using hypothermic cardiopulmonary bypass (CPB). In CPB intentional systemic hypothermia occurs with an open chest cavity and for part of this time the lungs are not ventilated and the heart is actively cooled separately. CPB provides myocardial and cerebral protection by decreasing metabolic demands and attenuating the detrimental effects of ischaemic tissue damage (Hossam et al, 2000a).

Heat exchange through the bypass circuit on CPB achieves dramatic cooling of the circulation and rapid temperature changes in the central core, but the peripheral compartment (muscle and fat) cools more slowly. Subsequently and before separation from CPB, rapid core warming to 37°C is achieved by warming the perfusate.

Despite the re-warming, residual hypothermia is common after CPB for a number of reasons. Heat redistributes from the blood and the warm vascular core to the cold peripheries, resulting in after-drop, where even with aggressive central and peripheral warming, there is ongoing heat loss after bypass from wound closure and transport time to the intensive care unit. General anaesthetics including opioids and barbiturates also affect thermoregulation by blocking afferent input, changing the setting point, or preventing efferent responses, either centrally or peripherally (Hossam et al, 2000b).
Residual hypothermia

Murakami (1995) suggests that patients aged 65 and over may experience more severe postoperative temperature drops and re-warming difficulties than younger patients.

Normal age-related physiological changes may predispose the older adult to thermoregulatory alterations. The ageing autonomic nervous system may contribute to a decreased shivering response, low resting peripheral flow, reduced vasomotor tone and decreased peripheral vascular reactivity to cold stimuli. Diminished muscle mass also leads to lower basal metabolic rate and heat production. Limited cardiovascular reserve, decreased cardiac output and impaired sweating ability may all alter heat production and conservation.

Undesired residual hypothermia – a temperature of less than 35°C – is common in this patient group (Inwood, 2002; Hossam et al, 2000a). The initial aim on return from theatre is therefore to help the patient to gain a normal body temperature of around 37°C.

Behavioural and physiological responses to hypothermia are undesirable in cardiac patients and may delay postoperative extubation in those on fast-track protocols (Villamaria et al, 1997). Inwood (2002) and Janke et al (1996) affirm that shivering, the body’s heat producing mechanism, should be intentionally abolished because as body movements increase the muscles become tense and energy is used to produce heat. Oxygen consumption can rise by 400–500 per cent.

The metabolic rate, carbon dioxide production and myocardial activity all increase. Shivering increases both the blood viscosity and the risk of disseminated intravascular coagulation and arterial oxygen saturation, mixed venous saturation and glycogen stores all decrease. It is recommended that shivering be abolished as soon as possible to avert increased metabolic demands and discomfort.

Hypothermia may also increase traumatic blood loss, since there is evidence of an association between hypothermia, trauma and abnormal bleeding. It is known that hypothermia prolongs prothrombin time and partial thromboplastin times and has an adverse effect on platelet function. Each fall in temperature by a degree is associated with a 15 per cent decrease in thromboxane B2.

REFERENCES


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which constricts blood vessels and aggregates platelets at bleeding sites.

Schmeid et al (1996) state that mild hypothermia is associated with multiple physiological derangements including coagulopathy. Inwood (2002) also states that hypothermia impairs hepatic and pancreatic function, reducing the release of insulin and uptake of glucose. It also increases serum glucose, resulting in circulating hyperglycaemia, but if insulin is administered while the patient is hypothermic, there can be a re-entry of glucose as normothermia is restored, resulting in hypoglycaemia.

Hossam et al (2000a) verify that hypothermia is also associated with an adrenergic response, which is manifested by increased norepinephrine, systemic vasoconstriction, hypertension, dysrhythmias and myocardial ischaemia.

Re-warming

Re-warming that occurs too rapidly can be equally detrimental, because acidosis that has accumulated in the stagnant blood in the periphery will return to the heart during re-warming.

A drop in pH occurs because of the sudden increase in lactic acid concentration, resulting in metabolic acidosis. Systemic acidosis depresses the functional activity of all organs. Inwood (2002) states that re-warming shock can occur if peripheral re-warming occurs before central warming promoting vasodilation. Cold, acidic blood is returned to the heart and increases myocardial depression. It may occur during re-warming if circulating volume is inadequate.

The evidence suggests that there is sufficient need to re-warm hypothermic patients following cardiac surgery, nevertheless it is equally pertinent that the most efficacious re-warming device is used.

Murakami (1995) states that there are a variety of re-warming methods (Table 1) including fluid-filled circulating blankets, warmed cotton blankets, radiant lights, heat shields and forced air-warming systems, which use conduction or radiation to minimise heat loss, replace heat and elevate body temperature. However, there is little or no evidence to show the importance of thermal management after coronary artery bypass surgery.

Evaluating the evidence

A search of databases including CINAHL and Medline yielded eight randomised controlled studies. Participants were aged 49 to 89 years and all had undergone cardiac surgery, in most cases coronary artery bypass grafting. None of the studies included emergency cases and all studies excluded patients who were considered high risk.

Harrison and Ponte (1996) investigated the effect of forced air-warming on nasopharyngeal and rectal temperatures in 20 patients following surgery. Using a space blanket and a forced air-warming device, they found that the air-warming system accelerated the rate of re-warming, not only of the skin but also of nasopharyngeal and rectal temperatures.

Conversely, Moors et al (1994) found that convective warming using the air-warming system after CPB did not accelerate the rate of warming the body core or the time to tracheal extubation.

Harrison and Ponte (1996) contend that the difference between their findings and Moors et al’s (1994) is in the use of vasodilators. They state that these may have caused cutaneous vasodilation, modifying the exchange of heat between the warming device and the patient. They also abolished any shivering with the use of drugs and state that studies that fail to accurately report the use of inotropes during recovery should be treated with caution due to the well-known thermogenic effects of catecholamines.

Pathi et al (1996) trialled three methods of re-warming patients after CPB. Patients were randomly allocated but not randomly sampled and warmed with a convective forced air-warming device, a conductive electric over-blanket or a space blanket. The air-warming device and electric blanket were found to be equally effective and better than the space blanket for increasing nasopharyngeal temperatures and reducing shivering. They also found

### Table 1. Methods of Patient Re-warming (Murakami, 1995)

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
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<tbody>
<tr>
<td>Active external re-warming methods</td>
<td>Fluid-filled circulating blankets, warmed cotton blankets, radiant heat shields, forced air warming systems</td>
</tr>
<tr>
<td>Passive external re-warming methods</td>
<td>Minimising direct contact with cold substances, applying reflective blankets or insulating material, covering the head, minimising drafts and increasing room temperature</td>
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**References**


that patients who were warmed actively reached extubation temperatures more quickly.

The idea that forced air-warming devices decrease shivering and rapidly increase skin-surface temperatures when compared with warm cotton blankets was tested by Mort et al (1996). They found that convection warming when compared with conductive warming with warmed blankets limited the incidence, duration and magnitude of shivering and that forced air therapy would not lead to excessive temperature changes.

Villamaria et al (1997) aimed to determine whether a forced air-warming system resulted in a faster rate of warming and improved outcomes compared with more conventional warming methods. Temperatures were recorded from the patient’s pulmonary artery catheter.

Although Pathi et al (1996) found that forced air-warming and electric blankets were equally effective in increasing temperature and Mort et al (1996) reported decreased shivering and increased peripheral temperature, neither detected a difference in core temperature between patients warmed with air devices and those warmed with blankets. Villamaria et al (1997) also concluded that forced air-warming did not increase the rate of core warming above that of standard techniques or result in an improvement in the clinical parameters measured (core temperature, length of ICU stay, blood loss, time on ventilator, major complications). However, they concluded that their study was limited by a small sample size (84, of whom 60 were randomised) and although adequate for comparing re-warming rates provided limited scope for detecting rare adverse clinical events.

However, in an open letter Ponte (1998) suggested that the studies by Villamaria et al (1997) may have differed substantially from their findings because of differing variables. There was no mention of the use of vasodilators or anaesthetic techniques or any reduced incidence of shivering in the studies. Ponte (1998) therefore disputed the findings and warned against dismissing the value of forced air-warming devices based on one study.

Janke et al (1996) compared the use of an electric under mattress with a forced air-warming device. The study measured oesophageal temperatures and found that the air device warmed faster than the electric under mattress, both centrally and peripherally. The air-warming device also warmed more patients to a core temperature of 37°C in four hours but did not reduce the time to extubation or alter important clinical aspects of postoperative care.

Hossam et al (2000b) undertook a trial to investigate whether forced air-warming or a circulating water mattress provided improved haemodynamic variables after coronary artery bypass grafts. They measured temperature via the tympanic membrane and concluded that aggressive cutaneous warming with a forced air-warmer is associated with higher mean body and mean skin temperature compared with a circulating water mattress. There was also a decreased requirement for vasodilatation therapy in patients when an air-warmer was used.

Finally Murakani (1995) compared the effects of two external re-warming methods – a fluid-filled circulating blanket and a reflective blanket – between two age groups. Potential patients were randomly assigned by age into either the active or passive re-warming method group. The study concluded that although the active external method was quicker both were effective in re-warming but contributed to different internal patterns of core re-warming.

**Limitations**

The study results may have been affected by performance bias due to the inability to ‘blind’ those initiating and receiving the care. Although the research consistently reveals that cardiac surgery patients returning to intensive care are frequently hyperthermic and at increased risk of adverse outcomes, evidence for alleviating these problems is scarce and contradictory and repeatedly refers to the same body of literature. It is apparent that there is no research to conclusively demonstrate the efficacy of a particular re-warming device. There are also so many variables within the studies that it is not feasible to analyse and compare findings. These include:

- Different warming devices;
- Different temperature measurement sites;
- Differing uses of inotropes and vasodilators;
- Differing importance placed on shivering and its cessation;
- Differing anaesthetic procedures;
- Differing cooling and re-warming temperatures before and after CPB.

There are also inconsistencies in terms of sampling and randomisation criteria. The studies have questionable external validity as Bowling (2003) confirms that this is reduced when easily accessible groups are used. In all of the studies the patients included are ‘stable’ elective theatre cases without complications, which is not representative of the population who undergo cardiac surgery.

A further limitation of the studies is that they rely on literature that is over 10 years old. The practices referred to may not be representative of modern methods (NHMRC, 2000).

**Implications for practice**

Upon completion of the review, it is now apparent that the evidence does not clarify the best method for re-warming patients. The evidence does, however, categorically demonstrate that there is sufficient need to re-warm hypothermic patients following cardiac surgery due to the severe side-effects of hypothermia.

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**REFERENCES**


