A Review of the Effects of Sedation on Thermoregulation: Insights for the Cardiac Catheterization Laboratory

Aaron Conway, BN (Hons), PhD, RN

Purpose: *To examine the effects that the sedative and analgesic medications commonly used in the cardiac catheterization laboratory have on thermoregulation.*
Design: *A structured review strategy was used.*
Methods: *MEDLINE and CINAHL were searched for published studies, and reference lists of retrieved studies were scrutinized for further studies. Data were extracted using a standardized extraction tool.*
Findings: *A total of nine studies examined the effect that sedative and analgesic medications have on thermoregulation. Midazolam has minimal impact on thermoregulation, whereas opioids, dexmedetomidine, and propofol markedly decrease vasoconstriction and shivering thresholds.*
Conclusions: *Patients who receive sedation in the cardiac catheterization laboratory may be at risk of hypothermia because of the use of medications that impair thermoregulation. Further research is required to identify the prevalence of unplanned hypothermia during sedation in the cardiac catheterization laboratory.*

Keywords: *hypothermia, sedation, cardiac, nursing, thermoregulation, review.*

HYPOTHERMIA INADVERTENTLY OCCURS in patients undergoing surgical procedures with general anesthesia when the strategies used to maintain normothermia are not sufficient to balance heat production with heat loss. This "unplanned" or "inadvertent" hypothermia is a common, yet preventable complication in the perioperative setting. It has been reported to occur in 50% to 90% of surgical patients.[1,2] Hypothermia is associated with increased risk of major adverse cardiac events, wound complications, thrombotic and hemorrhagic complications, and prolonged hospital stay.[3] The cardiac catheterization laboratory (CCL) is similar to the perioperative environment in that there is typically a low ambient room temperature, and procedures can be several hours in duration. Owing to these similarities, people undergoing procedures in the CCL may also be at risk of hypothermia. However, most procedures performed in the CCL use procedural sedation and analgesia as opposed to a full general anesthetic.[4] No studies to date have investigated whether or not unplanned hypothermia occurs in the CCL setting when sedation is used.

In an effort to provide recommendations for practice and future research regarding the prevention of unplanned hypothermia during sedation in the CCL, this review examines the effects of sedative and analgesic medications commonly used in the CCL setting on thermoregulation.

Aaron Conway, BN (Hons), PhD, RN, School of Nursing and Institute of Health and Biomedical Innovation, Queensland University of Technology, Brisbane, Queensland, Australia.

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Address correspondence to Aaron Conway, Institute of Health & Biomedical Innovation, Queensland University Technology, Kelvin Grove Campus, Kelvin Grove, Queensland 4059, Australia; e-mail address: aaron.conway@qut.edu.au.

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Background

Thermoregulation in Humans

In humans, metabolic functions deteriorate when core body temperature substantially deviates from normal.[3] In response to afferent thermal sensing, the hypothalamus triggers both behavioral and autonomic responses to maintain core body temperature between 36.5°C and 37.5°C.[5] The perception of thermal discomfort, which arises in response to changes in skin surface temperature, triggers specific behaviors that help to maintain core temperature within the normal range.[6] Such behaviors include reducing or increasing skin exposure or adjusting the ambient room temperature. In contrast, autonomic responses are provoked in response to input from not only the skin surface but also the abdominal and thoracic organs, spinal cord, hypothalamus, and other portions of the brain.[5,7,8] Autonomic responses are triggered when the core temperature either rises or falls below the interthreshold range, which is just 0.2°C.[5]

An increase in core temperature outside of the 0.2°C interthreshold range will trigger vasodilation and sweating. In a dry environment, sweating can dissipate more heat than is produced from the basal metabolic rate, resulting in a net heat loss.[2] Vasodilation of the thermoregulatory arteriovenous shunts, which are located in fingers and toes, facilitates transfer of heat from the core to the surface.[5] Small decreases in core temperature outside of the interthreshold range will trigger vasoconstriction, which reduces heat loss from convection and skin surface radiation.[5] Further decreases in the core temperature will provoke shivering. Shivering increases body temperature by at least doubling the metabolic rate.[2]

Unplanned Perioperative Hypothermia

As normothermia is classified as a core body temperature between 36.5°C and 37.5°C, the exact definition of hypothermia is 36.4°C.[5] In most clinical studies of unplanned perioperative hypothermia, however, core body temperature below 36°C has been used to diagnose hypothermic patients.[9] Although environmental factors, such as a low ambient room temperature, prolonged skin exposure, and infusion or irrigation using cold solutions, contribute to the development of hypothermia in the perioperative setting, they are not the main cause. Healthy volunteers placed in the perioperative environment maintain normothermia because their thermoregulatory mechanisms remain intact.[9] As such, unplanned perioperative hypothermia arises as a direct result of the administration of sedative, analgesic, and anesthetic medications that impair normal thermoregulatory mechanisms.[9]

The administration of sedative, analgesic, and anesthetic medications in the perioperative environment may lead to hypothermia because of several mechanisms. One mechanism is known as "core-to-peripheral heat redistribution."[9] The medications administered with sedation stimulate vasodilation of the thermoregulatory arteriovenous shunts, which results in a redistribution of heat from the core to the periphery.[1] Another mechanism by which the administration of sedative, analgesic, and anesthetic agents can decrease core body temperature is by decreasing the metabolic rate. Studies have shown that anesthetic agents reduce the metabolic rate by up to 40%.[10] An additional mechanism that contributes to the development of unplanned perioperative hypothermia is inhibition of autonomic responses to changes in core body temperature. The interthreshold range widens from 0.2°C to up to 4°C with the administration of anesthetic agents.[11] Consequently, autonomic thermoregulation responses, such as vasoconstriction and shivering will only be induced in response to much larger variations in core temperature than usual (Figure 1).[1]

Consequences of Unplanned Perioperative Hypothermia

Numerous harmful effects have been observed in patients who inadvertently develop hypothermia in the perioperative environment. Of particular concern is the evidence indicating that morbid cardiac events are more likely to occur in patients who become hypothermic.[12] In a randomized controlled trial of supplemental warming during abdominal, thoracic, or vascular surgery, it was found that reduction of core body temperature by 1.5°C tripled the rate of major adverse cardiac events.[12] Most patients undergoing procedures in the CCL are already at high risk of such complications.[13] Hypothermia has also been demonstrated