The Journal of Arthroplasty xxx (2017) 1–7

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Hypothermia in Total Joint Arthroplasty: A Wake-Up Call

Jordan B. Simpson, MD [a], Vijai S. Thomas, BS [b], Sabir K. Ismaily, BS [c], Pavel I. Muradov, MD [b], Philip C. Noble, PhD [c], Stephen J. Incavo, MD [b, *]

[a] Department of Orthopaedic Surgery and Rehabilitation, Texas Tech University Health Science Center, Lubbock, Texas
[b] Houston Methodist Orthopedics & Sports Medicine, Houston Methodist Hospital, Houston, Texas
[c] Institute of Orthopedic Research and Education, Houston, Texas

ARTICLE INFO

Article history:
Received 2 May 2017
Received in revised form
9 October 2017
Accepted 31 October 2017
Available online xxx

Level of Evidence:
III

Keywords:
total knee arthroplasty
total hip arthroplasty
perioperative hypothermia
hypothermic patients
normothermic patients
perioperative PH

ABSTRACT

Background: Total joint patients are particularly vulnerable to perioperative hypothermia (PH) (combined effects of anesthesia, radiation, and convective heat loss from exposed skin surfaces and cool temperatures in the operating room). There are limited studies on PH in these patients.
Methods: In a retrospective review of 204 patients undergoing primary hip and 179 undergoing primary knee replacement surgeries, time and temperature parameters were collected from the electronic health records from preoperative and postoperative recovery room nursing assessments, intraoperative anesthesia records, and floor nursing notes. Basic patient demographic data was recorded. Chi-squared and paired t-tests were used to compare between hypothermic and normothermic groups.
Results: At the time of incision, 60 of 179 (34%) total knee arthroplasty (TKA) patients and 80 of 204 (39%) total hip arthroplasty (THA) patients were hypothermic. In THA patients, 65% remained hypothermic for the duration of anesthesia compared to 33% of TKA patients. The largest drop in core body temperature in both THA and TKA patients occurred between preoperative holding and induction of anesthesia. In THA patients, spinal anesthesia had a significantly higher occurrence of PH. No significant patient factor was found to increase risk.
Conclusion: Emphasis on preoperative holding protocols, decreasing time from operating room entry to incision, and increasing ambient room temperature could reduce risk of hypothermia in total joint replacement patients.

Background

Core body temperature is highly regulated to maintain an average of 37°C by balancing heat gain and loss [1–3]. Hypothermia occurs when the body loses heat faster than heat can be produced. A change in core temperature of 3°C generally causes metabolic processes in the body to deteriorate [1–4]. In patients undergoing surgery, perioperative hypothermia (PH) can occur due to the inhibition of thermoregulation induced by anesthesia and heat loss associated with the patient's exposure to an environment maintained below normal skin temperature. Current literature establishes no clear consensus on the definition of hypothermia, which has been defined by temperatures ranging from 32°C to 36.5°C in studies across multiple specialties [5–10].

Rationale

In an era of increased accountability for outcomes in joint replacement surgery, modifiable factors such as PH have gained attention recently. Even with the renewed focus, PH continues to be a common issue occurring in 20%-90% of surgical cases across multiple specialties despite numerous described warming interventions [11–13]. Numerous studies in anesthesia, general surgery, trauma, and nursing literature document the increased incidence of adverse outcomes associated with hypothermia during the perioperative period [14–18]. Schmied et al associated mild hypothermia (≤35.0°C ± 0.5°C) with increased blood loss

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2017.10.057.

Each author certifies that he or she has no commercial associations that might pose a conflict of interest in connection with the submitted article. Institutional Review Board approval was obtained.

* Reprint requests: Stephen J. Incavo, MD, Houston Methodist Orthopedics & Sports Medicine, 6445 Main St., Outpatient Center, Suite 2500, Houston, TX 77030.

https://doi.org/10.1016/j.arth.2017.10.057
0883-5403/

(hypothermic 2.2 ± 0.5 L vs normothermic 1.7 ± 0.3 L, $P < .001$) as well as increased transfusion rates in total hip arthroplasty (THA) patients. In patients undergoing colorectal surgery, Kurz et al identified an increased risk of infection and delayed wound healing at temperatures <34.7°C ± 0.6°C. Other cited sequelae included morbid cardiac events, patient shivering and discomfort, prolonged stays in the postanesthetic unit, and prolonged hospital stay [5,19–26].

The total joint patient population is particularly vulnerable to hypothermia due to the combined effects of anesthesia, radiation, and convective heat loss from exposed skin surfaces, and cool temperatures in the operating room (OR). There are a limited number of studies looking at outcomes of PH in joint replacement patients, and no study has identified how often and at what point hypothermia occurs in primary total hip and total knee replacement surgeries [10,27–30].

Questions/Purposes

Therefore, the authors examined the core body temperature of joint replacement patients at our institution to answer the following questions: (1) What percentage of patients becomes hypothermic during the perioperative period of total hip and knee replacement procedures with warming treatments? (2) Is there a difference between the incidence and severity of hypothermia during total hip replacement and total knee replacement? (3) At which point in the perioperative process do joint replacement patients experience the greatest decrease in core body temperature? (4) Do any patient factors increase the risk of perioperative hypothermia?

Materials and Methods

After obtaining Institutional Review Board approval, a retrospective review was conducted of patients undergoing primary hip and primary total knee replacement surgery within our teaching institution. Patients with Current Procedural Terminology (CPT) codes for primary total knee arthroplasty (TKA) (27447) or THA (27130) procedures were identified from January 1, 2015 to October 31, 2015. These surgeries were performed by 11 different surgeons working in 14 ORs within a single hospital. Inclusion criteria included all patients over the age of 18 who had undergone a unilateral primary total hip or knee replacement. The authors excluded patients who (1) had an altered pre-existing metabolic state (ie, hyperthyroidism, hypothyroidism, hyperadrenalism, and hypoadrenalism) or (2) presented for surgery with a febrile illness (core temperature >37.5°C). A total of 383 patients (179 total knee and 204 total hip procedures) met the inclusion criteria for the study. Time and temperature parameters were collected from the electronic health record (EHR) from preoperative and postoperative recovery room nursing assessments, the intraoperative anesthesia record, and floor nursing notes. Basic demographic data relating to each patient, including their age, gender, body mass index (BMI), surgical blood loss, length of stay, and type of anesthetic agent administered, were also recorded from the EHR. OR temperature logs provided the average daily ambient room temperature within each OR. Patients with an incomplete time and temperature data set were excluded from the study.

Each patient's core body temperature was recorded at specific time points throughout the hospital encounter, from arrival at the preoperative holding area to recording of morning vitals on postoperative day 1. Body temperatures were recorded using 2 different thermometers: (1) a temporal artery thermometer (TAT-5000; Exergen, Watertown, MA) for recordings performed in the preoperative and postoperative holding areas and for any measurements performed within hospital wards, and (2) an esophageal probe thermometer (Covidien Mon-a-therm, Dublin, Ireland) for measurements performed by the anesthesiologist in the OR.

Prior to each operative procedure, each patient was placed in a warming gown (3M Bair Paws System, St. Paul, MN) and covered with warm blankets per the institution's total joint preoperative nursing protocol. In the preoperative holding area, the patient's temperature was recorded, and the patient was transferred to the OR. The patient's temperature was again recorded at the induction of anesthesia, the time of the skin incision, and the conclusion of anesthesia. These patients were anesthetized using either general anesthesia or spinal anesthesia as determined by the anesthetist. While under anesthesia the patient's core temperature was automatically recorded every 2 minutes. The time and temperature were also recorded at arrival to the postanesthesia care unit and from the morning vital signs from the inpatient ward on postoperative day 1.

If a patient was noted to be ≤36°C intraoperatively, nursing and anesthesia providers initiated active and passive warming protocols including the use of warm blankets, forced air warming, circulating water blankets, and warm intravenous fluids. The warming method varied depending on the anesthetist. Hypothermia in this study was defined by a core temperature of 35.5°C for any part of the procedure. We intentionally selected 35.5°C to prevent the inclusion of outlying healthy patients with low body temperatures from being included in the hypothermic cohort [31]. Throughout the remainder of this text, the term hypothermia will describe a temperature value of ≤35.5°C.

At the authors' institution heating, ventilation, and air conditioning technicians within the hospital maintenance department individually monitor and record the daily average temperature of each OR. The daily average temperature was sampled for 8 random weekdays in the ORs of interest over the period of this study. The mean daily OR temperature was 17.3°C ± 0.7°C (63.3°F ± 1.1°F).

Chi-squared and paired t-tests were used to compare between 179 TKA patients and 204 THA patients (ie, hypothermic knee vs normothermic knee, hypothermic hip vs normothermic hip, and hypothermic hip vs hypothermic knee).

Results

TKA was performed on 179 patients and THA on 204 for the 383 patients in this study. At the time of incision, 60 of 179 (34%) patients undergoing TKA were hypothermic. Seventeen of 179 (9%) of these TKA patients had a temperature of ≤35°C (Fig. 1). In patients undergoing THA at the time of incision, 80 of 204 (39%) were hypothermic. Twenty (10%) total hip patients had a temperature of ≤35° (Fig. 2).

On average, in TKA patients, the largest drop in the core body temperature was recorded between preoperative holding and the induction of anesthesia (−1.47°C ± 0.72°C) (Fig. 3). A similar drop was noted from preoperative holding to the time of incision (−1.28°C ± 0.48°C). The mean decrease in core body temperature from preoperative holding to incision (−1.28°C ± 0.48°C) in hypothermic patients was significant compared to normothermic TKA patients (−0.43°C ± 0.4°C), with a mean difference of −0.85°C ($P < .0001$). There was no significant difference between normothermic and hypothermic patients in terms of the decrease in core body temperature from the start of anesthesia to making the incision (mean difference 0.12, $P = .087$) (Fig. 4).

In hypothermic THA patients at the time of incision, the largest mean decrease in core body temperature from preoperative holding to incision (−1.31°C ± 0.36°C) was significant compared to normothermic THA patients (−0.53°C ± 0.52°C), with a mean