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The Role of Perioperative Hypothermia in the Development of Surgical Site Infection: A Systematic Review

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ABSTRACT

Surgical patients may experience inadvertent perioperative hypothermia, a condition that can cause a variety of complications, including surgical site infection (SSI). The authors of this systematic review used the Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols guidelines to examine the role of perioperative hypothermia in the development of SSI. The authors searched the PubMed, Cumulative Index Nursing and Allied Health Literature, Cochrane, and ScienceDirect databases for eligible articles published between January 2008 and November 2018 and identified seven studies that met the inclusion criteria. The results of this review indicate that the relationship between hypothermia and SSI is closely related to the type of the surgical intervention performed (eg, emergent, colorectal), and that severe hypothermia (eg, <35.0° C [95.0° F]) can increase the risk of developing an SSI. Perioperative nurses should monitor patients for inadvertent hypothermia and prevent its occurrence when possible.

Key words: *inadvertent hypothermia, surgical site infection, intraoperative nadir temperature, operative time, warming methods.*

Guidelines for safe surgical patient care include recommendations for maintaining normothermia during the perioperative period.[1,2] Although OR nurses and anesthesia professionals use various warming strategies (eg, forced-air warming, warm blankets, warmed IV fluids) during the perioperative period, some surgical patients experience *inadvertent hypothermia*[3] when their core body temperature drops below 36° C (96.8° F).[4,5] Researchers report various incidence rates, including

- 52.7% in patients who underwent shoulder arthroplasty;[6]
- 53.3% in patients who underwent orthopedic spinal surgery;[7]
- 64.9% in patients who underwent general, neurosurgical, orthopedic, spine, or vascular procedures resulting in Class I (clean) wounds;[8] and
- 77.2% in patients who underwent plastic surgery.[9]

The hypothalamus is the dominant thermoregulatory center.[10] Many general anesthetics impair normal *autonomic thermoregulatory control* (eg, vasoconstriction) and patients experience the redistribution of body temperature from the core to peripheral tissues.[11,12] Because anesthetized patients are unable to respond to temperature changes (eg, don additional clothing, change the environment), they rely on autonomic temperature control (eg, shivering, vasoconstriction) and perioperative personnel to manage external temperatures.[11] Although shivering can double metabolic heat production in adults, it is relatively ineffective when compared with other behaviors (eg, exercise) that can cause a five-fold increase in heat production. Volatile anesthetics (eg, isoflurane, sevoflurane) can inhibit the autonomic shivering response and thus prevent return to normothermia.[11] Some patients exhibit low-intensity, tremor-like muscle activity related to nonthermoregulative responses, and perioperative

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personnel should distinguish shivering from other types of involuntary muscle activity postoperatively.[13]

Inadvertent perioperative hypothermia can lead to many complications, including cardiac morbidity,[14,15] prolonged length of stay,[15] surgical site infection (SSI),[15] and increased blood loss.[3] Hypothermia also can adversely affect immune function and increase the risk of developing an SSI when subcutaneous vasoconstriction and subsequent tissue hypoxia disrupts neutrophil function.[16] The US Centers for Disease Control and Prevention (CDC) specifies criteria for SSI classification, including surveillance periods that vary from 30 to 90 days after surgical intervention depending on the type of SSI (ie, superficial incisional, deep incisional, organ/space).[17] Patients who develop an SSI can experience a prolonged hospital stay,[17,18] increased costs,[17] and perioperative morbidity[17] and mortality.[17,18] According to the World Health Organization's *Global Guidelines for the Prevention of Surgical Site Infection*[19] and the CDC's "Guideline for the prevention of surgical site infection, 2017,"[1] the risk of developing an SSI is closely associated with the type of surgical procedure and varies between 0.7% and 33%.[17] Statistics show that the SSI rates related to the type of surgery are 12.2% for elective segmental colectomy,[20] 6.8% for stoma reversal,[21] 4.6% for spinal injury (at 12 months),[22] 6.4% for total en bloc spondylectomy,[23] 2.1% for orthopedic surgery,[24] and 18% for elective colorectal surgery.[18]

Because perioperative hypothermia may affect the development of SSI, perioperative personnel should monitor patient temperatures throughout the perioperative period and address hypothermia.[25] The CDC recommends maintaining perioperative normothermia to prevent SSI and rates the recommendation as evidence level category IA.[1] Available guidelines include recommendations for measuring the patient's temperature[1,4,5] and using effective warming methods to promote normothermia during the perioperative period.[1,4,5,19]

However, the literature contains contradictory data on the association of perioperative hypothermia and the risk of SSI.[26] Although some researchers suggest that perioperative hypothermia is an important risk factor for SSI,[25,27,28] other researchers did not identify hypothermia as an independent risk factor for SSI development.[6,9,20,29] Some researchers did not include hypothermia when they examined the SSI risk factors.[23,30,31] The results of available hypothermia research also differ. Studies conducted more than 10 years ago suggest that hypothermia had no effect on the surgical wound–healing process during an emergent total aortic arch replacement[32] and that the risk of developing an SSI was lower in patients with a low body temperature who underwent bowel surgery.[33] However, the findings of a 2014 bibliographic study indicated that inadvertent hypothermia had a direct effect on surgical site healing and increased the incidence of infection in surgical incisions.[25] Therefore, the aim of this systematic review was to assess the available literature to determine whether there is an association between perioperative hypothermia and SSI.

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REVIEW METHODS AND SEARCH STRATEGY

We sought to answer the following question: *Is there a correlation between the incidence of perioperative hypothermia and the rate of SSI?* The review question was specified using the PICOS (population, intervention, comparison, outcome, and study design) framework.

Eligibility Criteria

The inclusion criteria comprised studies on adult patients, written in English, and with full text available. We specified the search terms *hypothermia*, *surgical site infection*, and *surgical wound infection* according to the PICOS components (P [surgery], I [hypothermia], O [surgical wound infections OR surgical site infection], and S [all studies except editorial letters, reviews, or systematic reviews]). We did not specifically search for articles comparing different types of warming interventions (C). We excluded editorial letters, reviews or systematic reviews, studies that were not directly related to the research topic, duplications, and articles that had been accepted but not yet published from the evaluation. Two independent reviewers (H.O.C. and S.U.) applied the inclusion-exclusion criteria and extracted the data from eligible studies by screening the titles, abstracts, and full-text articles.

Design and Search Strategy

We conducted this study in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis

Protocols (PRISMA-P) 2015 guidelines on reporting systematic reviews.[34] We conducted a systematic search to identify studies in several electronic databases (ie, PubMed, Cumulative Index Nursing and Allied Health Literature [CINAHL], Cochrane, ScienceDirect) between January 2008 and November 2018. We did not include *surgery* as a search term because SSI occurs in patients who have undergone surgery. After confirming the inclusion of the search terms in the Medical Subject Headings (MeSH) 2019, we determined the final version of the search was (*hypothermia* AND *surgical site infection*) OR (*hypothermia* AND *surgical wound infection*).

Study selection

We searched four databases to identify articles for inclusion in our review and identified 1,385 articles (Figure 1). After removing duplicate articles and studies that did not directly relate to the research topic, we evaluated the remaining articles. We excluded studies on pediatric patients, reviews, and articles that had been accepted but not yet published. As a result, seven articles met the specified criteria.[6,8,9,20,27-29]

Data extraction and synthesis

The two authors (H.O.C. and S.U.) independently extracted the results of the eligible studies using the data tool that we developed. The extracted data consisted of the author(s), year, country, type of center, study design, sample size, characteristics of participants, operative time, intraoperative *nadir* (ie, lowest) temperature, incidence of hypothermia, incidence of SSI, and primary outcomes.

Methodological quality appraisal

We used the Joanna Briggs Institute (JBI) critical appraisal tools[35] to assess the methodological quality of the studies.

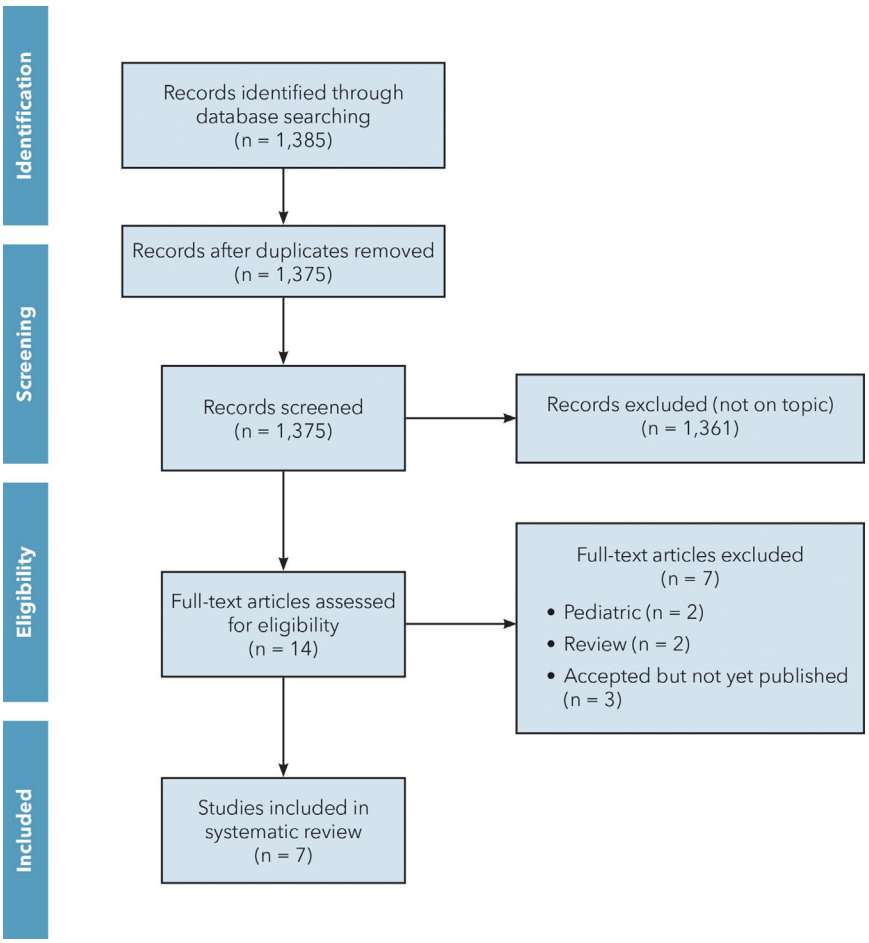

Figure 1. Flow diagram of literature search results. *Adapted from Moher D, Liberati A, Tetzlaff J, Altman DG; The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement*. PLoS Med. *2009;6(7):e1000097*. https://doi.org/10.1371/journal.pmed.1000097.

Two reviewers (H.O.C and M.Y.) independently analyzed the quality of the seven publications using the *JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies*[36] (8 items), *JBI Critical Appraisal Checklist for Case Control Studies*[37] (10 items), or *JBI Critical Appraisal Checklist for Cohort Studies*[38] (12 items) as appropriate for the specific type of research article. The authors discussed the assessment results to reach a consensus. The intraclass correlation coefficient that assesses interrater reliability was 0.95 for the two reviewers.

FINDINGS

Publication dates for the seven eligible studies ranged from 2012 to 2018 (Supplementary Table 1). With the exception of one prospective study in Japan,[29] the studies were conducted in the United States and had a retrospective design.[6,8,9,20,27,28] Most of the studies included patients who underwent a surgical procedure at a single center (ie, hospital) under general anesthesia[6,8,20,27,28] and included a variety of open procedures.[6,8,9,20,27,28] One group of researchers reviewed records from four surgical facilities[9] and another group of researchers studied emergent procedures.[27] The seven studies included a total of 7,746 participants; the number of participants in each study ranged from 170[28] to 3,628.[8] The mean age of the participants ranged from 30.9 (standard deviation [SD] = 12.4) years[27] to 69.0 (SD = 11.0) years.[6] Male participation exceeded 50% in four studies.[8,20,27,29]

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Operative Time

The operative time varied between a minimum of 1.5 hours[8] and a maximum of 10.3 hours.[28] In four studies, researchers considered the long duration of surgery to be a contributing factor for the development of SSI.[6,8,27,28] Tsuchida et al[29] provided data in a table that indicated prolonged length of surgery was a risk factor for SSI but did not discuss the relationship. However, Baucom et al[20] concluded that the operative time did not affect the development of SSI. Likewise, Constantine et al[9] indicated there was no relationship between operative time and SSI; however, this group of researchers only provided the average operative time without statistical analysis.

Perioperative Warming Methods

Researchers used a variety of active (eg, forced-air) and passive (eg, warm blankets) warming methods to prevent perioperative hypothermia. Active warming methods included forced-air warming devices,[6,20,27-29] and IV fluids or blood product warmers.[20,27-29] Passive warming methods consisted of using warm blankets,[28,29] increasing the OR temperature,[28,29] and wrapping the patient's extremities with pads according to the surgical position.[29]

Definition and Rate of Hypothermia

Researchers defined hypothermia as a body temperature <35.0° C (95.0° F),[27] <36.0° C (96.8° F),[6,8,20,28,29] or ≤36.0° C (96.8° F).[9] Eng et al defined hypothermia "as a recorded temperature less than 36.0° C [96.8° F] within the 30 minutes before or the 15 minutes immediately after anesthesia time."[28(p619)] Some researchers also classified hypothermia. For example, Tsuchida et al[29] classified hypothermia as mild (35.5° C to 35.9° C [95.9° F to 96.6° F]), moderate (35.0° to 35.4° C [95.0° F to 95.7° F]), or severe (<35.0° C [95.0° F]) and either early (ie, detection of the lowest temperature within two hours after the induction of anesthesia) or late nadir (ie, detection of the lowest temperature more than two hours after anesthesia induction). The authors found that of 528 patients, 358 (67.8%) developed mild hypothermia, 137 (25.9%) developed moderate hypothermia, and 33 (6.3%) developed severe hypothermia.[29]

Seamon et al[27] completed a cut-point analysis for patients undergoing a trauma laparotomy and identified that temperatures <35.0° C (95.0° F) were most likely to predict the development of postoperative SSI in this patient population. Brown et al[8] analyzed the nadir temperature in four different categories (≤34.9° C [94.8° F], 35.0° C to 35.4° C [95.0° F to 95.7° F], 35.5° C to 35.9° C [95.9° F to 96.6° F], and ≥36° C [96.8° F]) and found that 122 (11%) of 1,079 patients in the SSI group and 348 (14%) of 2,549 patients in the control group had a nadir temperature ≤34.9° C (94.8° F). The authors also found that 204 (19%) of patients in the SSI group and 526 (21%) of patients in the control group spent >75% of the intraoperative period in the hypothermic state (<36° C [96.8° F]).[8]

In studies evaluating the percentage of time at nadir temperature, Eng et al[28] determined the median value to be 7.8 (interquartile range = 4.5 to 13.6); Baucom et al[20]

identified the mean to be 4.9% (SD = 11.2) for the SSI group and 4.7% (SD = 10.7) for the non-SSI group. When reviewing all of the studies, we found that the incidence of hypothermia ranged from 9.5%[20] to 77.2%[9] and the rate of intraoperative nadir hypothermia ranged from 34.3° C (93.7° F)[20] to 35.7° C (96.3° F).[8] In addition, the incidence of early-nadir and late-nadir hypothermia was 23.7% and 13.8%, respectively.[29]

When reviewing all of the studies, we found that the incidence of hypothermia ranged from 9.5% to 77.2% and the rate of intraoperative nadir hypothermia ranged from 34.3° C (93.7° F) to 35.7° C (96.3° F).

Diagnosis and Rate of SSI

Researchers defined SSI as a superficial incisional,[6,8,27] a deep incisional,[6,8,27] or an organ/space[8,27,29] infection that developed within 30 days after surgery.[8,27] The incidence of SSI ranged from 5.02%[6] to 36.1%.[27] When we examined the studies that categorized SSI, we determined that SSI development was superficial incisional in 2.1%[6] to 17.6% of cases,[27] deep incisional in 0.6%[27] to 2.9% of cases,[6] and organ/space in 13.1%[29] to 15.8% of cases.[27]

Hypothermia and SSI

Findings from two studies showed that unintended perioperative hypothermia increased the risk of developing an SSI in some patient populations (ie, trauma laparotomy, cytoreductive surgery),[27,28] and three studies found no relationship between hypothermia and the risk of developing an SSI.[6,9,20] Tsuchida et al[29] found no significant difference in the incidence of SSI development between the patients with and without hypothermia, but severe and late nadir hypothermia increased the incidence of SSI. Brown et al[8] concluded that intraoperative hypothermia was not associated with SSI development but identified that higher intraoperative nadir temperature values were associated with SSI development.

Three of the four studies showing a relationship between hypothermia and SSI had high methodological quality scores,[8,27,29] and the quality score of the remaining study was medium.[28] The methodological quality scores of the three studies showing no correlation between hypothermia and SSI were medium.[7,9,20] We conclude that although hypothermia appears to have played a role in the development of SSI according to the patient population who underwent surgery, high intraoperative nadir hypothermia and severe and late nadir hypothermia also can have an important effect on the development of SSI.

Other Risk Factors

In addition to studying the effect of inadvertent hypothermia on SSI development, researchers identified patient characteristics that may be SSI risk factors, including age,[6,8,9,20,27-29] body mass index (BMI),[6,8,9,20,27,28] sex,[6,8,9,20,27,28] diabetes mellitus (DM),[8,9,20,28] and tobacco use[6,9,20,27,28] (Table 1). Some researchers also reported the effects of these risk factors on the development of hypothermia.[6,9,29] Some study results suggested that age,[27] BMI,[27] DM,[28] blood transfusion,[28] and tobacco use[27] were not associated with SSI development. However, Baucom et al[20] found that a five-point increase in BMI was a risk factor for the development of SSI. Additional study results showed that a lower BMI (ie, 29.8 kg/m^2 [SD = 6.3][6] or ≤18.5 kg/m^2 [29]), advanced age (ie, 70.3 (SD = 10.8)[6] or >65 years[29]), and male sex[6,29] were associated with an increased risk of hypothermia.

DISCUSSION

In this systematic review, we evaluated seven studies to determine the role of perioperative hypothermia in SSI development. Because the study designs differed, the methodological quality assessment forms also varied. The single prospective[29] and two retrospective case-control studies[8,27] we examined met all the assessment criteria, resulting in the highest quality scores. However, the retrospective cohort study[20] and three retrospective studies[6,9,28] did not meet all the assessment criteria, with scores ranging from 5 to 8.

The methodological quality assessment scores correlate with existing research study information. Study results or quality of evidence obtained in prospective studies are stronger than other nonexperimental designs.[39] An important disadvantage of retrospective studies is that participants may provide inaccurate information and records can be incomplete.[40] Researchers who apply a retrospective descriptive or cohort study design use past records

Table 1. Patient Demographics in the Systematic Review of Research on Inadvertent Hypothermia and Surgical Site Infection

Author (y)	Age, Mean (SD or range), y	BMI, Mean (SD or range), kg/m²	Sex, % male; % female	Diabetes Mellitus, %	Tobacco Use, %
Baucom et al[1] (2015)	61.8 (13.1)	28.9 (6.9)	51.7; 48	18.2	13.5[a]
Brown et al[2] (2017)	60[b] (47-72)[c] 60[b] (48-72)[d]	30[b] (25.9-35.5)[c] 28.7[b] (24.9-33.4)[d]	51; 49[c,d]	25.0[c] 18.0[d]	NC
Constantine et al[3] (2015)	50.4 (13.4)	27.8 (7.1)	17.8; 82.2	11.8	10.4
Eng et al[4] (2018)	54[b] (47-64)	25.7[b] (22.9-30.3)	31.2; 68.8	13.5	2.4[a]
Jildeh et al[5] (2018)	69.0 (11.0)[e] 70.3 (10.8)[f]	30.5 (6.4)[e] 29.8 (6.3)[f]	39.5; 60.4	NC	9.2[a]
Seamon et al[6] (2012)	30.2 (11.8)[c] 31.4 (12.7))[d]	28.6 (6.2)[c] 26.8 (5.6)[d]	89.7; 10.3	NC	38.7[c] 38.8[d]
Tsuchida et al[7] (2016)	61.2 (15.7)	NC	65.4; 34.6	NC	NC

SD = standard deviation; BMI = body mass index; NC = not clear (classified as underweight [BMI ≤ 18.5] and overweight [BMI > 25], but the averages are uncertain).
[a]Current smoker.
[b]Authors provided median.
[c]Surgical site infection group.
[d]Control (non–surgical site infection) group.
[e]All patients.
[f]Hypothermic patients.

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to identify an event.[41] In addition, the retrospective case-control research design can be more advantageous than descriptive cohort studies because the retrospective case-control studies reveal causality.

Patient and surgical factors such as age, alcohol abuse, blood loss, emergent procedures, duration of procedures, and anesthetic type are important risk factors for SSI development.[42] The available literature indicates that the incidence of SSI is greater during emergent procedures than it is during elective procedures.[42-44] In our review, researchers observed the highest incidence of SSI in patients undergoing emergent posttraumatic surgical interventions.[27] During emergent trauma laparotomies, contaminated open wounds, the critical state of the patient, and the inability to control factors such as blood loss or procedure duration may have led to SSI development.[45,46]

Although SSI can occur after clean surgical interventions,[4] the risk of SSI is higher in patients who are expected to have contaminated or dirty wounds in the gastrointestinal tract and those undergoing emergent surgery.[44] In a systematic review and meta-analysis of SSI epidemiology, 52.7% of the patients with dirty or infected wounds and 24.0% of patients with contaminated wounds were found

to develop an SSI.[47] The incidence of SSI was 8.8% after appendectomy[48] and 18.1% after elective colorectal surgery.[18] The studies we reviewed also showed that the SSI incidence was high in patients undergoing elective segmental colectomy[20] and gastrointestinal system surgery under general anesthesia.[29]

The results of studies on the effect of longer procedures on SSI development vary. Some researchers found that longer procedures increase the risk of SSI development,[42] especially in patients undergoing spine surgery[22,49] and open gastrectomy procedures.[50] However, procedure length did not have an effect on SSI in patients undergoing orthopedic[24] or elective colorectal surgery.[18] In the studies we reviewed, some indicated that a prolonged duration of surgery was a risk factor for SSI development;[6,8,27,28] however, one study revealed no effect of operative time on the development of SSI,[20] and the remaining two studies did not identify any specific relationship between operative time and SSI.[9,29] These differences may be related to variability in hospital conditions, the competence of the surgeon and surgical team members, patient population, sample size, and types of surgical procedures that researchers study.

Available guidelines recommend preventing perioperative hypothermia to help reduce the risk of developing an SSI.[1,4,5,19] Therefore, perioperative personnel should closely monitor a surgical patient's body temperature,[25,51,52] use active[25,51,52] or passive[25,52] warming methods during surgery, and administer warmed IV fluids or blood products to help maintain the patient's normal body temperature.[25,51,52] When researchers studied the effectiveness of active or passive warming methods, the results showed that the applications effectively reduced but did not eliminate perioperative hypothermia.[51,53,54] Researchers used active or passive warming methods, administered warmed IV solution or blood products, and monitored patient body temperature in all of the reviewed studies.[6,8,9,20,27-29] However, despite all these precautions, the researchers found hypothermia developed at a rate of 9.5%[22] to 77.2%.[9] Risk factors related to development of unintended perioperative hypothermia (eg, the cold environment of the OR, the infusion of cold solutions and blood during the procedure, duration of surgery) vary depending on the type of surgical intervention. Furthermore, it may be difficult to establish appropriate standard guidelines for each type of surgical intervention. As a result, the efforts and attempts of perioperative team members (eg, surgeon, nurse, anesthesiologist) to prevent hypothermia in different surgical specialties (eg, orthopedics, general surgery) may not be the same.

Researchers used active or passive warming methods, administered warmed IV solution or blood products, and monitored patient body temperature in all of the reviewed studies.

Because hypothermia can play a role in the development of SSI,[25] the guidelines on the prevention of SSI development recommend maintaining perioperative normothermia.[4,19] We recognize that the results of research on the relationship between unintended perioperative hypothermia and the development of SSI differ. Some study results indicated an association with SSI development;[27,28] others did not.[6,8,9,20,29] However, Tsuchida et al[29] reported that severe and late-nadir hypothermia were associated with SSI development. In addition, age greater than 65 years,[18] type of surgical intervention,[17] and duration of surgery[55] are independent risk factors for the development of SSI.

In studies reporting no association between hypothermia and SSI,[6,8,9,20,29] this finding may have been related to the shorter operative times (eg, mean of 3.1[6] to 3.6[20] hours) or the sample group consisting of patients undergoing plastic surgery[9] or shoulder arthroplasty.[6] Patients undergoing elective plastic surgery or shoulder arthroplasty may have a reduced risk of developing an SSI because of the elective nature of the procedure and higher probability of the wound remaining clean.

Patient-related risk factors, such as age, DM, obesity, tobacco use, alcohol use, and immunosuppression can play an important role in the development of SSI.[43] Norris et al[56] completed a systematic review on SSI incidence after knee fracture repair and noted that patients with a history of smoking, diabetes, or compartment syndrome are at greater risk for development of an SSI. This may be related to impaired microvascular blood flow and inadequate ability to transport antibiotics or necessary white blood cells to fight an infection. Wang et al[57] found that males, patients with DM or hypertension, and those with tobacco-use history had an increased incidence of SSI. Olowo-Okere et al[47] found that the incidence of SSI development

Key Takeaways

- Inadvertent hypothermia occurs when a patient's core body temperature drops below 36° C (96.8° F). Many general anesthetics impair normal autonomic thermoregulatory control (eg, vasoconstriction) and patients experience the redistribution of body temperature from the core to peripheral tissues.
- Inadvertent perioperative hypothermia can lead to many complications, including cardiac morbidity, prolonged length of stay, surgical site infection (SSI), and increased blood loss. Hypothermia can adversely affect immune function and lead to an SSI when subcutaneous vasoconstriction and subsequent tissue hypoxia disrupts neutrophil function.
- This systematic review of seven relevant studies sought to identify any correlation between the occurrence of perioperative hypothermia and the development of SSI.
- The results of the review showed an association between hypothermia and SSI during emergent procedures, colorectal procedures, and some longer procedures. Some studies showed that male sex, low body mass index, history of diabetes mellitus, and history of tobacco use were associated with hypothermia. A lack of prospective studies and heterogeneity of data collection limit interpretation of the results.

was elevated (eg, 18.6%) in patients older than 60 years. However, our systematic review included two studies that indicated age,[27,28] BMI,[27,28] presence of DM,[28] and tobacco use[27,28] were not associated with SSI development; and the lack of association may be related to a younger patient population,[27,28] lower BMI,[27,28] and lower incidence of DM[28] and tobacco use.[27,28]

LIMITATIONS

The results of this systematic review have several limitations. There was a small number (ie, seven) of studies, six of which had a retrospective design.[6,8,9,20,27,28] Some studies lacked a standardized protocol for measurement of intraoperative temperature,[6,27] did not test the reliability of the temperature measurement tools,[6] did not measure the hypothermia duration and the intraoperative temperature,[9] or evaluated different methods of warming the patient.[29] In addition, differences in sample sizes, patient groups, research designs, surgical interventions performed, emergent or elective nature of surgery, and duration of surgery of the reviewed studies may have affected conclusions related to the effect of risk factors on SSI development.

IMPLICATIONS FOR RESEARCH AND CLINICAL PRACTICE

We identified a limited number of studies that examined the role of hypothermia in the development of SSI in surgical patients, and most were retrospective cohort studies. Randomized controlled trials are needed to identify the role of hypothermia in the development of SSI for high-risk surgical procedures and patient groups. Perioperative nurses could use the results of additional research studies to identify specific risk factors for their patients that may lead to hypothermia and subsequent SSI development and provide nursing care to prevent adverse outcomes. Perioperative nurses play an important role in preventing patient complications and should participate in research on inadvertent hypothermia, closely monitor patients for hypothermia during the procedures, and apply warming measures to prevent inadvertent hypothermia.

CONCLUSION

Although a variety of recommendations to prevent perioperative hypothermia and SSI development exist, research indicates both conditions continue to occur. Researchers do not consider hypothermia to be a definitive risk factor in the development of SSI during some surgical interventions. However, the findings of this systematic review indicate that it may play a role in the development of SSI depending on the degree of hypothermia, type and duration of surgery, anesthetic type, and patient characteristics. Perioperative nurses should participate in research and patient care activities aimed at preventing unintended hypothermia.

SUPPORTING INFORMATION

Additional information may be found online in the supporting information tab for this article.

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