

# Correlation Between Intraoperative Hypothermia and Perioperative Morbidity in Patients With Head and Neck Cancer

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**Objective:** To determine if intraoperative hypothermia correlates with perioperative complications in patients undergoing head and neck surgery with regional or free flap reconstructions.

**Design:** Retrospective medical chart review.

**Setting:** Academic tertiary care hospital.

**Patients:** A sample of 136 patients who underwent ablative surgery for head and neck cancer and subsequently required reconstruction with free tissue or a regional flap in the last 10 years.

**Main Outcome Measures:** Rate of early (within 3 weeks of surgery) perioperative complications and its correlation with patient hypothermia (core body temperature,  $<35^{\circ}\text{C}$ ).

**Results:** There were 43 patients with complications. Two patients died. Complications included 10 partial or total flap losses, 9 hematomas, 8 episodes of pneumonia, 7 fis-

tulas, 7 wound infections, 5 wound breakdowns, and 2 cerebrospinal fluid leaks. Factors that did not correlate with complications included having received prior chemotherapy ( $P = .84$ ), having stage IV cancer ( $P = .16$ ), sex ( $P = .43$ ), tobacco use ( $P = .58$ ), prior radiotherapy ( $P = .30$ ), the presence of comorbidities ( $P = .43$ ), age ( $P = .27$ ), length of surgery ( $P = .63$ ), and the use of blood products perioperatively ( $P = .73$ ). Patients who were hypothermic had a significantly higher rate of complications than normothermic patients ( $P = .002$ ). Stepwise logistic regression analysis identified intraoperative hypothermia as a significant independent predictor for the development of early perioperative complications (odds ratio, 5.122; 95% confidence interval, 1.317-19.917).

**Conclusions:** Intraoperative hypothermia in head and neck surgery is correlated with perioperative complications. Maintaining normothermia through aggressive warming may decrease the incidence of perioperative morbidity for these patients.

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COMPLICATIONS FOLLOWING ablative head and neck surgery for cancer followed by regional or free flap reconstruction are common, resulting in patient morbidity,<sup>1</sup> increased length of hospital stay,<sup>1</sup> and cost.<sup>2,3</sup> Among the factors reported to influence perioperative morbidity are age, current tobacco use, comorbidities, excessive perioperative fluid administration, and preoperative hemoglobin level.<sup>2</sup> Although most factors such as age and comorbidities cannot be altered, identifying and eliminating factors that contribute to perioperative morbidity during surgery can lead to improved surgical outcomes.

Perioperative hypothermia with a drop in the core body temperature greater than  $2^{\circ}\text{C}$  below normal is often encountered during major surgery.<sup>4</sup> Some of the common factors that contribute to intraopera-

tive hypothermia are altered thermoregulation due to general anesthesia, altered body heat distribution, and exposure to the cold operating room environment.<sup>5-7</sup> A double-blinded randomized clinical trial involving patients undergoing abdominal surgery showed that patients assigned to routine intraoperative thermal care had increased incidence of wound infections, decreased healing, and prolonged hospital stay compared with a normothermic group who were aggressively warmed intraoperatively.<sup>8</sup> Other studies have shown increased blood loss, infections, and cardiac complications with intraoperative hypothermia.<sup>8-12</sup> A separate study not specific for head and neck surgery demonstrated decreased free flap survival in patients who were hypothermic intraoperatively, perhaps due to flap vasoconstriction.<sup>13</sup> Agrawal et al<sup>14</sup> showed that for general head and neck surgery

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without reconstruction, hypothermia was associated with delayed time to extubation, the development of neck seromas, and wound dehiscence.

Surgery involving head and neck reconstruction with regional or free tissue transfer is unique because multiple regions of the body are exposed for surgery. Therefore, the available surface area for active warming is decreased, and the area of exposed skin on the patient is greater than at single site surgery. Also, the operative time for head and neck ablative surgery followed by reconstruction is generally longer than other operations of the head and neck. The longer duration of anesthesia and exposure to cold places these patients at increased risk for experiencing intraoperative hypothermia. To examine the effects of intraoperative hypothermia in these patients, we performed a retrospective analysis of patients with head and neck cancer undergoing ablative surgery and regional or free flap reconstruction and tested the hypothesis that intraoperative hypothermia in this group of patients was associated with a greater incidence of perioperative complications.

## METHODS

This study was approved by the University of Texas Southwestern Medical Center Human Studies Committee. A total of 136 patients with the inclusion criterion, who were treated at the Department of Otolaryngology, University of Texas Southwestern Medical Center, Dallas, between 1997 and 2007, were identified. The inclusion criterion was any patient undergoing ablative surgery for head and neck tumors that required a regional or free flap for reconstruction. Preoperative variables that were recorded were age, sex, smoking history, tumor stage, and prior chemotherapy and radiotherapy. Perioperative variables that were studied were flap viability, perioperative complications, length of hospitalization, presence of comorbidities, operative time, use of blood products, mean intraoperative temperature, presence of intraoperative hypothermia, and the length of hypothermia. Hypothermia was defined as a core body temperature lower than 35°C. Temperatures were monitored via urinary catheter. Perioperative complications were defined as any complication occurring within 3 weeks of surgery. Infectious complications such as pneumonia, wound infections or other documented infections within the perioperative period, and local wound complications were also separately analyzed. Comorbidity was defined as any systemic condition that could potentially impact the perioperative course. The comorbidities included were hypertension, coronary artery disease, chronic obstructive pulmonary disease, diabetes, hypothyroidism, renal failure, hyperlipidemia, and cirrhosis.

All patients underwent active warming during surgery with forced air warmers and were covered with at least 1 layer of blankets and surgical drapes. Donor sites that were surgically prepared at the beginning of the procedure were covered with 1 layer of surgical drape. All patients received perioperative antibiotics. Intravenous fluids were room temperature and were not actively warmed. All patients received general anesthesia and endotracheal intubation. Vasoactive agents were not used. Postoperatively flaps were monitored by physical examination and Doppler flow detector. Patients received standard deep venous thrombosis prophylaxis with heparin, and free flap reconstruction patients were also administered 325 mg of aspirin per day.

The primary end point was the correlation of intraoperative hypothermia with perioperative complications. Other end points

**Table 1. Characteristics of Patients Who Experienced No Complications vs Patients With Perioperative Complications<sup>a</sup>**

Characteristic	No Complications (n=93)	Complications (n=43)	P Value
Age, y	57.5 (3.5)	61.0 (4.8)	.27
Length of surgery, h	10.3 (0.6)	10.6 (1.0)	.63
Time hypothermic, h	0.9 (0.4)	1.5 (0.8)	.19
Temperature, °C	36.1 (0.1)	35.9 (0.3)	.09

<sup>a</sup>Data are given as mean (SD) unless otherwise specified.

**Table 2. Other Patient Characteristics**

Characteristic	No Complications, No. (%)	Complications, No. (%)
Receiving preoperative chemotherapy	10 (11)	5 (12)
Receiving preoperative radiotherapy	70 (75)	28 (65)
Female	30 (32)	11 (26)
Tobacco users	56 (60)	24 (56)
With stage IV disease	59 (63)	32 (74)

included the correlation of other study variables with complications after surgery. Complications that were infectious or locally confined to the site of surgery were also studied separately.

For continuous variables, an unpaired *t* test was conducted to determine if rates of developing complications were associated with any of the study variables. A  $\chi^2$  test was used for binary variables including the presence or absence of any length of hypothermia. Stepwise logistic regression analysis was conducted to identify independent significant predictors of perioperative complications. Hypothermia was treated as a binary variable, either present or absent, for this analysis.

## RESULTS

The patients with complications were similar to the patients who did not have complications with respect to age, length of surgery, length of time they were hypothermic, and mean body temperature intraoperatively (**Table 1**). Other patient characteristics are given in **Table 2**. The most common pathologic condition was squamous cell carcinoma followed by sarcomas, adenocarcinomas, and other malignant neoplasms. There were 2 patients who had ameloblastomas.

There was no correlation in this group of patients between early perioperative complications and exposure to prior chemotherapy ( $P=.84$ ), having stage IV disease ( $P=.16$ ), sex ( $P=.43$ ), tobacco use ( $P=.58$ ), prior radiotherapy ( $P=.30$ ), the presence of any comorbidities ( $P=.43$ ), or requiring blood products during surgery ( $P=.73$ ). The presence of hypothermia, however, at any point during surgery was associated with perioperative complications ( $P=.002$ ) (**Table 3**).

Stepwise logistic regression analysis was conducted to identify independent significant predictors of perioperative complications. The following variables were used as independent variables: age, length of surgery, the length

**Table 3. The Number of Patients With the Characteristics Shown Who Developed Complications**

Characteristic	Patients With Complications, No. (%)	P Value <sup>a</sup>
Preoperative chemotherapy		
No (n=120)	37 (31)	.84
Yes (n=15)	5 (33)	
Hypothermia present		
No (n=119)	33 (28)	.002
Yes (n=15)	10 (67)	
Stage IV disease present		
No (n=32)	7 (22)	.16
Yes (n=91)	32 (35)	
Sex		
Female (n=41)	11 (27)	.43
Male (n=95)	32 (34)	
Tobacco user		
No (n=55)	19 (35)	.58
Yes (n=80)	24 (30)	
Preoperative radiotherapy		
No (n=37)	14 (38)	.30
Yes (n=98)	28 (29)	

<sup>a</sup>χ<sup>2</sup> Tests were conducted to investigate if the rates of developing complications are significantly different between 2 groups of patients.

**Table 4. The Odds Ratio of Developing Complications When Patients Were Hypothermic<sup>a</sup>**

	Odds Ratio (95% Confidence Interval) for Patients With Hypothermia	P Value
All complications	5.122 (1.317-19.917)	.02
Infectious and local wound complications	5.075 (1.363-18.896)	.02

<sup>a</sup>Stepwise logistic regression analysis was conducted to identify independent significant predictors of all complications and infectious and local wound complications. The other variables studied (age, length of surgery, time hypothermic, sex, tobacco use, presence of stage IV disease, previous radiotherapy, and previous chemotherapy) were not significant predictors of complications.

of time the patient was hypothermic intraoperatively, sex, tobacco use, presence or absence of stage IV disease, prior radiotherapy, prior chemotherapy, and the presence or absence of intraoperative hypothermia. For the last variable, hypothermia was treated as a binary variable that was either present or absent at any time during surgery.

The only independent factor to correlate with perioperative complications was the presence of hypothermia. Patients with hypothermia had a 5.1-times higher chance of developing complications compared with patients without intraoperative hypothermia (odds ratio, 5.122; 95% confidence interval, 1.317-19.917). When only local wound complications and infectious complications were analyzed, patients with hypothermia also had a greater than 5-times higher chance of developing local wound and infectious complications compared with patients without hypothermia (odds ratio, 5.075; 95% confidence interval, 1.363-18.896) (**Table 4**).

**Table 5. Early Perioperative Complications<sup>a</sup>**

Complication	No. of Complications
Partial or complete flap loss	10
Hematoma	9
Pneumonia	8
Fistula	7
Wound infection	7
Wound breakdown	5
Cerebrospinal fluid leak	2
Cardiac complications	2
Donor site breakdown	1
Deep venous thrombosis	1
Death	2

<sup>a</sup>Several patients had multiple complications.

Of 136 patients studied, 43 had perioperative complications. The most common complication was partial or complete flap loss followed by hematomas and infectious complications. The complications are listed in **Table 5**.

### COMMENT

It is well established that thermoregulation is disrupted during general anesthesia.<sup>6</sup> For example, while normal thermoregulation leads to shivering and vasoconstriction when the core body temperature falls 0.2°C, during general anesthesia this threshold is increased to 2°C to 4°C, leaving patients vulnerable to significant abnormal cooling.<sup>6</sup> The cold operating room environment, exposure of surgical wounds to cold room air, and the administration of room-temperature intravenous fluids also contribute to the cooling that patients can experience during surgery.

Many studies have investigated the detrimental effects of hypothermia during surgery.<sup>8,13,14</sup> These reported complications can include healing problems,<sup>8</sup> wound infections,<sup>14</sup> or failure of reconstructive flaps.<sup>13</sup> There are many potential mechanisms by which hypothermia can lead to these complications.

Local vasoconstriction may decrease blood flow to flaps used for reconstruction and inhibit the delivery of oxygen to the flap tissue. This can compromise local skin flaps as well as free tissue transfers used for larger reconstructions. Shivering postoperatively can also lead to increased oxygen consumption, further compromising oxygen delivery to the wound.<sup>15</sup> Local vasoconstriction by decreasing blood flow to the surgical site may also delay wound healing and increase the incidence of wound infection. In a randomized controlled trial involving open abdominal surgery, even mild hypothermia was shown to increase the incidence of wound infections and delay wound healing.<sup>8</sup> Another factor that may increase the incidence of wound infections is decreased cellular immunity due to hypothermia.<sup>16</sup>

Hypothermia is a known cause of coagulopathy and increased blood loss during surgery.<sup>17</sup> In the present study, there was an increased risk of bleeding complications including hematomas in patients who experienced hypothermia during surgery. Coagulopathy perioperatively not only may lead to complications related to bleeding such as hematoma but also may lead to an increased need

for blood transfusions.<sup>17</sup> Blood transfusion may in turn lead to further immunosuppression, placing the patients at increased risk for perioperative infections.<sup>18,19</sup> In this study, however, there was not a correlation between transfusion of blood intraoperatively and perioperative complications.

Consistent with evidence that general anesthesia can lead to altered thermoregulation, we observed that many of the hypothermic patients in this series experienced a large drop in body temperature right after the start of anesthesia (data not shown). The time of anesthesia induction when patients are most vulnerable to hypothermia from the anesthetic is also precisely the time when these patients are most often exposed for surgical preparation and positioning. We believe that this is a unique feature of multisite surgery and that the effects are multiplicative; eg, if the abdomen is being prepared for a rectus flap and the neck for a neck dissection, not only are these areas exposed, but also the intervening chest is more difficult to keep covered and actively warmed.

In this study, the mean temperatures between the patients who experienced complications and those who did not were not significantly different. Also, the length of hypothermia did not correlate with complications. However, we found that patients whose core temperatures fell below 35°C at any point during the surgery had a 5-fold increase in the rate of both infectious and overall complications. It may be that hypothermia at any point during surgery may lead to compromised immunity and coagulopathy independent of the length of time the patient is cold. This further emphasizes the importance of vigilance in maintaining normothermia during these operations, especially at the beginning of surgery when hypothermia is most likely.

We had some patients who were hypothermic during the operation rather than at the beginning (data not shown). The multiple regions of the body that are exposed surgically not only increase the cooling during regional and free flap surgery but also decreases the surface area available for active warming. Therefore, a patient who is normothermic in the beginning hours of a long operation may gradually cool as multiple surgical sites are exposed, and active warming limited to a relatively smaller surface area may not be able to stay abreast of the heat loss. Agrawal et al<sup>14</sup> also observed increased wound complications during head and neck surgery in patients who were hypothermic.<sup>14</sup> The duration of anesthesia in that study, however, was shorter than the 10 hours required for the average operation in the present study. Also, most of the patients studied by Agrawal et al<sup>14</sup> underwent parotidectomy or neck dissection—single site surgery that exposes a smaller area intraoperatively. Longer surgical time and more body surface exposure may place patients undergoing reconstructive procedures in addition to head and neck ablative surgery at greater risk for intraoperative hypothermia despite active warming. Agrawal et al<sup>14</sup> found that only 2 of 23 patients (8%) undergoing head and neck surgery who were actively warmed experienced core temperatures below 35°C. The rate of hypothermia for our study was 11% (15 of 136 patients), which is similar to the rate of 11.6% (5 of 38 patients) reported by Agrawal et al<sup>14</sup> for patients who were not actively warmed.

The other variables studied did not correlate with complications. A recent study found current smoking and American Society of Anesthesiology (ASA) class as well as preoperative radiotherapy to be predictors of morbidity following free flap surgery in the head and neck.<sup>2</sup> In the present study, we did not record ASA class but recorded comorbid conditions as being present or absent. Also, we did not distinguish between current and prior tobacco use. These methodological differences may explain the discrepancy in variables leading to morbidity. Studies that have looked at radiotherapy preoperatively have also had variable results regarding its impact on morbidity.<sup>20,21</sup>

In conclusion, intraoperative hypothermia increases the incidence of early perioperative complications in patients undergoing head and neck surgery with free or regional flap reconstruction. Although maintaining normothermia is relatively difficult owing to the longer average duration of these operations and the multiple surgical sites typically exposed, aggressive warming to maintain normal core body temperatures may reduce perioperative complications.

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**Author Contributions:** Dr Sumer had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Sumer and Truelson. *Acquisition of data:* Sumer. *Analysis and interpretation of data:* Sumer, Myers, and Leach. *Drafting of the manuscript:* Sumer. *Critical revision of the manuscript for important intellectual content:* Sumer, Myers, Leach, and Truelson. *Administrative, technical, and material support:* Sumer, Myers, and Leach.

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