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Thermal management and blood loss during hip arthroplasty

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Perioperative hypothermia is a common, but preventable complication of anaesthesia and surgery. Mild perioperative hypothermia increases the incidence of morbid myocardial outcomes, reduces resistance to surgical wound infections, and prolongs both postanaesthetic recovery and hospitalization. Hypothermia causes a coagulopathy due to inhibition of platelet function. In this short review, we will discuss three studies done in the last 6 years, which explored the influence of perioperative hypothermia and blood loss. All evaluated blood loss during hip arthroplasty and had similar methodologies. Two studies demonstrate that blood loss is increased, expecially during surgery, in hypotermic patients while a third study failed to identify any thermal influence on blood loss. The benefits of mantaining perioperative normothermia on blood loss thus remain unclear. We thus continue to recommend that surgical patients be kept normothermic.

Key words: **Hypotermia - Blood loss - Hip arthroplasty - Review**

Perioperative hypothermia is a common, but preventable complication of anesthesia and surgery.[1] Mild perioperative hypothermia increases the incidence of morbid myocardial outcomes,[2] reduces resistance to surgical wound infection,[3] and prolongs both postanesthetic recovery and hospitalization.[4] Hypothermia causes a coagulopathy due to inhibition of platelet function.[5] Defective thromboxane A_2 release, upregulation of platelet surface protein GMP-140, and downregulation of platelet glycoprotein Ib-IX complex seem to be the possible mechanism.[6]

In this short review, we will discuss three studies done in the last six years, which explored the influence of perioperative hypothermia on blood loss. All evaluated blood loss during hip arthroplasty and had similar methodologies.[7-9]

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Materials and methods

In 1996, Schmied *et al.* studied 60 hip arthroplasty patients (age 40-80 yr; ASA I-

TABLE I.—*Blood loss and allogeneic transfusion requirements in normothermic and hypothermic hip arthroplasty patients.*

Study		Normo-thermic	Hypo-thermic	Temperature Difference (°C)
Schmied *et al.*[7] *(general anesthesia):*				
—Intraoperative Blood Loss (ml)		690±230	920±400*	~1.5
—Total Blood Loss (ml)		1670±320	2150±550*	
—Allogeneic Blood (ml)		10±55	80±154*	
Johansson *et al.*[9] *(spinal anesthesia):*				
—Intraoperative Blood Loss (ml)	Visual method	698±314	665±292	~0.8
	Hb-method	662±319	657±348	
—Total Blood Loss (ml)	Hb-method	1066±441	1047±413	
	Balance method	1674±646	1507±652	
Winkler *et al.*[8] *(combined epidural-spinal anesthesia):*				
—Intraoperative Blood Loss (ml)		488 (368-721)	618* (480-864)	~0.5
—Total Blood Loss (ml)		1531 (1055-1746)	1678* (1366-1965)	
—Allogeneic Blood (ml)		289±408	401±470	

Blood-loss data are presented as means ± SD or medians (interquartile ranges). One unit of allogeneic blood equals roughly 350 ml of packed red-blood cells. * Significantly different from normothermic group, $p < 0.05$.

III) to test the hypothesis that intraoperative normothermia reduces blood loss and allogeneic blood requirements in patients undergoing total hip arthroplasty under general anesthesia.[7] Patients were randomly assigned to *normothermia* (T_{core} of 36.6±0.4°C) or mild *hypothermia* (T_{core} of 35.0±0.5°C). Crystalloid (10 $ml \cdot kg^{-1} \cdot h^{-1}$), colloid, scavenged red cells, and allogeneic blood were administered by a strict protocol. The first 500 ml estimated blood loss was replaced with additional crystalloid at a ratio of 3 ml/ml blood loss. The second 500 ml blood loss was replaced with heta-starch at a ratio of 1 ml/ml blood loss. Active skin (forced-air) and fluid warming were used to maintain normothermia in that group. Target hematocrit approach -depending on the age and heart disease history- was used to standardize transfusion requirements.

In 1999, Johansson *et al.* studied primary prosthetic hip arthroplasty patients, under spinal anesthesia.[9] Patients were randomized to the operative procedure with (n=25) or without (n=25) forced air warming. Core temperature was again measured from the tympanic membrane. Blood loss was calculated by three different methods; 1) intraoperative loss was estimated visually; 2) losses during and after operation were obtained by determination of lost hemoglobin (Hb-method); and 3) blood loss during hospital stay was calculated from the hemoglobin balance.

Finally, in 2000, Winkler *et al.* studied 150 ASA I-III patients undergoing primary hip arthroplasty. Their protocol was similar to that used by Schmied *et al.*,[7] other than using combined epidural-spinal anesthesia and their randomization groups. The authors compared the effects of aggressive warming with a conventional warming approach, which brought mean core temperatures to about 36.5 and 36.1°C, respectively. Otherwise, blood loss calculation and fluid and blood transfusion methodologies were similar to Schmied *et al.*'s study.

Results

In Schmied *et al.*'s study, by design, final intraoperative T_{core} was approximately

1.5°C warmer in patients assigned to extra warming. Two hours postoperatively, T_{core} remained significantly cooler in the unwarmed patients. Blood loss was significantly greater in the hypothermic patients at the end of surgery and at 3, 12, and 24 hours after surgery. Eight units of allogeneic packed red cells were required in seven of the 30 hypothermic patients, whereas only one normothermic patient required a unit of allogeneic blood ($p<0.05$). Most blood loss occurred after surgery, and all allogeneic blood was given postoperatively (Table I).

In the Johansson *et al.* study, in controls, core temperature decreased by 1.3±0.6°C (mean±SD) and in the warmed patients by only 0.5±0.4°C ($p<0.0001$). Preoperative variables and the number of allogeneic units transfused did not differ between the groups. Intraoperative blood loss and external losses during the entire hospital stay did not differ between groups, regardless of method used to measure blood loss (Table I). There was no covariation between blood loss and the decrease in core temperature.

In Winkler *et al.*'s study,[8] intraoperative mean arterial pressure was significantly less in the aggressive warming than conventional warming group: 80±9 *vs* 86±12 mmHg ($p<0.001$); this could have contributed to the results. By design, average intraoperative core temperatures were approximately 0.5°C warmer in the patients assigned to aggressive warming (36.5±0.3 *vs* 36.1±0.3°C, $p<0.001$). Mean skin temperature was nearly 1°C higher in the aggressive warming group (33.2±1.2 *vs* 32.4±1.1°C, $p=0.015$). Intraoperative blood loss and total blood loss over the first two postoperative days were significantly greater in the conventional warming than the aggressive warming group (Table I).

Discussion and conclusions

Despite ample evidence that mild hypothermia (decrease of only 1.4-1.9°C) provokes numerous adverse outcomes, the definition of intraoperative normothermia remains controversial. Normal body temperature averages 37°C and is rarely less than 36.5°C.[10] The normothermic or aggressively warmed groups of all the discussed studies have similar intraoperative mean and end-of-surgery core temperatures. Schmied *et al.*'s study suggested a relationship between core temperature and intraoperative blood loss, while intraoperative blood loss in Winkler *et al.*'s study was not altered by core temperature. However, Johansson *et al.*'s study — in which core temperature difference was only 0.8°C — did not show differences in intraoperative and total postoperative blood losses in the conventionally and aggressively warmed groups.

In conclusion, two studies demonstrate that blood loss is increased, especially during surgery, in hypothermic patients while a third study failed to identify any thermal influence on blood loss. The benefits of maintaining perioperative normothermia on blood loss thus remain unclear. However, it is well established that perioperative hypothermia also increases perioperative cardiac morbid events,[2] surgical wound infections,[3] and prolongs both postanesthetic recovery and hospitalization.[4] We thus continue to recommend that surgical patients be kept normothermic.

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Riassunto

Gestione della temperatura e perdite di sangue durante l'artroplastica dell'anca

L'ipotermia perioperatoria è una comune, ma prevedibile complicanza dell'anestesia e della chirurgia. Una lieve ipotermia perioperatoria aumenta l'incidenza della morbilità miocardica, riduce le resistenze alle infezioni chirurgiche e prolunga il recupero da anestesia che l'ospedalizzazione. L'ipotermia causa una coagulopatia dovuta all'inibizione della funzionalità delle piastrine.

In questa breve review vengono discussi tre studi condotti negli ultimi sei anni che hanno indagato l'influenza dell'ipotermia perioperatoria sulle perdi-

te ematiche. Tutti hanno valutato le perdite ematiche durante intervento di artroplastica dell'anca e hanno utilizzando una metodologia simile.

Due studi dimostrano un aumento delle perdite ematica, specialmente durante la procedura chirurgica, nei pazienti ipotermici, mentre il terzo studio non ha rilevato un'influenza della temperatura corporea sulle perdite ematiche. I benefici della normotermia nel periodo perioperatorio rimangono quindi da chiarire. Continuiamo quindi a raccomandare di mantenere i pazienti normotermici.

Parole chiave: Ipotermia - Perdite ematiche - Artroprotesi dell'anca - Review.

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