Hemostatic effect of hot saline irrigation during functional endoscopic sinus surgery: a randomized controlled trial

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Background: **The endoscopically magnified operative field in functional endoscopic sinus surgery (FESS) makes even a small amount of bleeding a potentially significant hindrance. It is thought that irrigation with hot saline during surgery may improve surgical field of view by producing a hemostatic effect. Our objective was to assess the effectiveness of hot saline irrigation (HSI) compared to room temperature saline irrigation (RTSI) in the control of intraoperative bleeding during FESS.**

Methods: **Sixty-two chronic rhinosinusitis (CRS) patients undergoing FESS were randomized to 2 treatment arms in an equal ratio. Subjects received either HSI (49°C) or RTSI (18°C), 20 mL every 10 minutes, for the duration of FESS. The Boezaart endoscopic field of view grading system was the primary outcome measure. Boezaart score, heart rate, and mean arterial blood pressure (MABP) were recorded at 10-minute intervals between irrigations.**

Results: **Mean endoscopic surgical field of view (Boezaart score) did not significantly differ between the HSI and RTSI groups (1.5 ± 0.6 vs 1.3 ± 0.5; $p = 0.23$). However, when FESS was longer than 2 hours in duration, the Boezaart scores were significantly better in the HSI group (1.6 ± 0.6 vs 1.2 ± 0.4; $p = 0.04$). We found that blood loss per minute was significantly reduced ($p = 0.02$) in all cases in which HSI was used (2.3 ± 1.0) compared to RTSI (1.7 ± 1.1). Despite this, heart rate ($p = 0.32$) and MABP ($p = 0.14$) did not significantly differ between treatment groups.**

Conclusion: **HSI may be beneficial in improving surgical field of view in FESS after 2 hours of operating time. A significant reduction in rate of blood loss may be attained with HSI.**

Key Words:
endoscopic sinus surgery; hemostasis; intraoperative blood loss; irrigation; surgical field of view

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The introduction of nasal endoscopes over 30 years ago paved the way for functional endoscopic sinus surgery (FESS) to become the primary surgical modality used to treat chronic rhinosinusitis (CRS). It possesses clear advantages over conventional sinonasal surgery that cannot be disputed. These comprise minimal morbidity to sinonasal mucosa, avoidance of facial scars, meticulous technique, superior visualization, a decreased incidence of complications, and better outcomes, as well as shortened recovery and hospital stay.[1,2] However, one of the main obstacles in performing FESS is intraoperative bleeding. A slight increase in bleeding can significantly hinder endoscopic visualization of the sinonasal cavity, potentially leading to an increased risk of major complications.

Perioperative optimization of patients has been shown to be a significant factor that could influence intraoperative bleeding during FESS. Numerous preoperative and intraoperative measures have proven their efficacy in reducing intraoperative bleeding. These mainly include preoperative corticosteroid use,[3,4] controlled hypotension,[5–9] the reverse Trendelenburg position (RTP),[10–12] topical and injectable vasoconstrictors,[13–15] and novel topical hemostatic biomaterials.[16,17]

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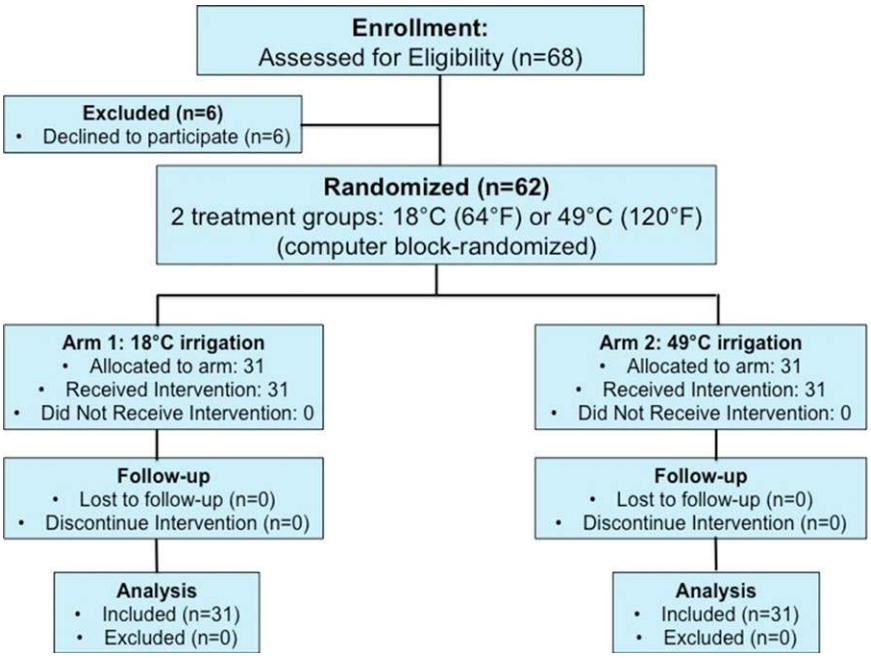

FIGURE 1. Flow diagram depicting the pathway of participants through this randomized controlled trial.

Another method of intraoperative control of bleeding that is widely used in endoscopic skull base and neurosurgical procedures is hot water or saline irrigation. However, the intraoperative hemostatic effect of hot water or saline irrigation in these surgical fields has never been studied. ESS is often a prerequisite to endoscopic skull-base procedures. Hence in this study, our aim was to assess the effectiveness of hot saline irrigation (HSI) compared to room temperature saline irrigation (RTSI) in the control of intraoperative bleeding during FESS.

Patients and methods

Study design

This study was designed as a double-blind randomized controlled trial (RCT) in which the objective was to assess the effect of saline irrigation temperature on intraoperative blood loss and endoscopic field of view during FESS.

Patient population

Patients were recruited from the St. Paul's Sinus Centre, a tertiary rhinology centre in Vancouver, Canada, from February 2013 to January 2014 (Fig. 1). The trial was conducted with ethics approval from the University of British Columbia Clinical Research Ethics Board (H12-02993) and registered as an institutionally funded clinical trial (www.clinicaltrials.gov; NCT01717274). The following inclusion and exclusion criteria were used to determine if a patient was eligible for enrolment into this study:

Inclusion criteria:

1. Patients at least 19 years old and above;
2. Patients with American Society of Anesthesiologist (ASA) classification less than II;
3. Patients with chronic or recurrent rhinosinusitis (as defined by the Canadian Practice Guidelines for CRS[18]) with or without nasal polyposis who were refractory to medical treatment.

Exclusion criteria:

1. Patients with severe ischemic heart disease (IHD), pulmonary disease, or renal disease;
2. Patients with coagulation or bleeding disorders;
3. Patients with tumors or vascular anomalies;
4. Patients with cystic fibrosis, allergic fungal sinusitis, or Wegener's granulomatosis;
5. Patients who are unable to speak, read, and write English.

Study protocol

Preoperative

All patients scheduled for FESS underwent a preoperative computed tomography (CT) scan. As a routine practice at our center, all patients were treated with a 1-week course of prednisolone (20 mg once per day) and oral antibiotics Clavulin (GlaxoSmithKline Inc., Ontario, Canada: 875 mg twice per day) prior to surgical intervention. Patients with known penicillin sensitivity were given Clindamycin (300 mg 3 times per day) as an alternative to Clavulin. Sixty-two patients were randomized in an equal ratio to each study arm (18°C or 49°C saline irrigation), based on a closed-envelope system. Thirty-one patients were allocated to each study arm. The patients were unaware of the temperature of saline irrigation they would receive during surgery.

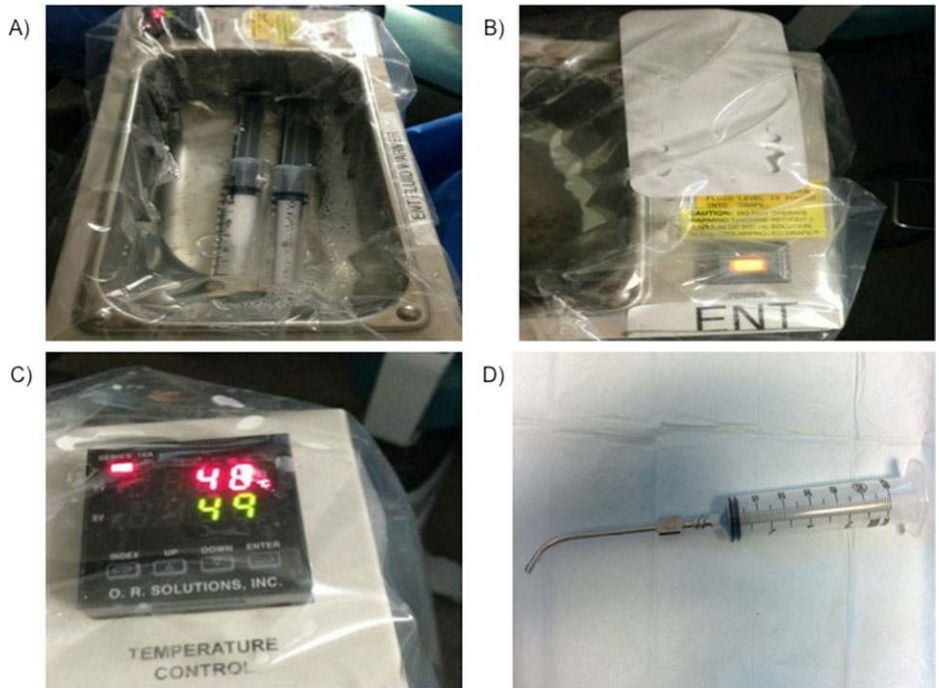

FIGURE 2. Operating room setup of fluid warming system. (A) A sterile, single-use polyurethane drape conforms to the body of the 6-L fluid warmer basin. Sixty-milliliter (60 mL) Toomey syringes are used to withdraw saline when irrigation is required. (B) Screen cover over the digital temperature reading maintains blinding for the operating surgeon. (C) The digital thermometer regulates fluid temperature within ±2°C of the set point. (Top row temperature: actual temperature of the fluid as measured by the warmer; Bottom row temperature: preset temperature of the warmer). (D) An olive-tip suction attached to the syringe is used during sinonasal irrigation.

Intraoperative

Patients were induced under general anesthesia with intravenous propofol. Anesthesia was maintained with inhaled desflurane and an intravenous infusion of remifentanil and propofol. The anesthetists were asked to keep the patients' mean arterial blood pressure (MABP) at about 75 mmHG during the procedure as a routine measure of reducing intraoperative blood loss. Once under general anesthesia, patients were intubated with an endotracheal tube. Following endotracheal intubation, both nasal cavities were packed with neuro-patties soaked with Otrivin (Novartis OTC, Quebec, Canada) (Xylometazolin 0.05%). A 10-cm Merocel surgical sponge was cut to one-third of its normal size and inserted into the back of the nasopharynx to prevent blood from flowing into the oropharynx and larynx. An artery forceps was clipped to the Merocel string to prevent dislodgement of the Merocel into the larynx or oropharynx. Patients were positioned in RTP, with their heads elevated 15 degrees above the horizontal axis of the operating table.

A medical-grade fluid warmer (ORS Fluid Warming System, Microtek Medical Inc, Columbus, MS) was used to maintain the temperature of the saline irrigation solution within ±2°C of the set point. Factory settings restricted this set point to a range between room temperature and 49°C (Fig. 2). The ambient temperature of the operating room was consistently kept at 18°C; thus, this was defined as the lower threshold of the temperature range ("room temperature"). The 6-L basin of the fluid warmer was lined with a single-use polyurethane drape according to manufacturer's instructions (ORS Fluid Warming Drapes, Microtek Medical Inc.) and filled with 2 L of normal saline (0.09% NaCl) solution. An external thermometer was placed in the basin to confirm that the temperature of the saline solution was within the accepted range (±2°C of set point). The fluid warmer was positioned behind the operating surgeon and managed by the circulating operating room (OR) nurse. Prior to the arrival of the operating surgeon, the circulating OR nurse adjusted the temperature of the warmer based on the treatment allocation card (indicating 18°C or 49°C saline) handed to them by a designated research assistant. The digital temperature display was concealed during surgery to maintain blinding for the operating surgeon. The surgical field was first irrigated with 20 mL of saline by the OR nurse 5 minutes after the commencement of sinus surgery, and again every 10 minutes until the end of surgery. For each saline irrigation, a 60-mL syringe attached to an olive-tip long-curved suction was used to draw up 20 mL of saline from the warmer. During each irrigation, the endoscope was placed in the nasal cavity to provide visual confirmation that the irrigation fluid was in contact with the sinus cavities. To ensure blinding of the operating surgeon to the temperature of the saline used, a Microdebrider (ENT 4.0-mm Tricut Blade; Medtronic, Minneapolis, MN) was used to suction the nasal cavity during the saline irrigations. An additional lavage could be performed between

procedural 10-minute intervals at the request of the operating surgeon.

The senior author (A.R.J.) and the rhinology fellows (E.C.G. and S.A.) performed all surgeries. FESS was performed with computer image guidance and using the Messerklinger technique (as described in Kennedy in 1985).[19] The Microdebrider (ENT 4.0-mm Tricut Blade) was used in all cases. The extent of the operation was based on the clinical symptoms and severity of the disease seen on the preoperative CT scan of the paranasal sinus. If there was a significant deviated nasal septum, an endoscopic septoplasty was performed. Epinephrine injections and topical epinephrine or cocaine neuro-patties were not used before or during surgery.

Assessment

The operating surgeon scored the degree of bleeding in the surgical field using the validated Boezaart and van der Merwe Grading System.[5] This is a scale from 0 to 5 that was used to outline the amount of suction required to rid the area of blood that obstructs the visual field. A score of 0 was given for an area with no bleeding, 1 for slight bleeding with no suction required, 2 for slight bleeding requiring suction, 3 for moderate bleeding that improves for several seconds once suction has occurred, 4 for moderate bleeding that restarts directly after suctioning, and 5 for severe bleeding that occurs faster than can be removed. The Boezaart score (BS), the systolic and diastolic blood pressures, heart rate, MABP, and site of surgery (sinuses or septum) were recorded every 10 minutes for the duration of the surgery. At the end of the procedure, total blood loss (TBL) was calculated by subtracting the total amount of irrigation fluid used from the fluid in the suction output container. The average blood loss per minute (mL/minute) was calculated by dividing the TBL (mL) by the duration of surgery (minutes). Boezaart scores and secondary outcomes were recorded at staggered 10-minute intervals with procedural saline irrigations so as to leave a 5-minute buffer between the processes. The endoscopic field of view (BS) was assessed by the operating surgeon. Whenever possible, a second non-operating surgeon contributes to the average BS to minimize experimental error that may result from the subjective nature of this assessment.

Baseline characteristics and outcome measures

Baseline characteristics were recorded for each subject and included: age (years), gender, history of sinus surgery, Lund-Mackay (LM) CT score (0 to 24), nasal polyposis, and requirement of nasal septal reconstruction or submucosal resection of inferior turbinate (SMRIT). The primary outcome of this clinical trial was the Boezaart scoring system (0–5). Secondary outcomes included total blood loss (mL), operating time (minutes), blood loss per minute (mL/minutes), heart rate (beats/minute), and mean arterial blood pressure (mmHg). Blood loss per minute was defined as total blood loss divided by total operating time. The incidence of complications during surgery was also documented.

Sample size

An a priori sample size calculation was completed to determine the number of subjects required to evaluate a significant difference in BS between surgical cases receiving 18°C vs 49°C saline irrigation. From previous research at our centre, the mean BS for cases receiving 18°C saline irrigation was 2.3 ± 0.7.[11] We hypothesized that the use of 49°C saline irrigation would reduce BS by 20%. Using this effect size, Type I error of 5% and Type II of 20%, a total of 62 patients (31 per arm) were required for this randomized controlled trial.

Statistical analysis

All outcome variables were considered as continuous. Explanatory variables such as age and Lund-Mackay CT score were considered continuous and all remaining explanatory variables were considered categorical. An intention-to-treat protocol was used for the statistical analysis. Subjects who withdrew, violated study protocol, or were lost to follow-up were categorized as treatment failures and included in the final analysis. Baseline characteristics of study participants were compared between treatment groups to evaluate comparability of randomization. Descriptive statistics of mean, standard deviation, frequency, and absolute proportions were used to summarize outcome and explanatory characteristics. Pearson's correlations were used to examine the linear relationship between outcome and explanatory data. Bivariate comparisons of the primary and secondary outcomes by treatment group were commuted using the parametric Student's *t* test and outliers were removed. A sensitivity analysis was performed using multivariable linear regression, to investigate the effect of treatment group on BS, adjusting for unbalanced baseline characteristics despite having been randomized with equal probability. In a secondary hypothesis-generating analysis, operating time was categorized into "short" or "long" by grouping surgical cases completed before or exceeding 120 minutes. Type I error of less than 0.05 was considered statistically significant. Statistical analysis was completed using SAS version 9.2 (SAS Institute Inc, Cary, NC) and GraphPad Prism version 5.0a (GraphPad Software Inc, La Jolla, CA).

Results

A total of 62 CRS individuals requiring FESS consented to participate in this randomized controlled trial, with equal distribution between the 18°C and 49°C treatment groups ($n = 31$, respectively). The mean age of the entire study sample was 49.7 ± 15.0 years, consisting of 61.3% males and 67.7% primary FESS cases.

Table 1 summarizes the distribution of baseline characteristics between the 18°C and 49°C saline groups. Age, gender, Lund-Mackay CT score, and individuals

TABLE 1. Participant characteristics of randomized controlled trial investigating the effect of 18°C vs 49°C saline irrigation during functional endoscopic sinus surgery

	18°C saline group (n = 31)		49°C saline group (n = 31)	
Continuous characteristics	Mean	SD	Mean	SD
Age (years)	50.3	16.1	49.2	13.9
Bilateral Lund-Mackay score (0–24)	12.3	5.5	13.5	5.1
Categorical characteristics	n	%	n	%
Males	18	58.1	20	64.5
Primary sinus surgery	20	64.5	22	71.0
Nasal polyposis	22	71.0	16	51.6
Participants requiring NSR	22	71.0	23	74.2
Participants requiring SMRIT	4	12.9	6	19.4

NSR = nasal septal reconstruction; SD = standard deviation; SMRIT = submucosal resection of inferior turbinate.

TABLE 2. Bivariate comparison of primary and secondary outcomes of randomized controlled trial comparing 18°C vs 49°C saline irrigation during functional endoscopic sinus surgery

	18°C saline group (n = 31)		49°C saline group (n = 31)		
Outcomes	Mean	SD	Mean	SD	*p*
Primary outcome					
Boezaart endoscopic field of view score (0–5)	1.5	0.6	1.3	0.5	0.23
Secondary outcomes					
Heart rate (beats/minute)	55.3	10.7	53.0	6.2	0.32
Mean arterial blood pressure (mmHg)	74.8	8.0	71.9	7.1	0.14
Total blood loss (mL)	262.3	129.6	191.6	123.4	0.04
Operating time (minutes)	115.7	34.5	117.1	31.5	0.87
Blood loss rate (mL/minute)	2.3	1.0	1.7	1.1	0.02

requiring nasal septal reconstruction or SMRIT appeared similarly distributed between the treatment groups (Table 1). In our study sample, mean BS appeared most strongly correlated with total blood loss ($r = 0.37$) and blood loss per minute ($r = 0.31$), but to a lesser extent with mean heart rate ($r = 0.23$), mean arterial blood pressure ($r = 0.25$), and total operating time ($r = 0.16$). Interestingly, total blood loss and total operating time were strongly correlated ($r = 0.44$).

Table 2 summarizes bivariate comparisons of the primary and secondary outcomes, by treatment group. Regarding the primary outcome, BS appeared higher for cases randomized to receive the 18°C saline irrigation when compared to the experimental 49°C arm (1.5 vs 1.3, respectively; Table 2). However, this finding was not statistically significant ($p = 0.23$; 95% confidence interval [CI] mean difference: −0.11 to 0.45). Despite randomization, the distribution of individuals presenting with nasal polyposis appeared greater in the 18°C saline arm, when compared to those enrolled in the 49°C saline arm (71.0% vs 51.6%, respectively; Table 1).

Effect estimates from unadjusted and adjusted linear regression did not appear to differ after accounting for nasal polyposis (beta coefficient ± standard error: unadjusted = −0.17 ± 0.14, $p = 0.23$; adjusted = −0.15 ± 0.14, $p = 0.29$). Similarly, no significant difference was found between the 18°C and 49°C saline groups in regard to mean heart rate ($p = 0.32$, 95% CI mean difference: −2.3 to 7.5), mean arterial blood pressure ($p = 0.14$, 95% CI mean difference: −1.0 to 6.4), and total operating time ($p = 0.87$, 95% CI mean difference: −18.8 to 27.9). Total estimated blood loss and blood loss per minute appeared greater for cases receiving 18°C vs 49°C saline (Table 2). These findings were statistically significant ($p = 0.04$, 95% CI mean difference: 4.1 to 106.9; $p = 0.02$, 95% CI mean difference: 0.10 to 0.88).

The relationship between mean BS and treatment group did not appear consistent throughout the entirety of surgery

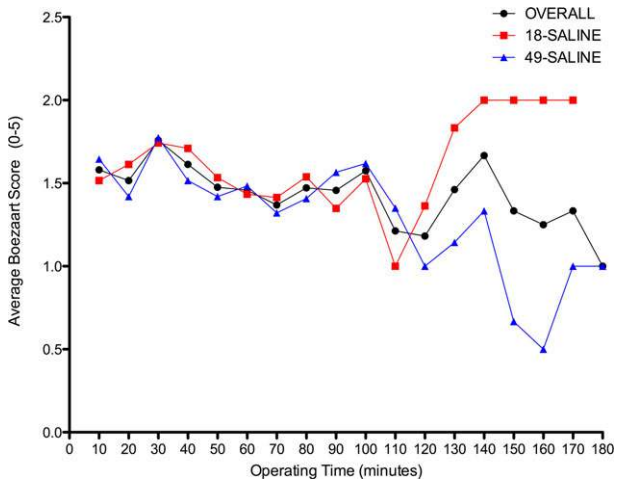

FIGURE 3. Line graph of average Boezaart score vs operating time, stratified by overall sample, 18°C, and 49°C saline irrigation groups.

(Fig. 3). As a result in a secondary analysis, cases were stratified into short cases (<120 minutes) and long cases (≥120 minutes). Thirty-two of 62 cases were long cases (ie, exceeded 120 minutes). Comparisons of subject demographic and baseline clinical characteristics among long cases (≥120 minutes) stratified by treatment group are provided in Table 3. This consisted of 48.4% and 54.8% having received 18°C and 49°C saline irrigation, respectively. Among short cases, 18°C and 49°C treatment groups appeared to have similar mean BS (1.4 ± 0.5 vs 1.5 ± 0.6). However among long cases, individuals receiving 18°C saline irrigation appeared to have higher mean BS (1.6 ± 0.6) when compared to 49°C counterparts (1.2 ± 0.4). This finding was statistically significant ($p = 0.04$, 95% CI mean difference: 0.03 to 0.41). Similarly, total blood loss appeared greater for long cases receiving 18°C vs 49°C saline (321.1 ± 113.9 vs 219.1 ± 124.2).

TABLE 3. Bivariate comparison of subject baseline characteristics and outcomes for long cases (≥120 minutes) of randomized controlled trial comparing 18°C and 49°C saline irrigation during functional endoscopic sinus surgery

	18°C saline group (N = 31)		49°C saline group (N = 31)	
	Long cases (≥120 minutes) (n = 15; 48.4%)		Long cases (≥120 minutes) (n = 17; 54.8%)	
Continuous characteristics	Mean	SD	Mean	SD
Age (years)	47.9	18.5	47.6	14.7
Bilateral Lund-Mackay score (0–24)	14.1	5.9	13.7	4.6
Categorical characteristics	n	%	n	%
Males	11	73.3	10	58.8
Primary sinus surgery	8	53.3	12	70.6
Nasal polyposis	11	73.3	7	41.2
Participants requiring NSR	10	66.7	14	82.4
Participants requiring SMRIT	1	6.7	1	5.9
Outcomes	Mean	SD	Mean	SD
Primary outcome				
Boezaart endoscopic field of view score (0–5)	1.6	0.6	1.2	0.4
Secondary outcomes				
Heart rate (beats/minute)	54.2	10.6	52.7	6.6
Mean arterial blood pressure (mmHg)	76.4	7.7	71.8	7.0
Total blood loss (mL)	321.3	113.9	219.1	124.2
Operating time (minutes)	143.1	23.2	136.8	19.1
Blood loss rate (mL/minute)	2.2	0.7	1.6	0.9

NSR = nasal septal reconstruction; SD = standard deviation; SMRIT = submucosal resection of inferior turbinate.

Discussion

Hot water irrigation (HWI) was first used by obstetricians in controlling postpartum bleeding over 100 years ago.[20] For the control of intractable epistaxis, it was first utilized by Guice and Fayette in 1878 (The first patient was treated by N L Guice in 1878, but the technique was published in 1884). In an attempt to explain its hemostatic effect, Stangerup and Thomsen[22] conducted an animal study to investigate the histopathological changes associated with its use. In their study, 24 rabbits were exposed to 5 minutes of intranasal HWI with varying ranges of temperatures from 40°C to 60°C. They found that exposure to HWI between the temperatures of 48°C and 52°C led to edema of the mucosa and subsequent narrowing of the intranasal lumen. They postulated that mucosal edema leads to compression of the bleeding vessels and this may trigger and accelerate the clotting cascade. However, mucosa exposed to HWI at or beyond 52°C showed evidence of epithelial necrosis.[22] Following this, Stangerup et al.[23] conducted a human trial comparing standard tamponade treatment to HWI at 50°C in 44 patients with posterior epistaxis. They found that HWI was as effective as tamponade treatment but resulted in shorter hospital stays and less pain. In 2006, Schlegel-Wagner et al.[24] reported an 82% success rate with HWI used as first-line therapy for posterior epistaxis in 103 participants. Their center advocated the use of HWI in the outpatient clinical setting.[24,25]

The studies mentioned in the previous paragraph used tap water (hypotonic solution) to irrigate the nasal cavity and the potential for sinonasal mucosal damage caused by hypotonic solution irrigations is a concern. In 2005, Kim et al.[26] conducted a study on cultured human nasal epithelial cells by exposing them to pure water, or isotonic, hypotonic, or hypertonic saline solutions. They observed that cells exposed to pure water or hypotonic saline suffered from moderate to severe cellular damage. However, cells exposed to isotonic saline appeared healthy with no evidence of damage. Therefore, we decided to use normal saline irrigation in this study. Despite their use in common clinical practice, neither HWI nor hot saline irrigation (HSI) have been formally studied for their use in FESS. HSI for the control of intraoperative bleeding has only been described and shown to be effective for adenoidectomy.[27] In an RCT involving 120 adenoidectomy patients by Ozmen and Ozmen,[27] operating and hemostasis times were reduced in patients irrigated with 50°C saline compared to those irrigated with 25°C saline postadenoidectomy. Although HSI is widely used in sinus, skull base, and neurosurgical procedures, this study is believed to be the first RCT assessing its effectiveness in FESS.

Our study showed that the overall BS in patients receiving 49°C saline and 18°C saline was 1.3 and 1.5, respectively. The difference in this result was not statistically significant. However, in surgeries longer than 2 hours, there was a significant improvement in endoscopic field of view (average BS of 1.2 in the 49°C group vs 1.6 in the 18°C group). This difference was not apparent in short cases (surgeries less than 2 hours). The lack of improvement in endoscopic field of view in short cases in the 49°C treatment group may be attributed to the presence of 3 confounding factors in our study: (1) preoperative oral steroid treatment; (2) the 15° RTP (RTP-15); and (3) hypotensive anesthesia during FESS. In this study, a 1-week course of preoperative oral prednisolone was given to all patients undergoing FESS. This is a routine practice at our center. Preoperative oral prednisolone has been shown to reduce blood loss and operating time, and improve visualization of the surgical field.[3] The proposed mechanism is believed to be a reduction in mediators of inflammatory process in the sinonasal mucosa that inhibits damage to blood vessels, transudation formation, and tissue edema.[3] We placed all patients in RTP-15 during FESS because our study by Hathorn et al.[11] showed that FESS performed in this position significantly improved the endoscopic field of view and reduced intraoperative blood loss when compared to the horizontal position. It is postulated that by decreasing venous return to the heart, RTP reduces intraoperative blood loss during FESS.[12] A Cochrane review in 2013 concluded that hypotensive anesthesia using propofol during FESS may improve surgical field, although the effect is small.[6] In light of this evidence and although preoperative steroids, hypotensive anesthesia, and RTP-15 are not the standard of care in FESS, we felt it was unethical to withhold these from our patients. We conducted the current study to determine if the addition of HSI to our current preoperative and intraoperative regimen would further optimize surgical conditions.

As depicted in Figure 3, the improvement in surgical field of view, which is likely from preoperative oral steroid, RTP-15, and intraoperative hypotensive anesthesia, appears to wear off in sinus surgery that takes longer than 2 hours. Once the duration of surgery passes the 2-hour mark, the endoscopic field of view in the 2 study arms had contrasting trends. It worsened in the group that received RTSI and improved further in the group that received HSI. The reason for this phenomenon is unclear. We postulate that perhaps in long cases, the endoscopic field of view may be worse and the additional hemostatic effect from HSI becomes apparent. Another possible explanation is that 2 hours is the time taken for HSI to accelerate the coagulation cascade for the volume, frequency, and temperature of saline used in this study. The results of this study suggest that for short FESS cases, the combination of preoperative oral steroids, positioning patients in RTP-15, and intraoperative hypotensive anesthesia may be adequate measures for reducing blood loss and providing a good endoscopic field of view. RTP during FESS is simple, cost-free, and has been shown to be safe and effective.[10–12] In cases that are likely to take longer than 2 hours (such as patients with complicated sinus anatomy, sinonasal tumors or bleeding disorders), the addition of HSI may be beneficial in improving visualization during FESS. Although this study showed there was no overall improvement in endoscopic field of view between the 2 study groups, total estimated blood loss and blood

loss per minute was significantly less in the 49°C group compared to that in the 18°C group. However, the improvement in total blood loss and blood loss per minute with the use of HSI was subtle.

There were a few limitations in our study. Patients with nasal polyposis were more prevalent in the 18°C group (85% vs 51.6% in the 49°C group) despite randomization. Bleeding and surgical field of view have been shown to be worse in patients with CRS with nasal polyposis due to increased inflammation and vascularity in these patients.[11,12,28] However, in our study, statistical analysis showed that nasal polyposis did not appear to confound the difference in mean endoscopic field of view score between the 18°C and 49°C groups. In assessing intraoperative blood loss during FESS, we used both subjective (endoscopic field of view) and objective (total blood loss and total blood loss per minute) assessments. The endoscopic field of view scores relies on the surgeon's subjective perspective, which may result in bias and experimental error. To reduce bias, the surgeons and patients were both blinded to the temperature of the irrigation fluid used during surgery. This ensures that the surgeon's assessment of endoscopic field of view would not be influenced by the knowledge of the experimental arm being assessed. To reduce inconsistencies in the BS, an additional non-operating surgeon (also blinded to treatment) contributed to the average BS. The total blood loss was determined by deducting the total amount of irrigation fluid used during surgery from the total amount of fluid captured in the suction containers (containing blood and irrigation fluid) at the end of surgery. The downside of this method of calculation is the potential of missing fluids that are not captured by the suction container (eg, fluids that dripped down the nasopharynx or fluids that leaked out of the nose during irrigation). To minimize this error, a Merocel sponge was inserted to the back of the nasopharynx and the suction tube was placed tight around the nostril during irrigation. Although the temperature of 49°C was preset on the fluid warmer system, an external thermometer confirmed that the actual range of the temperature was between 47°C and 49°C. It was not possible for us to keep the temperature of the irrigation fluid at 49°C at all times throughout the surgery. We allowed additional saline irrigations in between the scheduled lavages to clear the surgical field but these were very infrequent and the total volume of additional irrigations used per case was less than 50 mL. Hence, we did not document the total amount of additional irrigation used.

Conclusion

This study demonstrates that HSI does not confer any additional improvement in endoscopic field of view for short cases of FESS, given that patients are on preoperative oral steroids, placed in RTP-15, and kept slightly hypotensive during the surgery. However, in FESS cases of more than 2 hours' duration, a larger improvement in endoscopic field of view was noted. Overall, total blood loss and blood loss per minute were marginally improved by HSI during FESS across all cases.

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