Five-degree, 10-degree, and 20-degree reverse Trendelenburg position during functional endoscopic sinus surgery: a double-blind randomized controlled trial

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Background: Using the reverse Trendelenburg position (RTP) during functional endoscopic sinus surgery (FESS) is a safe, simple, and cost-free method that has been found to reduce intraoperative blood loss. However, the critical angle of RTP that produces the least amount of bleeding without compromising surgical technique and safety remains unanswered. The objective of this study was to assess the effects of 5-degree, 10-degree, and 20-degree RTP (5-RTP, 10-RTP, and 20-RTP, respectively) on intraoperative bleeding during FESS.

Methods: This double-blind randomized controlled trial involved 75 patients with chronic rhinosinusitis (CRS) with and without nasal polyposis undergoing FESS. Twenty-five patients were enrolled into each group: 5-RTP, 10-RTP, and 20-RTP. Boezaart endoscopic field-of-view score (BS), total blood loss (TBL), mean arterial blood pressure (MABP), operating time, and blood loss per minute were recorded. An intention-to-treat analysis was used, with a Bonferroni adjustment for multiple comparisons.

Results: Intervention groups were comparable in age, sex, nasal polyposis, and disease severity. Mean values of BS and TBL were as follows: 5-RTP (2.0, 231 mL), 10-RTP (1.8, 230 mL), and 20-RTP (1.4, 135 mL). The differences in means were significant for BS ($p < 0.01$) and TBL ($p = 0.03$). There was no significant difference in MABP ($p = 0.85$), operating time ($p = 0.10$), or blood loss per minute ($p = 0.11$) between the 3 groups. Pairwise comparison between 5-RTP vs 20-RTP found significant difference in BS ($p < 0.01$) but not TBL ($p = 0.04$). Significance was not found in similar comparisons of 10-RTP vs 20-RTP and 5-RTP vs 10-RTP ($p > 0.03$).

Conclusion: FESS in 20-RTP produced the best BS and lowest blood loss without compromising surgical technique.

Key Words:
endoscopic sinus surgery; reverse trendelenburgh position; intraoperative blood loss; surgical field

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Functional endoscopic sinus surgery (FESS) is the gold standard in the surgical management of patients with chronic rhinosinusitis (CRS) who have failed maximal medical treatment.[1] Given the small operative field in FESS, even a small amount of bleeding can significantly impair surgical field visualization. This often leads to increased operative time and surgeon frustration, and may increase the risk of complications. Thus, several techniques have been described in the literature to reduce intraoperative bleeding during FESS. These include the use of preoperative nasal decongestants (such as topical oxymetazoline, cocaine, and adrenaline) and oral steroids, as well as intraoperative tranexamic acid, topical adrenaline, injection of the lateral nasal wall with lidocaine and adrenaline, and the head-up position during surgery. The success rates of these methods have been variable and some of these techniques are associated with adverse cardiopulmonary events.[2–9]

Positioning patients in the reverse Trendelenburg position (RTP) during FESS is a simple and effective method of reducing intraoperative bleeding. In our recently completed randomized controlled trial comparing the 15-degree

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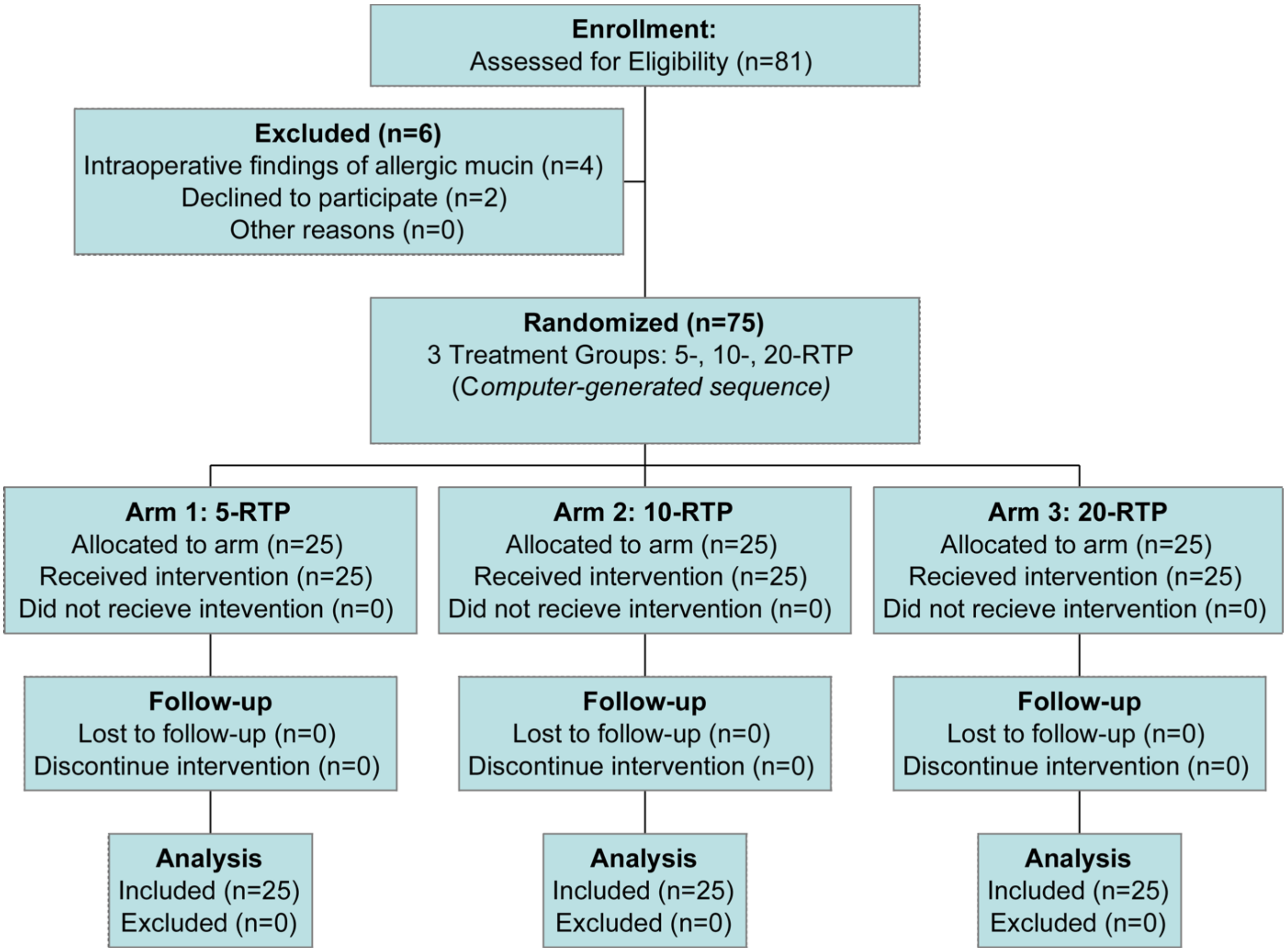

FIGURE 1. Flow diagram showing pathway of participants through this randomized controlled trial.

RTP (15-RTP) and horizontal position (HP) for FESS, 15-RTP provided a better field of view and less intraoperative blood loss.[10] However, 1 important question arose from this study: what is the critical angle of RTP that produces the least amount of intraoperative bleeding without compromising cerebral perfusion pressure (CPP) and surgical technique? Hence, in this trial, we aimed to study the effects of 5-degree RTP (5-RTP), 10-degree RTP (10-RTP), and 20-degree RTP (20-RTP) on intraoperative bleeding during FESS. We chose 20-RTP as the upper limit because we found operating in a position greater than this angle may be technically challenging, especially for surgeons who sit while performing FESS. In terms of clinical safety, studies have shown that positioning patients at up to 30-RTP during anesthesia did not result in clinically significant decrease in CPP or other complications.[11–13]

Patients and methods

Study design

This study was a double-blind randomized controlled trial (RCT) in which the objective was to assess the effects of 5-RTP, 10-RTP, and 20-RTP on intraoperative bleeding during FESS.

Study subjects

Patients were recruited from the Rhinology Clinic at St. Paul's Sinus Centre in Vancouver, Canada, from February to May 2013 (Fig. 1). The study was reviewed and approved by the University of British Columbia Clinical Research Ethics Board. The following inclusion and exclusion criteria were used to determine if a patient was eligible for the study:

Inclusion criteria:

1. Patients aged 18 years old and above;
2. Patients with American Society of Anesthesiologist (ASA) physical status classification score of less than III;
3. Patients with chronic or recurrent sinusitis (as defined by the Canadian Practice Guidelines for CRS) with or without nasal polyposis refractory to medical treatment who had consented for FESS.

Exclusion criteria:

1. Patients with severe ischemic heart disease, pulmonary, 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, and Wegener's granulomatosis.

All patients scheduled for FESS had a preoperative computed tomography (CT) scan and had their Lund-Mackay score recorded.

Study protocol

Preoperative

All patients were treated with a 1-week course of prednisone (20 mg once per day) and oral antibiotics Clavulin (GlaxoSmithKline Inc., Ontario, Canada) (Clavulin 875 mg twice per day [bid], or Clindamycin 300 mg three times per day [tid] if allergic to penicillin) prior to surgical intervention. This is a routine practice for patients receiving FESS at St Paul's Sinus Centre. Seventy-five patients were randomized to the 3 study arms (5-RTP, 10-RTP, and 20-RTP), based on a closed-envelope system. Twenty-five patients were allocated to each study arm. The patients were unaware of the angle of RTP in which they were positioned during surgery.

Intraoperative

Anesthesia and patient positioning. Patients were induced under general anesthesia with intravenous propofol. Anesthesia was maintained with inhaled desflurane and an intravenous infusion of remifentanil and propofol. Once under general anesthesia, patients were intubated with an endotracheal tube.

Following endotracheal intubation, both nasal cavities were packed with neuropatties soaked with Otrivin (Novartis OTC, Quebec, Canada) (Xylometazolin 0.05%). The patients were then positioned by the research assistant, based on the angle of RTP contained in the closed envelope. This was done by first placing a protractor beside the patient's head (along the horizontal axis of the operating table). The head part of the operating table was then electronically raised to the desired angle (5, 10, or 20 degrees). The surgical field was then prepped and draped by the nurse. A disposable U-drape was used to cover most of the head and body of the patient, leaving only the nose, eyes, and image-guided system (IGS) patient tracker exposed (Fig. 2A–D). Only after the patient was completely draped was the surgeon allowed to enter the operating room. This was to ensure that the surgeon was blinded to the angle of the RTP set for the patient.

Surgery. All surgeries were performed by the 2 senior authors (E.C.G. and A.R.J.). FESS was performed with IGS and using the technique described by Messerklinger (in Kennedy[14]). The Microdebrider (ENT RADenoid 3.5-mm Tricut Blade; Medtronic, Minneapolis, MN) 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 neuropatties were not used before or during surgery.

Assessment

The degree of bleeding in the surgical field was scored by the operating surgeon using the validated Boezaart and van der Merwe Grading System.[6] 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 then can be removed.[14] The Boezaart score (BS), the systolic and diastolic blood pressures, heart rate, mean arterial blood pressure (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, the total blood loss (TBL) was calculated by subtracting the total amount of irrigation fluid used from the fluid in the suction bottle. The total blood loss per minute (TBL/min) was calculated by dividing the TBL by the duration of surgery in minutes.

Baseline characteristics and outcome measures

Baseline characteristics recorded for each subject included, age (years), sex, history of sinus surgery, nasal polyposis, and disease severity as measured by the Lund-Mackay CT scoring system. The primary outcomes for this clinical trial were mean BS, total blood loss (mL), and blood loss per minute (mL/min). Secondary outcome variables were operating time (minutes) and MABP. The incidence of complications was also documented.

Sample size

A sample size calculation was completed a priori to determine the number of patients required to evaluate a significant difference in BS. From a previous head position study completed at our center, a 40% difference was found in BS between the HP and 15-RTP groups. Using this difference as our effect size, Type I error of 5%, and Type II error of 20%, a total of 75 patients (25 patients in each arm) were required for this clinical trial.

Statistical analysis

All continuous explanatory variables were summarized by mean and standard deviation. Continuous explanatory variables included age (years) and disease severity (Lund-Mackay CT score). Categorical explanatory variables including sex, history of sinus disease, and nasal polyposis

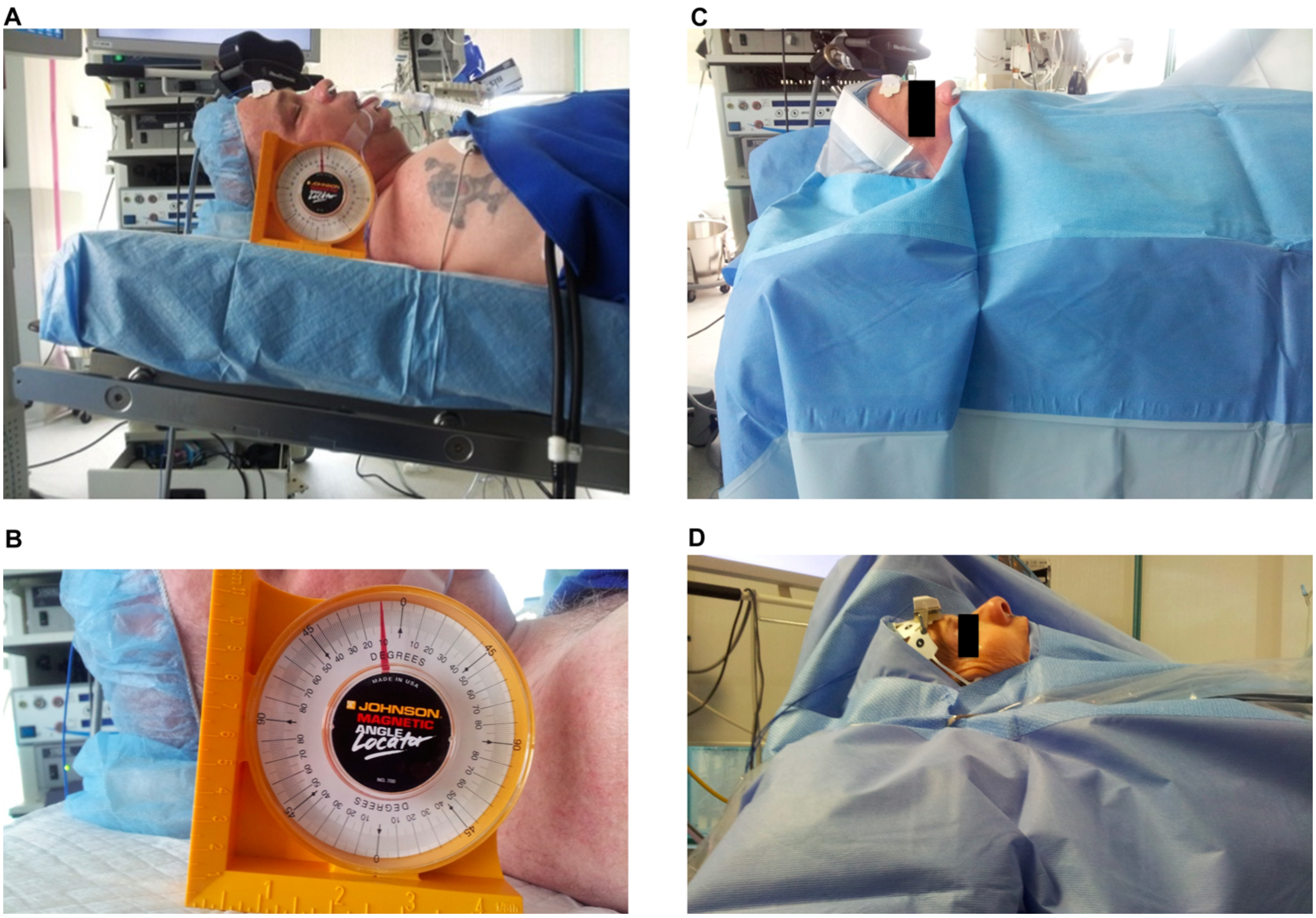

FIGURE 2. (A) A magnetic protractor is placed on the operating table, beside the patient's head. The head part of the operating table is then elevated to the desired angle by the research assistant. (B) This patient was positioned in 10-RTP. (C) A patient positioned in 10-RTP and fully draped, exposing only the eyes, nose, and patient tracker. (D) A patient positioned in 20-RTP and fully draped. 10-RTP = 10-degree reverse Trendelenburg position; 20-RTP = 10-degree reverse Trendelenburg position.

were summarized by frequency and proportion. The incidence of nasal septal reconstruction was also recorded as a categorical dichotomous variable. Primary and secondary outcome variables were considered continuous. An intention-to-treat protocol was used for the statistical analysis. Subjects withdrawn, violating study protocol, or lost to follow-up were considered as treatment failures. No patients were to be excluded from the final analysis. Baseline characteristics were compared between the study groups to evaluate comparability from randomization. One-way analysis of variance (ANOVA) was used to test the hypothesis that there was no difference in the means of the outcome variables between the study arms. Individual observations and study groups were considered independent. Parametric 1-way ANOVA was used for observations drawn from normally distributed outcome variables and equal between-group variance. The nonparametric Kruskal Wallis test was used when parametric assumptions were not met. The F value, degree of freedom (df), and p value were reported. Type 1 error less than 0.05 was considered significant. Pairwise comparisons using Tukey and Dunnett test methods were completed to determine which study group differed among significant ANOVA findings. A Bonferroni adjustment for multiple comparisons was utilized. Values of $p < 0.02$ were considered significant for pairwise comparisons. Linear regression was used to model the relationship between the primary outcomes and head position, adjusting for baseline characteristics that were unequally distributed postrandomization. Variables were entered into the model to obtain adjusted effects. Statistical analysis was completed using GraphPad Prism Version 5.0a (GraphPad Software Inc.; 2008) and RStudio Version 0.95.265 (RStudio Inc.; 2011).

Results

A total of 75 patients were enrolled into this randomized controlled trial, with 25 patients in each study groups. The mean age of the entire study population was 49.9 ± 15.2 years, consisting of 38 (51%) males and 37 (49%) females.

TABLE 1. Baseline characteristics

Baseline variables	5-degree RTP (n = 25)	10-degree RTP (n = 25)	20-degree RTP (n = 25)
Age, years, mean ± SD	48.2 ± 15.0	53.6 ± 12.9	47.9 ± 17.2
Males, n (%)	12 (48)	12 (48)	14 (56)
Primary surgery, n (%)	18 (72)	15 (60)	15 (60)
Nasal polyposis, n (%)	3 (12)	2 (8)	3 (12)
Nasal septal reconstruction, n (%)	17 (68)	17 (68)	9 (36)
Lund-Mackay score, mean ± SD	10.8 ± 4.5	10.5 ± 5.8	10.3 ± 5.2

RTP = reverse Trendelenburg position; SD = standard deviation.

TABLE 2. Intraoperative results

Intraoperative variables	5-degree RTP (n = 25)	10-degree RTP (n = 25)	20-degree RTP (n = 25)	*p*
Boezaart score (0–5)	2.0 ± 0.6	1.8 ± 0.4	1.4 ± 0.6	<0.001
Estimated BL (mL)	231 ± 148	230 ± 161	135 ± 108	0.026
Operating time (minutes)	120 ± 41	106 ± 49	93 ± 42	0.103
BL/minute	2.2 ± 1.7	2.1 ± 1.1	1.4 ± 1.2	0.112
MABP	73 ± 6	74 ± 7	75 ± 10	0.615
Heart rate (bpm)	58 ± 8	60 ± 10	58 ± 11	0.823

Values are mean ± SD.

BL = blood loss; bpm = beats per minute; MABP = mean arterial blood pressure; RTP = reverse Trendelenburg position; SD = standard deviation.

TABLE 3. Pairwise statistical comparison between operating positions

Comparison	Difference	95% CI	*p*
Boezaart score (0–5)			
5-RTP vs 10-RTP	0.2	−0.1 to 0.6	0.3
5-RTP vs 20-RTP	0.6	0.3 to 0.9	<0.001
10-RTP vs 20-RTP	0.4	0.03 to 0.75	0.03
Estimated BL (mL)			
5-RTP vs 10-RTP	1.2	−94.1 to 95.5	0.99
5-RTP vs 20-RTP	95.8	0.5 to 191.1	0.05
10-RTP vs 20-RTP	94.6	−0.7 to 189.9	0.05

Values are mean ± SD.

5-RTP = 5-degree RTP; 10-RTP = 10-degree RTP; 20-RTP = 20-degree RTP; BL = blood loss; CI = confidence interval; RTP = reverse Trendelenburg position; SD = standard deviation.

Nasal polyposis were present in 8 (11%) cases. Forty-eight (64%) patients were primary FESS cases. Baseline characteristics of age, sex, primary surgery, and nasal polyposis were comparable between the 5-RTP, 10-RTP, and 20-RTP groups (Table 1). Lund-Mackay CT scores were similar in the 5-RTP (10.8 ± 4.5), 10-RTP (10.5 ± 5.8), and 20-RTP (10.3 ± 5.2) groups (Table 1). Despite equal probability of randomization, 17 (68%) patients in the 5-RTP and 10-RTP groups required nasal septal reconstruction, compared to 9 (36%) in the 20-RTP group.

The mean BSs were significantly different between the 5-RTP (2.0 ± 0.6), 10-RTP (1.8 ± 0.4), and 20-RTP (1.4 ± 0.6) groups (F value: 8.7, df: 72, $p < 0.001$). Similarly, mean BL was significantly different between the 5-RTP (213 ± 148), 10-RTP (230 ± 161), and 20-RTP (135 ± 108) groups (F value: 3.8, df: 72, $p = 0.03$). Mean values for operating time, BL/min, and MABP did not significantly differ between the study groups ($p = 0.10$, 0.11, 0.62, respectively). Comparisons of mean values are summarized in Table 2. In order to determine which head position significantly differed in terms of BS and TBL, pairwise comparisons were completed (Table 3). Difference in BS was reported for 5-RTP vs 20-RTP (0.6), 10-RTP vs 20-RTP (0.4), and 5-RTP vs 10-RTP (0.2). The difference in BS was statistically significant between the 5-RTP and 20-RTP groups ($p < 0.001$; 95% CI, 0.3 to 0.9). A significant difference was not found between 10-RTP vs 20-RTP and 5-RTP vs 10-RTP ($p = 0.03$; 95% CI, 0.03–0.8; and $p = 0.3$; 95% CI, −0.1 to 0.6, respectively). Differences in mean BL were recorded for 5-RTP vs 20-RTP (95.8 mL), 10-RTP vs 20-RTP (94.6 mL), and 5-RTP vs 10-RTP (1.2 mL). Pairwise comparisons of differences in mean BL did not significantly differ ($p = 0.05$, 0.05, and 0.99, respectively).

The incidence of nasal septal reconstruction was unequally distributed among study groups (5-RTP and 10-RTP: 68%, 20-RTP: 36%). We found that the regression estimates and standard error between the primary outcomes and head position, with or without adjustment for septal reconstruction, were comparable. The changes in BS and TBL were similar between unadjusted and adjusted models (Table 4). The reference group for the multivariate linear regression model was patients oriented 5-RTP without nasal septal reconstruction performed. The incidence of nasal polyposis in our series was too small (10.7%) to allow statistical analysis of its impact on BS, TBL, and operating time.

Discussion

RTP is a head-up and feet-down tilt varying from 10 to 30 degrees.[15] This position has been used for many years by neurosurgeons to reduce intracranial pressure during craniotomy.[16] Recently, RTP has also been shown to be effective in reducing bleeding in FESS.[10,17] The proposed mechanism is a decrease in venous return from the effect

TABLE 4. Comparison of Boezaart score and blood loss estimates adjusted for NSR*

	Unadjusted			Adjusted		
Variables	Regression estimate	Standard error	*p*	Regression estimate	Standard error	*p*
Boezaart score						
10-RTP	0.23	0.15	0.12	0.23	0.15	0.13
20-RTP	– 0.39	0.15	0.01	– 0.42	0.16	0.01
Total blood loss						
10-RTP	1.2	39.8	0.98	1.2	39.9	0.97
20-RTP	– 94.6	39.8	0.02	– 103.4	41.4	0.01

*Reference group: patients oriented in 5-RTP, not requiring NSR.
5-RTP = 5-degree RTP; 10-RTP = 10-degree RTP; 20-RTP = 20-degree RTP; NSR = nasal septal reconstruction; RTP = reverse Trendelenburg position.

of gravity, resulting in a lower cardiac output. The mean arterial pressure (MAP), however, is maintained due to compensatory measures by the blood pressure regulatory mechanism in the aortic arch and carotid sinuses. Therefore, it is postulated that the decrease in venous return, and not in MAP, reduces blood loss during FESS in RTP.[17] Other benefits of RTP during anesthesia include improved oxygenation in obese patients and reduced postoperative nausea and vomiting.[11,12] In obese patients undergoing bariatric surgery, tilting the patient's head up will counteract the abdominal push on the diaphragm. This, in turn leads to an increase in lung functional residual capacity (FRC) and improved oxygenation.[11] Reduction in postoperative nausea and vomiting in the head-up position is believed to be a result of a decrease in craniocervical venous congestion.[12]

In 2008, Ko et al.[17] was the first to study the effects of RTP during FESS. Their RCT involved 30 patients placed in the HP and 30 patients in 10-RTP during FESS. Their study showed that FESS in 10-RTP resulted in significantly less intraoperative TBL and BL/min, and improved surgical field compared to that in the supine position. However, there were several limitations in their study. Epinephrine injections were routinely administered in the surgical field as well as in the pterygopalatine fossae, but the volume injected was not standardized. Anesthetic drugs used were also not standardized. Their subjects had mild CRS disease with a mean Lund-Mackay score of 2.37 in both groups. In 2013, a single-blind RCT from our center analyzed the effects of 15-RTP vs HP on intraoperative blood loss and endoscopic views during FESS. Both outcome measures were significantly reduced in the 15-RTP group. In our study, anesthetic agents were standardized and no epinephrine were injected or applied topically before or during surgery. However, there were questions about the optimal angle that leads to the least amount of intraoperative blood loss and is comfortable for the operating surgeon without compromising surgical technique.

This study showed that there was a gradual reduction in intraoperative blood loss and improvement in surgical visual field as the RTP angle was raised from 5 to 20 degrees. The mean BS scores and TBL for each study group were as follows: 5-RTP (2.0, 231 mL), 10-RTP (1.8, 230 mL), and 20-RTP (1.4, 135 mL). These differences were statistically significant ($p < 0.001$, 0.03). In our 2013 study by Hathorn et al.,[10] the mean BS and TBL for 15-RTP were 1.66 and 247 mL, respectively. These values were more favorable than that in the 5-RTP and 10-RTP groups but less favorable than that in the 20-RTP group. Hence, there was a consistent improvement in surgical field view and less intraoperative bleeding as the head was elevated higher. The improvements in BS and TBL were minute when comparing 5-RTP to that of 20-RTP. However, there was a drastic improvement in BS and TBL in 20-RTP compared to that in 10-RTP, suggesting that the relationship between the BL and TBL and the degree of RTP may not be linear. The surgical site (sinus vs septum) did not have any impact on the degree of intraoperative bleeding. All patients in this study received a 1-week course of preoperative oral antibiotics and oral steroids. Preoperative oral steroids have been shown to reduce intraoperative blood loss and improve surgical field visualization.[9] This confounding factor might have minimized the overall TBL and BS in our series. However, the effect would have been seen in all patients in the study.

Raising the angle of RTP to more than 20 degrees is not without potential compromise. The main concerns in performing FESS in a high-angle RTP are technical challenges (such as difficult ergonomics during surgery and alteration of the plane of the skull base), risk of reduced cerebral perfusion pressure (CPP), and venous air embolism. As we routinely sit during FESS, we found that the ergonomics of instrument handling were more technically challenging at an angle higher than 20-RTP. With a high-angle RTP (defined as RTP angle >20 degrees), the patient's chest may obstruct the surgeon's operating hands, limiting angulation of instruments upward as ethmoid cells are removed along the skull base. This is more pronounced in obese or barrel-chested patients. In addition, the plane of the skull base is tilted inferiorly from a posterior to anterior direction with higher head elevation. In the hands of the inexperienced or junior surgeon, the unrecognized change in skull base orientation may potentially lead to intracranial penetration and cerebrospinal fluid (CSF) leak. The 5-RTP, 10-RTP, and 20-RTP during FESS in this study did not pose any technical difficulties or cause any complications.

The second issue from positioning patients in a high-angle RTP is a potential reduction in cerebral perfusion. Elevation of the head will lead to reduction in cerebral blood volume (CBV).[18] This results from an increased in blood outflow from the intracranial compartment. A decrease in CBV will cause a drop in intracranial cerebral pressure (ICP) and a potential decrease in CPP.[19] However, a reduction in CPP in the cerebral autoregulatory range (50–80 mmHg) induces cerebral vasodilatation and increases CBV and ICP to compensate for the dropped CPP.[18] In this manner, the CPP is maintained between 50 and 80 mmHg. In the management of neurosurgical patients in the intensive unit, head elevation at 30 degrees has been shown to cause a decrease in ICP with no change in CPP.[20–22] Hence, up to 30 degrees RTP (30-RTP) should be safe during FESS. As explained previously, we chose not to place patients in 30-RTP during FESS because we found that operating in this position can be technically challenging.

The third potential hazard of a high-angle RTP is venous air embolism. Venous air embolism (VAE) occurs when there is a negative pressure gradient between the operative site and the right atrial pressure.[23] It is most commonly reported in craniotomies in the sitting position.[24] However, VAE can happen in any surgical procedures[24] and neurosurgical procedures in any positions including the lateral, supine, or prone positions.[25] The clinical effects of VAE are dependent on the rate and volume of air entry.[24] These range from an asymptomatic episode to severe cardiopulmonary and neurological consequences.[25] In the field of rhinology, VAE is very rare and there has only been 1 case reported in the literature[23]; it occurred during endoscopic excision of a sphenoid sinus giant cell tumor with the patient in a supine position. A high-angle RTP has a theoretical higher risk of air embolism due to negative pressures in the jugular bulb[19] and a higher position of the surgical wound relative to the heart.[24] However, the rarity of this condition makes it difficult to determine the critical angle of RTP before the risk of venous embolism is increased. In addition, risk factors for VAE that are present in neurosurgical procedures such as the presence of large uncompressed venous channels in the surgical field or a high degree of vascularity are not commonly seen in rhinologic procedures. In this study and our previous study on the effects of 15-RTP during FESS, no VAE or other complications were encountered.

There were a few limitations in this study. Although the surgeons were blinded and the degree of RTP was difficult to guess, there were times when the surgeons were able to guess if it was a higher angle (10 or 20 degrees) or lower angle (5 or 10 degrees) RTP. Draping the head and entire body of the patient with a U-drape helped disguise the degree of head elevation before the operating surgeon entered the operating room. Like in the previous RTP-15 study, attempts were made to reduce bias by having a second non-operating surgeon and a research assistant contribute to the average BS. The option of recording video clips of the surgery every 10 minutes for 1 minute and getting an independent surgeon to assess these clips were considered during the design of this study. However, we felt that the operating surgeon should be the best assessor of "how bloody" a surgical field is in real time. The TBL was calculated by deducting the total amount of irrigation fluid used during surgery from the total amount of fluid in the suction containers (which contained blood and irrigation fluid). Although this was probably the best method to assess the amount of blood loss objectively, there were some fluids that would not be accounted for. These included fluids that dripped down the nasopharynx and fluids that might have leaked out of the nose during nasal irrigation. To minimize these, a Merocel sponge was inserted to the back of the nasal cavity and the suction tube was placed tight against the patient's nostril during sinus irrigation. Finally, the number of patients with nasal polyposis in this study was too small to allow generalization of the findings of this study to this group of patients.

Conclusion

This study showed that 20-RTP during FESS produced the best surgical field view with the least amount of intraoperative blood loss. It is a simple, effective, safe, and cost-free method that should be used routinely for sinus surgery. For a sinus surgeon who has always operated with patients in the horizontal position, the alteration in the plane of the skull base in the RTP should be noted when adopting this new position.

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References

1. Meltzer EO, Hamilos DL. Rhinosinusitis diagnosis and management for the clinician: a synopsis of recent consensus guidelines. *Mayo Clinic Proc*. 2011;86:427–443.
2. Riegle EV, Gunter JB, Lusk RP, Muntz HR, Weiss KL. Comparison of vasoconstrictors for functional endoscopic sinus surgery in children. *Laryngoscope*. 1992;102:820–823.
3. Yaniv E, Shvero J, Hadar T. Hemostatic effect of tranexamic acid in elective nasal surgery. *Am J Rhinol*. 2006;20:227–229.
4. Eberhart LH, Folz BJ, Wulf H, Geldner G. Intravenous anesthesia provides optimal surgical conditions during microscopic and endoscopic sinus surgery. *Laryngoscope*. 2003;113:1369–1373.
5. Tirelli G, Bigarini S, Russolo M, Lucangelo U, Gullo A. Total intravenous anaesthesia in endoscopic sinus-nasal surgery. *Acta Otorhinolaryngol Ital*. 2004;24:137–144.
6. Boezaart AP, van der Merwe J, Coetzee A. Comparison of sodium nitroprusside- and esmolol-induced controlled hypotension for functional endoscopic sinus surgery. *Can J Anaesth*. 1995;42:373–376.

7. Javer AR, Gheriani H, Mechor B, Flamer D, Genoway K, Yunker WK. Effect of intraoperative injection of 0.25% bupivacaine with 1:200,000 epinephrine on intraoperative blood loss in FESS. *Am J Rhinol Allergy*. 2009;23:437–441.
8. Higgins TS, Hwang PH, Kingdom TT, Orlandi RR, Stammberger H, Han JK. Systematic review of topical vasoconstrictors in endoscopic sinus surgery. *Laryngoscope*. 2011;121:422–432.
9. Khosla AJ, Pernas FG, Maeso PA. Meta-analysis and literature review of techniques to achieve hemostasis in endoscopic sinus surgery. *Int Forum Allergy Rhinol*. 2013;3:482–487.
10. Hathorn IF, Habib AR, Manji J, Javer AR. Comparing the reverse Trendelenburg and horizontal position for endoscopic sinus surgery: a randomized controlled trial. *Otolaryngol Head Neck Surg*. 2013;148:308–313.
11. Perilli V, Sollazzi L, Modesti C, et al. Comparison of positive end-expiratory pressure with reverse Trendelenburg position in morbidly obese patients undergoing bariatric surgery: effects on hemodynamics and pulmonary gas exchange. *Obes Surg*. 2003;13:605–609.
12. Tominaga K, Nakahara T. The twenty-degree reverse-Trendelenburg position decreases the incidence and severity of postoperative nausea and vomiting after thyroid surgery. *Anesth Analg*. 2006;103:1260–1263.
13. Mavrocordatos P, Bissonnette B, Ravussin P. Effects of neck position and head elevation on intracranial pressure in anaesthetized neurosurgical patients: preliminary results. *J Neurosurg Anesthesiol*. 2000;12:10–14.
14. Kennedy DW. Functional endoscopic sinus surgery. Technique. *Arch Otolaryngol*. 1985;111:643–649.
15. Shane SM, Ashman H. The prevention of postoperative shock and postanesthesia hypotension by use of the reverse Trendelenburg position during surgery under light, etherless, general anesthesia. *Am J Surg*. 1957;94:102–107.
16. Rolighed Larsen JK, Haure P, Cold GE. Reverse Trendelenburg position reduces intracranial pressure during craniotomy. *J Neurosurg Anesthesiol*. 2002;14:16–21.
17. Ko MT, Chuang KC, Su CY. Multiple analyses of factors related to intraoperative blood loss and the role of reverse Trendelenburg position in endoscopic sinus surgery. *Laryngoscope*. 2008;118:1687–1691.
18. Bouma GJ, Muizelaar JP, Bandoh K, Marmarou A. Blood pressure and intracranial pressure-volume dynamics in severe head injury: relationship with cerebral blood flow. *J Neurosurg*. 1992;77:15–19.
19. Tankisi A, Cold GE. Optimal reverse Trendelenburg position in patients undergoing craniotomy for cerebral tumors. *J Neurosurg*. 2007;106:239–244.
20. Durward QJ, Amacher AL, Del Maestro RF, Sibbald WJ. Cerebral and cardiovascular responses to changes in head elevation in patients with intracranial hypertension. *J Neurosurg*. 1983;59:938–944.
21. Feldman Z, Kanter MJ, Robertson CS, et al. Effect of head elevation on intracranial pressure, cerebral perfusion pressure, and cerebral blood flow in head-injured patients. *J Neurosurg*. 1992;76:207–211.
22. Moraine JJ, Berre J, Melot C. Is cerebral perfusion pressure a major determinant of cerebral blood flow during head elevation in comatose patients with severe intracranial lesions? *J Neurosurg*. 2000;92:606–614.
23. Celebi N, Artukoglu F, Celiker V, Aypar U. Repeated attacks of venous air embolism during endoscopic sinus tumor surgery: a case report. *Int J Pediatr Otorhinolaryngol*. 2005;69:1437–1440.
24. Mirski MA, Lele AV, Fitzsimmons L, Toung TJ. Diagnosis and treatment of vascular air embolism. *Anesthesiology*. 2007;106:164–177.
25. Albin MS, Carroll RG, Maroon JC. Clinical considerations concerning detection of venous air embolism. *Neurosurgery*. 1978;3:380–384.