AMERICAN ACADEMY OF OTOLARYNGOLOGY–HEAD AND NECK SURGERY FOUNDATION

Otolaryngology–Head and Neck Surgery
148(2) 308–313

DOI: 10.1177/0194599812466529
http://otojournal.org
SAGE

# Comparing the Reverse Trendelenburg and Horizontal Position for Endoscopic Sinus Surgery: A Randomized Controlled Trial

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*No sponsorships or competing interests have been disclosed for this article.*

Received August 6, 2012; revised September 21, 2012; accepted October 11, 2012.

## Abstract

*Objective*. To determine whether the 15-degree reverse Trendelenburg position (RTP) during functional endoscopic sinus surgery improves endoscopic field of view and reduces intraoperative blood loss when compared with the horizontal position (HP).

*Study Design*. A prospective, randomized controlled trial.

*Setting*. St Paul's Sinus Centre, Vancouver, Canada.

*Subjects*. Patients with chronic rhinosinusitis (CRS), with or without nasal polyposis, receiving functional endoscopic sinus surgery were included. Patients were excluded if they had severe or uncontrolled hypertension and cardiovascular disease, continued use of anticoagulants, impaired coagulation, or a sinonasal tumor.

*Methods*. Sixty-four patients with CRS undergoing functional endoscopic sinus surgery (FESS) were randomized to either 15-degree RTP (experimental arm) or HP (control arm) from October 2011 to February 2012. Boezaart endoscopic field-of-view grading system was the primary outcome measure. Lund-Mackay computed tomography (CT) score, total blood loss, blood loss per minute, mean arterial pressure, heart rate, anesthetic technique, and surgery time were also recorded.

*Results*. There was a significant difference in mean Boezaart scoring between RTP and HP: 1.66 vs 2.33 ($P < .001$), with RTP producing a better endoscopic field of view. There was also a lower total blood loss and blood loss per minute with RTP ($P = .01$, $P = .03$). There was no significant difference in disease severity ($P > .05$), time of surgery ($P > .05$), or mean arterial pressure ($P > .05$) between the 2 surgical positions.

*Conclusion*. The 15-degree RTP improves the endoscopic field of view and reduces blood loss during FESS. We would therefore recommend its use.

## Keywords

reverse Trendelenburg position, endoscopic sinus surgery, intraoperative bleeding, surgical field

Because of the highly vascular nature of the sinonasal mucosa and the narrow surgical area, small amounts of blood can substantially impair endoscopic visualization of surgical field. Any obstruction of the endoscopic field of view may increase the risk of surgical complications. Several techniques can be used to control blood loss and improve surgical field during sinus surgery, such as preoperative corticosteroid treatment,[1] local vasoconstrictors,[2] controlled hypotension,[3-6] and total intravenous anesthesia (TIVA).[7] A simpler method to achieve the same goal may be adjusting patient position.

Functional endoscopic sinus surgery (FESS) performed in the horizontal position is standard at the St Paul's Sinus Centre. Surgeon experience has found that placing patients in the horizontal position (HP) allows for consistent orientation of the sinus anatomy and in particular the skull base. The horizontal position with the surgeon sitting while operating is standard practice in many tertiary North American sinus centers (unpublished data). However, the reverse Trendelenburg position (RTP), a head-up, feet-down tilt varying from 10 to 30 degrees, is also commonly used during FESS.[8,9] The RTP reduces venous return and cardiac output by retaining blood in the lower parts of the body.[10,11] It has been shown to decrease blood loss in neurosurgery, where it is commonly used to reduce intracranial pressure,[10,12-14] and in abdominal surgery.[11] There is, however, surprisingly little literature specifically looking at FESS and the effect of RTP.

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This article was presented at the 2012 AAO-HNSF Annual Meeting & OTO EXPO; September 9-12, 2012; Washington, DC.

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**Table 1.** Boezaart Scale for Endoscopic Surgical Field of View

| Boezaart Score | Description |
|---|---|
| 0 | No bleeding, virtually bloodless field |
| 1 | Slight bleeding, blood suctioning is not required |
| 2 | Mild bleeding, occasional suctioning without interference of surgical field |
| 3 | Moderate bleeding, suctioning is usually used; bleeding threatens surgical field but improves after suctioning |
| 4 | Heavy bleeding, suctioning is frequently used; bleeding threatens surgical field directly after suction is removed |
| 5 | Severe bleeding, bleeding appears faster than suctioning and is uncontrollable |

## Methods

A prospective, randomized controlled trial was conducted at the St Paul's Sinus Centre (SPSC) in Vancouver, Canada. This trial was conducted with the approval of the University of British Columbia Clinical Research Ethics Board. Patients receiving FESS for chronic rhinosinusitis (CRS) with or without polyposis were consented for enrollment between November 2011 and May 2012. Inclusion criteria were a diagnosis of CRS, based on the Canadian clinical practice guidelines for sinusitis[15]; age between 19 and 75 years; and an American Society of Anesthesiologists (ASA) physical status classification system score of less than III.[16] Patients were excluded if they had severe or uncontrolled hypertension and cardiovascular disease, continued use of anticoagulants, impaired coagulation, or a sinonasal tumor. Routine coagulation tests were not performed, but patients were asked about personal history and family history of bleeding disorders. If a history of bleeding problems was identified, a coagulation screen was carried out. Patients with mild or moderate hypertension, diabetes, chronic renal disease, and other major uncritical medical conditions were included. As per standard preoperative practice at the SPSC, all patients were treated with a 1-week course of corticosteroids and oral antibiotics. Anticoagulants and herbal medications were ceased 7 days prior to surgery. Computer tomography (CT) imaging was reviewed in axial, coronal, and sagittal planes and scored according to the Lund-Mackay (LM) staging system.[17] All operations were performed by the 2 senior authors (IFH and ARJ). The nose was prepared preoperatively using xylometazoline spray, and intraoperatively, neuropatties soaked with a topical vasoconstrictor (xylomatazoline) were used in all cases. Epinephrine injections and topical hemostatic agents (such as Surgicel) were not routinely used.

Sixty-four patients were randomized by a closed-envelope system to either the control (HP) or experimental (RTP) group. All patients were first positioned in a 0-degree horizontal orientation, to allow anesthesia to be administered. Patients in the HP group (32 patients) remained in this position for the duration of the surgery. Experimental study subjects were tilted to a 15-degree RTP (32 patients), according to a magnetically attached protractor, accurate to $\pm 1$ degree. Experimental positions were verified at the operating table's fulcrum point and at the patient's head. All patients received general anesthetic, by a combination of intravenous and inhaled agents. Anesthesia was induced with propofol according to the patient's weight, preexisting health conditions, and discretion of the attending anesthesiologist. Anesthesia was maintained with inhaled desflurane and an intravenous infusion of remifentanil and propofol. This was the same for all cases, and therefore there was no difference in anesthetic technique between the 2 groups.

The primary outcome measures were the Boezaart scale for surgical field,[4] total blood loss (TBL), and blood loss per minute (BL/min). The Boezaart score, systolic and diastolic blood pressure, and mean arterial blood pressure (MABP) were recorded every 15 minutes. The total blood loss and time of surgery were recorded at the completion of surgery, and from this the blood loss per minute was calculated. Total blood loss was calculated by the circulating nurse by subtracting the amount of irrigation used from the total volume in the suction bottles. A second nurse always corroborated the TBL calculation. The Boezaart scoring system is a scale assigning a numerical value from 0 to 5, to quantify the extent of endoscopic visual impairment from intraoperative blood loss (**Table 1**).[4] Mild bleeding requiring infrequent suctioning without interference in surgical field is scored a lesser numerical value than extensive bleeding causing significant visual obstruction.

The Microdebrider (ENT RADenoid 3.5-mm Tricut Blade; Medtronic, Minneapolis, Minnesota) was used in all cases. Statistical analysis of data was conducted using GraphPad Prism version 5.0a (GraphPad Software, La Jolla, California). The independent Student *t* test was used to compare age, time of surgery, MABP, TBL, and BL/min between the HP and RTP groups. The Mann-Whitney *U* test was used to calculate the difference in LM score and Boezaart surgical field of view between both groups. A $P$ value of less than .05 was considered significant. Discussion with a statistician indicated that based on a previous study,[8] a total sample size of 64 patients would be needed to achieve a statistical power of 80%. To determine the sample size, a confidence interval of 95% was used to create a responsive range of double the standard deviation. In consideration of the location and vascularity of the paranasal sinuses, a Boezaart score of 3 was expected during surgery. A clinically significant change in intraoperative bleeding will be defined as a change in Boezaart scoring by 20%, or 1 point in relation to the scale.

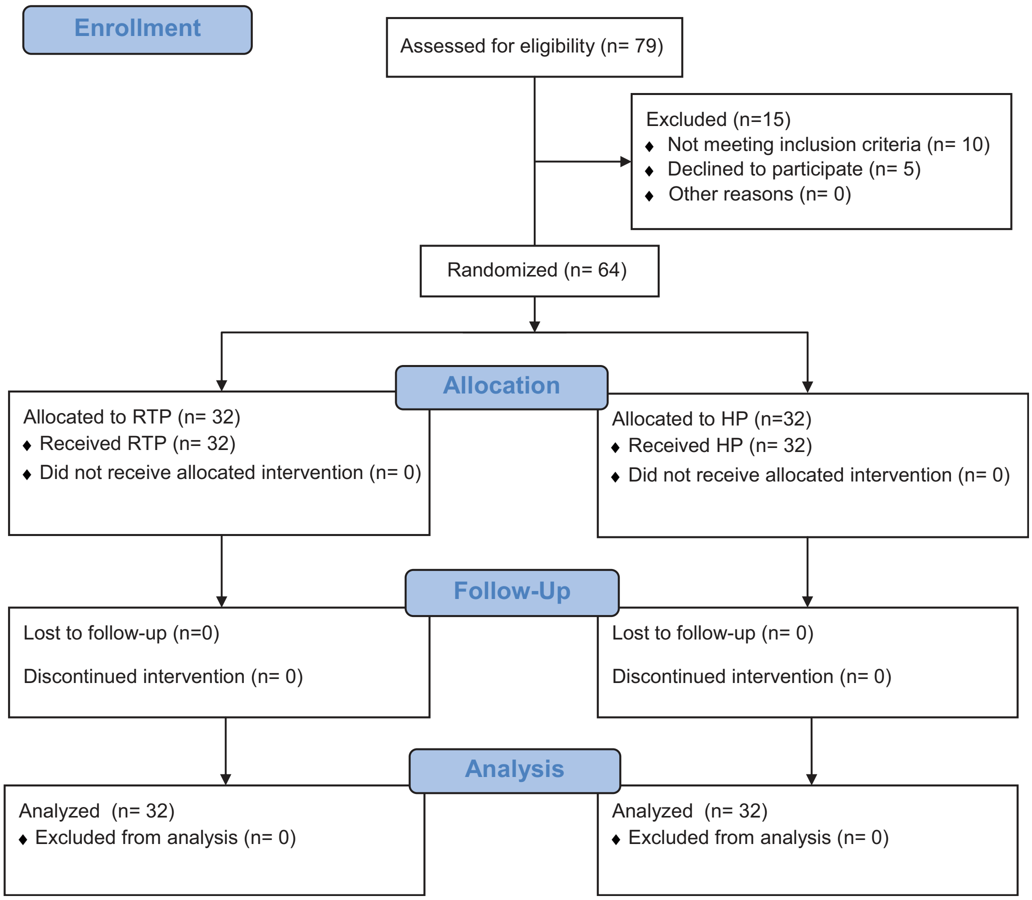


**Figure 1.** Flow diagram showing the pathway of participants through the randomized controlled trial. HP, horizontal position; RTP, reverse Trendelenburg position.

**Table 2.** Characteristics of HP and RTP Groups

| Characteristics | HP Group (n = 32) | RTP Group (n = 32) | *P* Value |
|---|---|---|---|
| Age, y | 50.06 ± 11.69 | 52.13 ± 10.59 | .504 (NS) |
| Sex, No. | | | 1.000 (NS) |
| Male | 15 | 14 | |
| Female | 17 | 18 | |
| Polyposis, No. | 6 | 10 | .387 (NS) |
| CT score (Lund-Mackay system) | 10.94 ± 6.85 | 13.06 ± 7.61 | .283 (NS) |
| TOS, min | 94.38 ± 34.87 | 87.47 ± 35.94 | .434 (NS) |
| MABP, mm Hg | 68.57 ± 7.34 | 68.83 ± 10.71 | .910 (NS) |
| TBL, mL | 426.3 ± 333.0 | 247 ± 198.2 | .01 (95% CI, 265.1-408.2) |
| BL/min, mL/min | 4.26 ± 2.44 | 2.68 ± 1.62 | .003 (95% CI, 2.918-4.021) |
| Surgical field, Boezaart system | 2.33 ± 0.67 | 1.66 ± 0.55 | <.001 (95% CI, 1.822-2.169) |

Values are presented as mean ± SD unless otherwise indicated. Abbreviations: BL/min, blood loss per minute; CI, confidence interval; CT, computed tomography; HP, horizontal position; MABP, mean arterial blood pressure; NS, nonsignificant ($P > .05$); RTP, reverse Trendelenburg position; TOS, time of surgery; TBL, total blood loss.

## Results

Sixty-four patients were included and completed the study, with a mean age of 58 years. There were 32 patients (15 men and 17 women) in the HP group and 32 patients (14 men and 18 women) in the RTP group (**Figure 1**). Multiple variables were compared between the HP and RTP arms, such as LM score, Boezaart surgical field score, MABP, TBL, TOS, and BL/min (**Table 2**). Similar severity of disease was observed between the HP and RTP

**Table 3.** Results of HP and RTP Groups for Cases with Polyposis

| | HP Group (n = 6) | RTP Group (n = 10) | *P* Value (95% CI) |
|---|---|---|---|
| TBL, mL | 750.0 ± 186.2 | 369.5 ± 83.38 | .05 (307.7-716.7) |
| BL/min, mL/min | 6.475 ± 1.274 | 3.626 ± 0.5426 | .04 (3.158-6.239) |
| Surgical field, Boezaart system | 2.859 ± 0.6983 | 2.009 ± 0.5404 | .05 (1.944-2.711) |

Values are presented as mean ± SD. Abbreviations: BL/min, blood loss per minute; HP, horizontal position; RTP, reverse Trendelenburg position; TBL, total blood loss.

**Table 4.** Results for Those Patients with and without Polyps

| Total Population (RTP and HP) | Polyps | No Polyps | *P* Value (95% CI) |
|---|---|---|---|
| n | 16 | 48 | |
| TBL, mL | 512.2 ± 383.7 | 278.1 ± 221.4 | .0038 (265.1-408.2) |
| BL/min, mL/min | 4.698 ± 2.891 | 3.063 ± 1.787 | .0255 (2.92-4.023) |
| Surgical field, Boezaart system | 2.327 ± 0.7199 | 1.885 ± 0.6553 | .037 (1.82-2.169) |

Values are presented as mean ± SD unless otherwise indicated. Abbreviations: BL/min, blood loss per minute; HP, horizontal position; RTP, reverse Trendelenburg position; TBL, total blood loss.

groups, as no significant difference was found when comparing respective LM score ($P > .05$). The RTP group showed significantly reduced TBL ($P = .01$), BL/min ($P = .003$), and Boezaart field of view ($P < .001$). No significant difference was noted in TOS between the HP and RTP groups ($P > .05$). Subanalysis comparing CRS with or without polyps yielded similar results as found in the study population as a whole. Polyposis was present in 6 (19%) patients in the HP group and 10 (31%) in the RTP group. The RTP polyp group showed significantly reduced TBL ($P = .05$), BL/min ($P = .04$), and Boezaart field of view ($P = .05$) when compared with the HP polyp group (**Table 3**). Chronic rhinosinusitis with polyposis showed a significantly higher TBL ($P = .0038$), BL/min ($P = .0255$), and Boezaart score ($P = .037$) compared with CRS without polyps (**Table 4**). This was also the case within both the RTP and HP groups. No adverse events were encountered in any patients in the control or experimental surgical positions.

## Discussion

Functional endoscopic sinus surgery is the established surgical technique for the management of CRS with or without polyposis. The surgery is performed within a small cavity, and therefore even a small amount of bleeding can impair the surgical field and the surgeon's ability to visualize a particular area. The sinonasal mucosa in CRS is often severely inflamed and, in combination with a rich blood supply, can result in rapid bleeding. This can prolong surgery and may increase the chance of complications.[18] Major complications such as cerebrospinal fluid leaks, orbital damage, and carotid artery injury are rare in FESS, with figures of 0.5% to 2% quoted.[19,20] A simple method to reduce blood loss and improve surgical field is therefore welcome. Many techniques have been used to achieve this goal, with the most studied method being hypotensive anesthesia. Reducing mean arterial pressure (MAP) excessively may reduce cerebral perfusion and precipitate ischemia in ''at-risk'' patients. Increasing the concentration of the inhaled volatile agent can induce hypotension, but this is associated with peripheral vasodilation and rebound tachycardia that may in fact increase bleeding.[21] Many different hypotensive agents have also been studied, including β-blockers,[6,22] captopril,[3] and sodium nitroprusside.[4] There remains concern with the use of hypotensive agents in those patients with cardiovascular disease.[6] Other studies have shown that TIVA can improve surgical field and decrease blood loss independent of any reduction of MAP.[7,23,24] However, there remains a need for a simple method to improve surgical field during FESS, such as patient position.

Our study has confirmed that a 15-degree RTP significantly reduces TBL ($P = .01$), BL/min ($P = .003$), and surgical field ($P < .001$) compared with HP. All other variables, including MAP and Lund-Mackay score, showed no significant difference between the 2 groups. There was a trend toward surgery in the RTP group taking less time, but this was not statistically significant. The same anesthetic technique was used in all patients, and no epinephrine was injected or used topically in any of the procedures. Therefore, it seems that RTP significantly improves surgical field and reduces blood loss. This supports the previous findings by Ko et al.[8] Their study showed a reduction in blood loss and an improvement in surgical field with RTP. However, the severity of disease in this population was relatively mild, and the anesthetic technique was not consistent (both desflurane and sevoflurane were used randomly). The investigators also injected lidocaine and epinephrine into the operative field and pterygopalatine fossa in all patients, but the volume given was not standardized—only an upper limit of 10 mL was set. In our study, the anesthetic technique was standardized, and disease severity was much greater with mean LM scores in the RTP group of 13.06 and in the HP group of 10.94. The improvement in surgical field with RTP therefore appears to be maintained even with severe disease. Other studies have used RTP to reduce blood loss, but none of them used RTP as a statistical variable.[3,4] Our findings also showed that bleeding and surgical field are worse in CRS with polyps in either position, again confirming the previous studies in this area.[7,8] This is due to the increased inflammation and vascularity present in the mucosa in CRS with polyps. However, it must be noted that stratification of the patient sample into polyps and no polyps diminishes the power of the hypothesis test. Another limitation of the study is that the surgeon was obviously not blinded to the surgical position of the patient. Attempts were made to try to negate any possible bias in this regard by having 2 surgeons and a third researcher attributing a Boezaart score every 15 minutes and an average score recorded.

The reverse Trendelenburg position is thought to decrease cardiac output and subsequently lower MAP. However, MAP was not found to be significantly different between the 2 groups. Ko et al[8] concluded that as there was no difference in MAP between the 2 positions in their study, as was also the case in our study, the reduction in venous return in the RTP is the most likely mechanism that blood loss is reduced. However, a study measuring nasal mucosal blood flow using laser Doppler blood flowmetry showed that elevation of the head by an angle of 20 degrees reduced nasal mucosal blood flow by 38.3%.[25] Therefore, the mechanism of reduced blood loss in the RTP may be a combination of reduced venous return and reduced arterial blood flow.

The reverse Trendelenburg position has been used between 5 and 30 degrees.[3,4,8,10-14] It has been shown to be safe and effective in neurosurgery at reducing blood loss and intracranial pressure without compromising cerebral perfusion pressure.[10,12-14] However, there remains a concern that in certain patients, prolonged RTP will reduce cerebral perfusion, resulting in ischemia. Venous air embolism has also been reported in a patient undergoing FESS for a tumor excision in a head-up position.[26] It is therefore important to place the patient head up but not to such an extent as to cause complications. The 10- and 15-degree RTP are the only positions specifically studied in FESS and have been shown to significantly improve surgical field and reduce blood loss. It would therefore seem appropriate to place patients in at least 10 degrees RTP and no more than 15 degrees. Any further head-up tilt would seem to be unnecessary. However, currently it is not clear whether a 5-degree RTP would have the same beneficial effect. The 5-degree RTP position has been used in previous FESS research[3,4]; however, position was not a variable being studied, and 5 degrees was used arbitrarily by the operating surgeon. This is something that would be useful to study in the future. At 5 degrees, the potential risk of reduced cerebral perfusion is lower, and if the positive results were replicated, then this would be a more preferable position.

In conclusion, RTP has been shown to significantly reduce TBL, BL/min, and surgical field in FESS. We would therefore recommend RTP as a simple method to reduce blood loss, improve surgical field and visualization, and potentially reduce complications in FESS. It should be noted that changing the patient position from HP to RTP will alter hand-instrument angles. Therefore, a surgeon who has always used the HP should be aware of the changes that occur in these angles when initially adopting the RTP.

## Acknowledgments

We authors thank Rachelle Moshfeghi, BSc, CCRP, for support and guidance regarding the initial design of the study and subsequent ethics application.

## Author Contributions

**Iain F. Hathorn**, design, data acquisition, data interpretation, drafting/revising and approval of manuscript; **Al-Rahim R. Habib**, design, data acquisition/analysis, drafting and approving manuscript; **Jamil Manji**, design, data acquisition/analysis, drafting and approving manuscript; **Amin R. Javer**, design, data interpretation, revising and approving manuscript.

## Disclosures

**Competing interests:** None.

**Sponsorships:** None.

**Funding source:** None.

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