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Total intravenous anesthesia improves intraoperative visualization during surgery for high-grade chronic rhinosinusitis: a double-blind randomized controlled trial

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Abstract

Background: Total intravenous anesthesia (TIVA) has been proposed as a method to reduce blood loss during endoscopic sinus surgery (ESS). Impaired sinonasal visualization due to mucosal bleeding may be burdensome in cases of chronic rhinosinusitis (CRS) with high-grade inflammatory disease, suggesting a role for TIVA in that disease subgroup.

Methods: A double-blind, randomized controlled trial was conducted of adults undergoing ESS at a tertiary medical center. Patients considered for inclusion had high-grade CRS defined as either sinonasal polyposis or a preoperative Lund-Mackay score of ≥ 12 . Subjects were randomized to receive either TIVA or inhaled anesthesia (IA) during ESS. The primary outcome measure was intraoperative visibility as rated by 3 blinded reviewers utilizing the 10-point Wormald Surgical Field Grading Scale. Secondary outcomes included operative blood loss, complications, and change in quality of life evaluated by the 22-item Sino-Nasal Outcome Test (SNOT-22).

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Public clinical trial registration: <http://clinicaltrials.gov/show/NCT02578862>. Total Intravenous Versus Inhaled Anesthesia in Endoscopic Sinus Surgery for Advanced Paranasal Disease.

Results: A total of 72 patients were randomized into TIVA (n = 37) and IA (n = 35) study arms. Aggregate median (interquartile range) Womald scores across all reviewers demonstrated a more favorable visual field with TIVA compared to IA (3.5 [2.4–3.9] vs IA 4.1[3.0–5.8], $p=0.0089$). There was significantly less blood loss in the TIVA = group compared to the IA group (200 mL [100–450] vs 300 mL [200–500], $p=0.046$). Baseline patient characteristics were comparable between cohorts with no significant postoperative complications. No significant changes were detected between postoperative SNOT-22 scores at 3 months ($p=0.278$) and at 6 months ($p=0.396$) following ESS.

Conclusion: TIVA contributes to improved intraoperative visualization and decreased blood loss in patients undergoing ESS for high-grade inflammatory sinus disease.

Keywords

total intravenous anesthesia; chronic rhinosinusitis; endoscopic sinus surgery; intraoperative visualization; nasal polyposis; Lund-Mackay; Sino-Nasal Outcome Test

Successful endoscopic sinus surgery (ESS) is dependent on identification of anatomic landmarks within a confined surgical field. Bleeding from the well-vascularized sinonasal mucosa impairs endoscopic visualization and may lead to complications.¹ Operating in close proximity to the skull base, orbits, and vital neurovascular structures suggests the need for an optimal visual field with minimal mucosal oozing. To this end, a multifactorial approach may be required to limit perioperative bleeding and optimize surgical field visualization.

Several adjunctive methods have been advanced to improve the intraoperative visual field in ESS, including injection of local anesthetics, reverse Trendelenburg positioning, topical decongestants, and controlled hypotension. Total intravenous anesthesia (TIVA) has been suggested as an alternative option, owing to the physiologic decrease in cardiac output without the peripheral vasodilation associated with inhalational anesthesia (IA).² Multiple prospective studies have evaluated changes in intraoperative visual field and blood loss associated with TIVA for ESS.^{3–12} Results from those studies have been inconsistent, with some authors demonstrating improved surgical field visualization and decreased blood loss, while others failed to find significant differences. Recent systematic reviews came to varying conclusions as well,^{2,13,14} suggesting that more high-quality research is needed to further define the role of TIVA for ESS.

A common feature of previous studies has been the inclusion of heterogeneous patient populations who underwent ESS without carefully defining the phenotypic characteristics of the underlying disease. There is scant literature evaluating the effect of TIVA on ESS performed for cases CRS characterized by severe mucosal inflammation, including nasal polyposis and other forms of advanced paranasal sinus disease with extensive opacification on preoperative sinus computed tomography (CT). This may represent a disease population that would particularly benefit from TIVA, as the hyperemia that accompanies inflamed tissue characteristically results in increased bleeding; in turn, reduced intraoperative visibility may impair surgical progress and increase the risk of preventable surgical complications such as injury to the orbit or cranial base. The primary aim of this randomized

controlled trial was therefore to compare the effect of TIVA vs IA on intraoperative visualization in patients undergoing ESS for high-grade inflammatory sinus disease.

Patients and methods

The study was approved by the institutional review board of Ochsner Clinic Foundation (Protocol #2015.131.A) and registered at clinicaltrials.gov (NCT02578862). All research procedures were carried out during the study period of July 2015 to December 2017 with a total of 72 patients included in the study. During the study period, patients undergoing ESS for CRS were identified and evaluated for inclusion by the principal investigator (E.D.M.) at the time of preoperative evaluation. All patients had previously failed to improve with appropriate medical therapy including nasal saline irrigations, topical intranasal corticosteroids, and systemic antibiotics in accordance with published guidelines.¹⁵ Inclusion criteria were established as English-speaking patients aged 18 years or older who required ESS for the treatment of high-grade CRS. High-grade CRS was defined as either (1) polyposis grossly apparent on nasal endoscopy performed at the time of initial evaluation, or (2) a Lund-Mackay score (LMS) of 12 or greater (out of a maximum 24 points), indicating an elevated degree of sinus opacification of preoperative CT imaging. Exclusion criteria consisted of unilateral sinus disease or planned unilateral surgery, neoplastic sinonasal disease, disease extending through the skull base or orbital wall, known nonpharmacologic coagulopathy (platelet <50,000/mL or international normalized ratio [INR] >1.2), daily use of anticoagulant pharmacotherapy (including aspirin), and allergy to 1 of the study medications.

A full description of the research purpose, personnel, procedures, risks, and benefits was presented, and a copy of the study consent documentation was provided for home review. Eligible patients were then assigned a randomly generated unique study identification number. During the preoperative evaluation, all patients were asked to complete the 22-item Sino-Nasal Outcome Test (SNOT-22) questionnaire. Patient characteristics were recorded including age, height, weight, body-mass index (BMI), and American Society of Anesthesiologists' Physical Status score (ASA PS). Aspirin-exacerbated respiratory disease (AERD) was defined as CRS with polyposis, symptomatic asthma, and a clinical history consistent with pulmonary hyperreactivity upon ingestion of nonsteroidal anti-inflammatory drugs. Allergic fungal rhinosinusitis (AFRS) was defined as CRS with polyposis and histopathologic confirmation of noninvasive fungal elements within a sinus lumen. Comorbidities recorded included cardiopulmonary disease, renal disease, liver disease, diabetes, peripheral vascular disease, and tobacco use. On the day of surgery, eligible participants were admitted to the Day of Surgery Department, where a member of the anesthesia team reviewed study information and obtained informed consent. Anesthetic group allocation was performed by a member of the anesthesia staff via a randomly drawn, sealed envelope. At no time was the patient, surgeon, or members of the surgical team made aware of the patient's allocation.

Anesthesia protocol

Preoperative medications were given according to the standard of care, which included midazolam 1 to 2 mg intravenously (IV) prior to being taken to the operating room. Standard anesthetic monitors were placed. Induction of general anesthesia followed the normal standard of care. Induction of anesthesia for both groups consisted of: propofol 2 mg/kg, lidocaine 0.5 to 1 mg/kg, fentanyl 1 to 2 μ g/kg, and muscle relaxation by either succinylcholine 1 to 2 mg/kg or cisatracurium 0.15 to 0.2 mg/kg to facilitate intubation. Maintenance of anesthesia consisted of cisatracurium 0.03 to 0.04 mg/kg and the appropriate anesthetic per protocol described below. Patients in the IA group received sevoflurane in an end-expiratory concentration of 1.4% to 3% corresponding to near minimum alveolar concentration (MAC) of ~0.5% to 1.5%. The carrier gas flow for both groups consisted of a combination of oxygen and air to a total flow rate of 2 L/min to maintain appropriate oxygenation. Patients in the TIVA group received an infusion of propofol in a dose of 100 to 200 μ g/kg/min for maintenance. Sevoflurane concentration was adjusted in the IA group and propofol and remifentanyl dosing were adjusted in the TIVA group with the goal of maintaining mean arterial pressure 70 to 80 mmHg.

During the procedure the surgeon was blinded to the type of anesthesia by shielding the vaporizers and propofol and remifentanyl syringes so that the contents are not visible. Blinding of the surgical team was further ensured by placing sham syringes for the IA and shielding the vaporizers for the TIVA cohort. Both groups were allowed to utilize phenylephrine, ephedrine, labetalol, or esmolol as needed to maintain target blood pressure. Patients were reversed with neostigmine and glycopyrrolate at the conclusion of the case. Post-operative pain relief included either morphine or dilaudid per standard of care. No acetaminophen or nonsteroidal anti-inflammatory agent was given to either group for pain control.

Surgical protocol

All patients were placed in 15-degree reverse Trendelenburg positioning. Ten minutes prior to the start of surgery, cottonoids treated with 4% cocaine were placed into the nasal cavity bilaterally. At the start of the surgery, local injection of 1% xylocaine with 1:100,000 epinephrine was performed under endoscopic visualization into the submucosa at the anterior attachment of the middle turbinate and crista ethmoidalis. Cottonoids soaked with topical thrombin and epinephrine were available for intraoperative maintenance of hemostasis. ESS was completed following the modified Messerklinger technique, with utilization of endoscopic surgical equipment for video documentation of the surgical field.

At the conclusion of the surgery, video recording of the operative field was performed. Recording equipment consisted of the Storz AIDA digital capture system connected to a 4-mm 0-degree rigid endoscope (Karl Storz, Tuttlingen, Germany) by a high-definition camera. The visual field was recorded following the standardized method reported by Athanasiadis et al.¹⁶ with the following protocol. Prior to completion of surgery, old blood was suctioned from the nasal cavity with care not to traumatize mucosal surfaces and reinitiate bleeding. The surgical field was then recorded in a systematic fashion, with observation of 4 intranasal sites: frontal recess, ethmoidal cavity (endoscope positioned just

anterior to the middle meatus), sphenoidal recess, and postnasal space. Each site was serially recorded for 10 seconds each, and repeated bilaterally, for a total of eight 10-second clips per patient. The video was recorded in MPEG2 digital format and transferred to a password-protected workstation. The videos were edited in a uniform sequence and identifying patient information was removed. Three fellowship-trained rhinologists (J.M.L., H.P.B., and G.M.O.) independently graded each of the videos using the Wormald Surgical Field Grading Scale (Table 1).¹⁶

Following completion of surgery, total blood loss was calculated by the nursing circulator, with subtraction of the volume of intraoperative irrigation from the total volume contained in all suction canisters and saturated towels. The patient was transferred to postoperative recovery and released home upon meeting established criteria. Operative duration and postanesthesia recovery unit (PACU) time were obtained from the official times recorded by the circulating nurse and PACU nurse, respectively. Tissue eosinophilia was determined by histopathologic analysis of surgical specimens by a pathologist, and defined as greater than 10 eosinophils per high-powered field.

The primary outcome measure was intraoperative visibility scores as reported by the independent raters utilizing the Wormald Scale. Additional analysis examined secondary outcome measures including estimated blood loss, operative duration, postanesthesia care unit recovery time, antiemetic use, and change in SNOT-22 score at 3 and 6 months postoperatively. Subgroup analysis was performed examining the presence of nasal polyps, tissue eosinophilia, AERD, and AFRS. Other factors considered were extent of preoperative disease (LMS) and presence of comorbidities.

Statistical methods

Estimated sample size was calculated with 95% confidence intervals and 10% margin of error, which yielded a target of 96 patients required to show a significant difference in endoscopic visualization between the TIVA and IA groups. Assuming a loss to follow-up rate of 10%, a total of 110 patients were planned for enrolled. Interim analysis was planned after enrollment of 36 and 72 patients. Intention-to-treat analysis was utilized for primary and secondary study outcomes.

Categorical variables were presented as percentages with differences between the groups assessed using χ^2 tests. Continuous variables with non-skewed distributions were presented as mean (95% confidence interval [CI]) and standard deviation with differences between groups assessed using Student *t* tests. Continuous variables with skewed distributions were presented as median and interquartile range (IQR) with differences between groups assessed by the Wilcoxon rank-sum test. Analysis of variance was used to determine the linear fit of 2 continuous variables. Values of $p < 0.05$ were taken to signify statistical significance. The statistical software package JMP 13.2 (SAS Institute, Inc., Cary, NC) was used for statistical analysis.

Results

This study was performed in accordance with Consolidated Standards of Reporting Trials (CONSORT). The study participant flow diagram is presented in Figure 1. A total of 80 patients were screened, of which 72 met enrolment criteria and agreed to participate. There were 35 randomized to the IA group and 37 allocated to the TIVA group, with 2 patients failing to complete follow-up in the IA group. The primary outcome was met at the second interim analysis; therefore, enrollment was discontinued at 72 patients. Baseline demographic and comorbidity data are given in Table 2. There were no significant differences between the TIVA and IA groups for age, gender, BMI, ASA class, or the various comorbidities. There was no significant difference in the median [IQR] preoperative LMS (TIVA 14 [13–16] vs IA 15 [13–20], $p = 0.714$) or SNOT-22 score (TIVA 48 [37–59] vs IA 46 [27–58], $p = 0.372$).

The primary outcome of median (IQR) Wormald Scale scores for each reviewer and an aggregate score across all three reviewers are presented in Figure 2. All 3 reviewers reported superior intraoperative visibility in the TIVA group compared to the IA group: reviewer 1, TIVA 4.0 [IQR, 3.0–4.8] vs IA 5.1 [IQR, 3.8–5.9], $p = 0.012$; reviewer 2, TIVA 3.7 [IQR, 2.3–4.5] vs IA 5.1 [IQR, 3.4–6.6], $p = 0.009$; reviewer 3, TIVA 2.4 [IQR, 1.9–2.9] vs IA 3.0 [IQR, 2.7–4.1]; $p = 0.0002$. The aggregate score across all reviewers similarly demonstrated intraoperative visibility in the TIVA group (3.5 [IQR, 2.4–3.9]) that was superior to the IA group (4.1 [IQR, 3.0–5.8], $p = 0.009$). Wormald Scale scores for each individual subsite are presented in Table 3.

Secondary outcome measures of median (IQR) blood loss, operative duration, PACU time, and postoperative length of stay are shown in Figure 3. There was significantly less blood loss in the TIVA group (200 [IQR, 100–450] mL) compared to the IA group (300 [IQR, 200–500] mL, $p = 0.046$). PACU recovery time was shorter in the TIVA group (1.3 [IQR, 1.0–1.6] hours) than the IA group (1.7 [IQR, 1.2–2.5] hours, $p = 0.030$). There was no significant difference in median operative time (TIVA 3.4 [IQR, 2.9–3.9] hours vs IA 3.4 [IQR, 2.8–4.0] hours, $p = 0.943$), median postoperative hospital length of stay (TIVA= 9.3 [IQR, 8.2–10.4] hours vs IA 9.4 [IQR, 8.8–12.8] hours, $p = 0.175$), or frequency of treatment with postoperative antiemetics (TIVA 27/37 [73%] vs IA 20/35 [57%], $p = 0.158$) between treatment groups.

Mean (95% CI) SNOT-22 scores did not differ significantly between the TIVA and IA groups at 3 months (TIVA 20.1 [95% CI, 12.6–27.6] vs IA 14.2 [95% CI, 6.4–22.0], $p = 0.278$), or 6 months (TIVA 21.5 [95% CI, 10.0–33.0] vs IA 15.2 [95% CI, 5.9–24.6], $p = 0.396$) postoperatively. Significant improvement from baseline SNOT-22 as reflected by mean change scores was seen postoperatively in both TIVA and IA groups (Fig. 4). No complications or serious adverse events were reported in either study arm.

Bivariate analysis of the predictive value of LMS on aggregate Wormald Scale score is presented in Figure 5. No significant association was found for either the TIVA ($p = 0.126$) or IA ($p = 0.100$) arms. When the treatment arms were combined, the association between LMS and Wormald Scale score was statistically significant ($p = 0.020$).

Subgroup analysis of aggregate median (IQR) Wormald Scale scores according to CRS phenotypic characteristics is presented in Figure 6. Significant differences in intraoperative visibility between TIVA and IA groups were preserved when stratified by the presence of polyposis (TIVA 3.1 [IQR, 2.4–3.9] vs IA 4.5 [IQR, 3.0–5.9], $p = 0.005$) and tissue eosinophilia (TIVA 3.1 [IQR, 2.4–3.9] vs IA 4.1 [IQR, 3.0–5.9], $p = 0.027$). In contrast, a difference in intraoperative visibility was not observed in patients without polyposis (TIVA 3.7 [IQR, 3.2–4.0] vs IA 3.1 [IQR, 2.8–3.5], $p = 0.317$) or tissue eosinophilia (TIVA 3.6 [IQR, 2.6–3.9] vs IA 4.3 [IQR, 3.5–5.1], $p = 0.123$). The presence of AERD or AFRS was not associated with a difference in intraoperative visibility.

Discussion

Anesthesia utilized during ESS should provide optimal conditions for surgical field visualization. Inhaled anesthetics such as sevoflurane and isoflurane induce hypotension by acting directly on the smooth muscle of blood vessels, causing vasodilation of both peripheral and cerebral blood vessels and increasing blood flow to the paranasal sinuses.^{17,18} A possible physiologic benefit of propofol is its induction of hypotension by depressing central sympathetic tone, thereby inducing a state of controlled hypotension without peripheral vasodilation.¹⁹ Additional techniques to limit bleeding during ESS include patient positioning and use of regional anesthesia. Previous randomized controlled trials have examined the use of reverse Trendelenburg position in ESS and found that this position improves endoscopic visualization and decreases blood loss.^{20,21} Regional anesthesia techniques such as pterygopalatine fossa injections with lidocaine and epinephrine may induce local nasal mucosal vasoconstriction and provide improved analgesia.^{22,23}

In this randomized, double-blinded, controlled clinical trial, the use of TIVA resulted in improved visual field and decreased total blood loss when compared to conventional IA. These findings suggest that TIVA should be considered for preferential use in place of volatile anesthesia during ESS for high-grade CRS, including patients with nasal polyposis or a preoperative LMS 12. The secondary outcome of postoperative SNOT-22 scores showed significant improvement from baseline in both treatment arms, indicating that patient-reported quality-of-life improves after ESS regardless of anesthetic type.

Multiple studies have assessed the effect of TIVA on visual field in ESS with varying results. The recent study by Aujla et al.⁴ compared quality of surgical field with TIVA (propofol) vs IA (isoflurane) using a 6-point scale. Similar to our results, they noted improved quality of surgical field at the completion of cases when using TIVA. The systematic review by DeConde et al.² found statistically significant improved surgical visibility score with TIVA compared to IA across 7 studies.^{3,8,9,11,12,24,25} Notably, not all of these studies had preoperative LMS or proportion of patients with nasal polyposis available for analysis. Two other systematic reviews returned mixed results, with a Cochrane review finding a possible improvement in surgical field using TIVA,²⁶ while Kelly et al.¹⁴ found that no conclusions could be made secondary to the heterogeneity and limitations of available studies. Meta-analysis has not been possible due to numerous confounding variables related to study design and outcome measures of estimated blood loss and intraoperative visual field.

The present study found a statistically significant improvement in Wormald Scale scores among patients with high-grade CRS undergoing ESS with TIVA across independent assessment by 3 blinded, fellowship-trained rhinologists. All patients had high-grade CRS defined by LMS >12 or presence of bilateral nasal polyposis. Bivariate analysis of LMS vs Wormald Scale score demonstrated less favorable visualization scores for higher preoperative LMS. This association did not reach statistical significance for either TIVA or IA arms, but did reach significance for the entire study population, suggesting that preoperative CT may be useful to predict intraoperative visibility. Importantly, subgroup analysis of aggregate Wormald Scale scores showed preservation of a positive effect of TIVA on intraoperative visualization for cases with polyposis and tissue eosinophilia, which supports the hypothesis that use of TIVA may be particularly beneficial during surgery in patients with these phenotypic characteristics.

Conflicting data exists on the relationship between TIVA and intraoperative blood loss in ESS. A recent report by Al-Bar et al.²⁷ found TIVA anesthesia may not provide any appreciable reduction in intraoperative blood loss when compared to conventional anesthesia protocols. DeConde et al.² noted there was no significant difference in blood loss in six studies when using TIVA or IA, although heterogeneous variables and outcomes existed across included studies. In contrast, our study demonstrated a significant improvement in total blood loss in the TIVA group. No significant differences were found between cohort demographics or comorbidities.

Our data revealed no difference in operative time, total time of hospital stay, or postoperative antiemetic requirement; however, time spent in the PACU was shorter in the TIVA group. There is little data comparing anesthesia complications and recovery times in TIVA and IA, with varying results for postoperative pain, nausea, and vomiting.^{28,29} Evaluating differences in major complication rates including orbital injury and cerebrospinal fluid leak is difficult given the low incidence of occurrence. While it is expected that improving visual field during ESS should aid in reducing perioperative complications, the current study was not powered to detect these differences.

This double-blind, randomized, clinical trial contains several weaknesses that must be considered. The single-site study design has the potential to limit external validity; therefore, multisite study of TIVA in ESS is necessary to validate study findings and definitively alter patient care. Mean arterial pressure was maintained between 70 and 80 mmHg for both TIVA and IA groups, although the means for both groups were not recorded, and the possibility of a significant difference between groups is unknown. Agents utilized to maintain hemodynamic stability were not administered via a protocol, as these medication differences are driven by patient response during surgery. Although statistically significant differences in intraoperative visibility were found, the clinical significance of those observed differences is unclear, as the minimal significant difference for that parameter has not been determined and will require further study. The amount of topical epinephrine and thrombin used to limit bleeding during ESS was also not quantified and represents a potential confounding factor in this study. Moreover, a single recording of bleeding was utilized at the end of the case, which was chosen to allow standardization of the recording at a specific, common time in each case, before application of any hemostatic dressing, stent, or packing.

Last, total blood loss was calculated by the nursing staff at the end of each case, although this staff was not the same for all cases.

Conclusion

The results of this double-blind, randomized controlled clinical trial support the use of TIVA in patients with high-grade CRS undergoing ESS. TIVA appears to significantly improve endoscopic visualization and total blood loss during ESS. This study provides evidence for the use of TIVA over IA for a select population of patients undergoing ESS for recalcitrant CRS, particularly those with polyposis or tissue eosinophilia. Additional rigorously controlled studies are warranted to establish a standard for optimal anesthetic conditions during ESS.

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FIGURE 1.

CONSORT flowchart. CONSORT = Consolidated Standards of Reporting Trials.

FIGURE 2. Wormald Surgical Field Grading Scale median scores per reviewer (A-C) and aggregate mean scores (D) across all 3 reviewers.

FIGURE 3.

(A) Median estimated blood loss. (B) Median operative time. (C) Median (PACU) recovery time. (D) Median postoperative hospital length of stay. PACU = postanesthesia care unit.

FIGURE 4.

Matched pairs analysis of change in SNOT-22 scores from baseline to (A) 3 months postoperatively and (B) 6 months postoperatively. SNOT-22 = 22-item Sino-Nasal Outcome Test.

FIGURE 5. Bivariate analysis of Lund-Mackay score and aggregate Wormald Surgical Field Grading Scale median scores for TIVA (top panel) and IA (bottom panel) groups. IA = inhaled anesthesia; TIVA = total intra venous anesthesia.

FIGURE 6.
Subgroup analysis of aggregate Wormald Surgical Field Grading Scale median scores according to phenotypic characteristics.

TABLE 1.Wormald Surgical Field Grading scale¹⁵

Grade	Assessment
0	No bleeding
1	1–2 points of ooze
2	3–4 points of ooze
3	5–6 points of ooze
4	7–8 points of ooze
5	9–10 points of ooze (sphenoid fills in 60 seconds)
6	>10 points of ooze, obscuring surface (sphenoid fills in 50 seconds)
7	Mild bleeding/oozing from entire surgical surface with slow accumulation of blood in the postnasal space (sphenoid fills by 40 seconds)
8	Moderate bleeding from entire surgical surface with moderate accumulation of blood in the postnasal space (sphenoid fills by 30 seconds)
9	Moderately severe bleeding with rapid accumulation of blood in the postnasal space (sphenoid fills by 20 seconds)
10	Severe bleeding with nasal cavity filling rapidly (sphenoid fills in <10 seconds)

Baseline characteristics of subjects undergoing functional endoscopic sinus surgery for high-grade chronic rhinosinusitis after randomization to anesthetic treatment arms*

TABLE 2.

Characteristics	Total intravenous anesthetic (n = 37)	Inhaled anesthetic (n = 35)	p
Demographics			
Age (years), mean [IQR]	45 [20–77]	55 [25–81]	0.234
Gender, n (%)			0.299
Female	16(43.2)	11 (31.4)	
Male	21 (56.8)	24 (68.6)	
BMI (kg/m ²), mean [IQR]	31 [21–56]	28 [19–53]	0.099
ASA PS, n (%)			0.854
I	2 (5.4)	3 (8.6)	
II	28 (75.7)	25(71.4)	
III	7(18.9)	7 (20.0)	
Disease factors			
Polyposis	31 (83.8)	33 (94.3)	0.156
Tissue eosinophilia	28 (75.7)	30 (85.7)	0.282
AFRS	5(13.5)	3 (8.6)	0.505
AERD	3(8.1)	3 (8.6)	0.943
Patient assessments			
Lund-Mackay score, median [IQR]	14 [13–16]	15 [13–20]	0.714
SNOT-22 score, median [IQR]	48.0 [37–59]	45.5 [27–58]	0.327
Comorbidities, n (%)			
Systemic hypertension	16(43.2)	13(37.1)	0.598
Diabetes mellitus	2 (5.4)	3 (8.6)	0.597
Reactive airway disease	16(43.2)	16(45.7)	0.833
Coronary artery disease	1 (2.7)	1 (2.9)	0.968
Renal disease	0(0)	2 (5.7)	0.086
Non-sinus dysrhythmias	0(0)	1 (2.9)	0.227

Characteristics	Total intravenous anesthetic (n = 37)	Inhaled anesthetic (n = 35)	p
Congestive heart failure	1 (2.7)	0(0)	0.246
Tobacco use	8(21.6)	13(37.1)	0.146
COPD	3(8.1)	4 (11.4)	0.634
Peripheral vascular disease	3(8.1)	1 (2.9)	0.320
Liver disease	2 (5.4)	0(0)	0.099

* Values of $p < 0.05$ are considered statistically significant.

AERD = aspirin-exacerbated respiratory disease; AFRS = allergic fungal rhinosinusitis; ASA PS = American Society of Anesthesiologists' Physical Status Score; BMI body mass index; COPD = chronic obstructive pulmonary disease; IQR = 25%–75% interquartile range; SNOT-22 = 22-item Sino-Nasal Outcome Test.

TABLE 3.

Wormald Surgical Field Grading scale median scores by anatomic subsite^{*}

	Right side				Left side			
	Frontal	Ethmoid	SE recess	Choana	Frontal	Ethmoid	SE recess	Choana
Anesthetic								
TIVA	3.3	3.3	3.3	2.7	3.3	3.3	3.3	3
IA	4.3	4.2	4.8	3.3	4.0	4.3	4.3	3.7
<i>p</i>	0.0196	0.0108	0.0027	0.0500	0.0284	0.0029	0.0106	0.1031

^{*} Values of $p < 0.05$ are considered statistically significant.

IA = inhaled anesthetic; SE = sphenothmoidal; TIVA = total intravenous anesthetic.