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RHINOSINUSITIS (J. MULLOL, SECTION EDITOR)

Optimization of the Surgical Field in Endoscopic Sinus Surgery: an Evidence-Based Approach

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Abstract

Purpose of Review The advent of endoscopic sinus surgery (ESS) has enabled the development of minimally invasive surgical procedures in Rhinology. However, proficiency with ESS techniques can still be hampered by poorly controlled bleeding limiting visibility of the surgical field (VSF). This can lead to increased operating time and, more importantly, increased risk of major and minor complications. To optimize the VSF and mitigate the risk of complications, many strategies have been explored.

Recent Findings This is a narrative review of the relative risks and benefits of pre- and intra-operative interventions aimed at optimizing intraoperative conditions during ESS. The value of these interventions is determined based on their impact on intraoperative blood loss, time of surgery, and the VSF, and weighed against their adverse event profile.

Summary This review provides a comprehensive overview of the evidence relating to the safety and efficacy of interventions used to improve intraoperative conditions during ESS.

Keywords Hemostasis · Blood loss · Endoscopic sinus surgery · Surgical field · Rhinosinusitis · Evidence-based

Introduction

The incorporation of the Hopkins rod-lens system in sinonasal surgery revolutionized the field of Otolaryngology and introduced new diagnostic concepts and surgical techniques that kept expanding over the last 30 years. As visualization of the sinonasal cavity evolved, functional endoscopic sinus surgery (FESS) has become the gold standard in treating medically refractory chronic rhinosinusitis (CRS) [1]. While great strides have been made in the domain of endoscopic imaging technology, visualization during FESS remains a challenge due to the vascularity of the narrow corridors of inflamed sinuses. Excess bleeding during sinus surgery can hypothetically lead to an increase in operative time, difficulty of surgery and devastating complications [2–6].

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A bloodless field in FESS is the ideal surgical state that rhinologists strive to achieve, and a significant amount of research and development has been dedicated to pursuing this aim in the last 10 years. To measure the impact of each intervention on bleeding during FESS, subjective and/or objective measures are typically employed. Subjective endoscopic grading of the visibility of the surgical field (VSF) is widely used and two main grading systems exist. A 6-point scale as proposed by Boezaart et al. [7] and an 11-point scale proposed by Athanasiadis et al. [8] (Wormald Bleeding Scale). Both provide a dynamic method of measuring the amount of bleeding in the surgical field but the inter- and intra-rater reliability of each system can be a limiting factor [8]. The main objective variables are total blood loss (TBL) and operative time (OT). However, the objectivity of measuring the TBL that has been debated as the quantity of ingested fluid is typically not considered in its calculation and can be a limitation of its use [9]. As an objective measure, OT may provide insight as to the downstream impact of less tangible benefits gained from intraoperative interventions. For example, as bleeding increases in the surgical field, maneuvers to clean the endoscope, suction, and pack increase as well, leading to a gradual increase in OT [10].

Optimizing CRS patients prior to and during FESS is of paramount importance to reduce surgical site bleeding and improve outcomes. Nowhere is this more evident than in cases with advanced sinonasal inflammatory disease where bleeding has been documented to be excessive and complication rates are higher [11–13]. Here, we review the pre- and intraoperative reported measures to optimize hemostasis in patients undergoing endoscopic sinus surgery (ESS).

Intranasal Corticosteroids

The clinical efficacy and use of intranasal corticosteroids (INCS) in all forms of CRS, with and without nasal polyps, has been extensively studied and is recommended in medical management of the disease due to its anti-inflammatory effects and favorable safety profile [14]. The vasoconstrictive properties of topical corticosteroids (CS) have been demonstrated in the dermatology and respirology literature. The potency of topical CS can be measured by the amount of skin blanching post application on the skin [15]. Also, inhaled CS use has been associated with a decreased density of vessels in the bronchial walls of asthmatic patients [16]. Intranasal use of budesonide did not, however, show the same effects on mucosal blood flow demonstrated by laser doppler and 133Xe washout-methods [17]. The theoretical decrease in mucosal vascularity from usage of INCS could be related to its well-documented effects in reducing inflammatory cell infiltration, capillary permeability and local inflammatory mediator production and release in affected sinonasal tissue [18, 19].

To our knowledge, only a single study has investigated the effects of INCS on bleeding during FESS in CRS patients. Albu et al. randomized 70 primary CRS patients to receive either a placebo or mometasone furoate 200 μg twice daily 4 weeks prior to FESS. Compared to the placebo group, the mometasone furoate group demonstrated significantly decreased TBL by 16.2% (mean difference = 27.7 ml), OT by 16% (mean difference = 11.2 min) and the Boezaart score by 0.8 points. Sub-classification of patients into different phenotypes, CRS with (CRSwNP) and without (CRSsNP) nasal polyps has also demonstrated the same beneficial and significant effects of INCS on bleeding during FESS. Patients with polyps extending beyond the middle meatus were excluded from the study on the rationale that the volume of polyps might hinder the possible effects of INCS [20]. Hence, the effects of using preoperative INCS on that population are still unknown. Knowing the poor sinus distribution of pressurized sprays in un-operated or operated sinuses [21], other topical intranasal corticosteroid delivery methods such as budesonide-impregnated nasal saline irrigation could potentially yield better results; however, this has not been investigated to date.

Oral Corticosteroids

Despite the short-lived benefits and known detrimental effects, the use of oral corticosteroids (OCS) is still considered a valid option in managing cases of CRSwNP [14]. In 2016, two Cochrane reviews were published on the use of OCS as adjunct or stand-alone therapy and included ten trials with a total of 552 participants. The improvement in symptom severity and polyp size was demonstrated but the quality of evidence was low and long-term data was lacking [22, 23].

In a survey sent to members of the American Rhinologic Society (ARS) in 2012, 88.8% of 170 respondents were using systemic corticosteroids preoperatively and 58.8% admitted that although there was no solid evidence supporting its use, they still prescribed it. The powerful anti-inflammatory effects of OCS and the prevailing surgical dogma passed down from mentors may have influenced them to choose that practice [24]. Multiple metanalyses and reviews have been published on the use of OCS preoperatively in CRSwNP cases [25–28]. Unfortunately, each of these did not include all trials as shown in Table 1 due to multiple reasons. Inconsistencies related to study design, standard protocols, operative variables, and dosage schedules of preoperative systemic steroids used created major concerns in the possible interpretation of results if included. In a metanalysis, Pundir et al. [26] only included two trials on the effect of corticosteroids on intraoperative outcomes in FESS. The first trial included was that of Siekiewicz et al. in which they reported significantly better VSF and OT with no significant change in TBL using 30 mg of prednisone for 5 days preoperatively in CRSwNP cases [29]. The other study is by Albu et al. [20] in which preoperative INCS and not OC was used in CRS cases as mentioned in the above section. Pundir et al. [26] reported that VSF, OT, and TBL all significantly improved in the joined corticosteroid group. However, combining the data of these two trials did not adequately answer the question whether preoperative OCS in CRSwNP cases decreased bleeding in FESS. In another metanalysis, Hwang et al. [28] attempted to answer that question by enrolling five trials. The data from Sieskiewicz et al. [29], Fraire et al. [31], Ecevit et al. [32], Gunel et al. [33], and Albu et al. [20] trials were included for a total of 187 participants. Due to the heterogeneity in methodology between trials, the standardized mean difference (SMD) was used to study the effect size of preoperative corticosteroids on operative variables. They have shown that the effect size is 0.6 regarding TBL, 0.85 regarding VSF, and 0.84 regarding OT favoring the use of OCS preoperatively. Subgroup analysis comparing preoperative systemic and topical intranasal corticosteroid administration showed similar positive significant effects on operative bleeding variables in these cases. In an attempt to compare prescription patterns of preoperative OCS, Atighechi et al. [10] has found that a 5-day course of 1 mg/kg of prednisone led to a significant decrease

Table 1 Trials on preoperative use of Oral Corticosteroids in CRSwNP cases

Author (year)	Study design	n	Oral steroid type and initial daily dose	Oral steroid preoperative duration	Preoperative tapering of oral steroids	Visibility of the surgical field intergroup score difference	Operative time intergroup difference	Total blood loss intergroup difference	Other finding (s)
Sieskiewicz et al. (2006) [29]	Randomized controlled	36 participants	Prednisone 30 mg	5 days	Not done	0.9 points in Boezaart Score favoring steroids ($p < 0.05$)	11 min favoring steroids ($p < 0.05$)	28 ml favoring steroids (NS)	n/a
Wright et al. (2007) [30]	Randomized placebo-controlled	26 participants	Prednisone 30 mg	5 days	Not done	n/a	8.8 min favoring placebo (NS)	3.2 ml favoring placebo (NS)	Higher degree of surgical difficulty in placebo group
Fraire et al. (2012) [31]	Non-randomized controlled trial	31 CRSwNP participants	Prednisone 30 mg	5 days	Not done	1.4 points in Boezaart Score favoring steroids (NS)	5 min favoring steroids (NS)	31.5 ml favoring steroids ($p < 0.05$)	n/a
Ecevit et al. (2015) [32]	Randomized placebo-controlled trial	22 participants	Prednisone 60 mg	17 days	Reduced on day 7 to 10 mg every other day to stop on day 17	1 point in Boezaart Score favoring steroids ($p < 0.05$)	10.7 min favoring steroids ($p < 0.05$)	243 ml favoring steroids ($p < 0.05$)	Hospital stay significantly less in steroid group ($p < 0.05$)
Gunel et al. (2015) [33]	Randomized placebo-controlled trial	65 participants	Prednisone 1 mg/kg for 2 days	10 days	Tapered over 10 days	1 point in 10-point scale favoring placebo (NS)	n/a	36 ml favoring placebo (NS)	n/a
Atighechi et al. (2013) [10]	Randomized controlled trial	80 participants	Prednisone 1 mg/kg	Group A: 1 day Group B: 5 days	Not done	No significant difference	n/a	60.5 ml favoring 5-day course of OC ($p < 0.05$)	n/a

n/a not applicable, *NS* non-significant in TBL (mean difference = 60.5 ml) compared to a 1-day course with no significant change in VSF in CRSwNP cases.

Despite the improvement in operative variables mentioned above, two issues should be considered when using OCS in CRSwNP preoperatively. The usage of OCS can alter proinflammatory marker and cell levels within nasal polyps which can be a concern especially in academic centers conducting research on collected sinonasal tissue [34]. The other critical point is to inform patients about the possible psychiatric, metabolic, and gastrointestinal side effects of short-term OCS use and rule out contraindications of usage [35, 36]. Based on the best available evidence, preoperative OCS doses in CRSwNP cases should not exceed 1 mg/kg per day, for up to 2 weeks, to optimize surgical bleeding in FESS.

The risk-benefit ratio of using preoperative OCS in CRSsNP cases could potentially be high due to the lack of data showing efficacy in these cases [14]. Fraire et al. conducted the only randomized controlled trial that studied the effect of preoperative OCS in 23 CRSsNP cases [31]. The addition of preoperative OCS did not significantly alter operative bleeding variables (OT, VSF, and TBL) in these cases. Hence, the use of preoperative OCS in CRSsNP cases in not recommended currently.

Local Injection of Vasoconstrictors

The value of local injection of vasoconstrictors in FESS is often a subject of debate between centers. The body of literature surrounding this intervention is inconclusive with regard to efficacy, and thus the risk of adverse events should guide the choice to use injectable vasoconstrictors over other options highlighted in this review.

When compared to topical epinephrine in a case-control study, Lee et al. found that local infiltration of epinephrine yielded no additional benefit in terms of duration of surgery and total blood loss [37]. Given that local infiltration with epinephrine was associated with a sharp spike in mean arterial blood pressure (MABP), it was thought that this may have nullified any potential vasoconstrictive benefit [37]. This phenomenon was also noted in another RCT comparing patients receiving local infiltration with epinephrine (1:200,000 with bupivacaine 0.25%) to a normal saline injection control arm. MABP was significantly higher in the group receiving epinephrine injections compared to the control group (72.2 vs 77.1 mmHg) [38].

Such hemodynamic changes, however, have not consistently been associated with the use of injected epinephrine. In a separate RCT where subjects received a unilateral injection of epinephrine (1:80,000 with lidocaine 2%) into the PPF during FESS, there was no significant difference in MABP compared to controls [39]. While a statistically significant improvement in the endoscopic visual field was also demonstrated when compared to the control side, this only constituted a 0.40 difference in Boezaart score between treatment arms (2.59 vs 2.99) [39].

Epinephrine, often combined with lidocaine, can be locally injected into either the lateral nasal wall or the pterygopalatine fossa (PPF). When the maxillary artery enters the pterygopalatine fossa (PPF), it divides into five terminal artery branches that supply the nasal cavity: the sphenopalatine artery, descending pharyngeal artery, greater and lesser palatine arteries, and the artery of pterygoid canal. The latter technique of injecting epinephrine into the PPF aims to induce vasoconstriction of the sphenopalatine artery. The safety and efficacy of this intervention can be highly dependent on operator technique. Infiltration of the PPF beyond the greater palatine canal can potentially cause major complications related to intravascular injection of anesthetic, as well as procedural trauma to the infraorbital and orbital nerves [40, 41]. In order to establish a safe infiltration protocol, a study of 22 adult Caucasian cadavers (including eight females) was undertaken. The average length of the greater palatine canal (18.5 mm, 95% CI 17.9–19.1) and soft tissue depth overlying the foramen (6.9 mm, 95% CI 6.2–7.6) was measured using high-resolution computed tomography (CT) images [41]. Needles penetrating 10 mm in depth did not reach the PPF and those penetrating up to 20 mm only reached the junction of the PPF and the greater palatine canal [41]. Based on this cadaver study cohort, it was determined that the needle should be bent at a 45° angle 25 mm from the tip in order to facilitate safe delivery of adrenaline into the PPF by preventing over-insertion [41].

In a study by Eloy et al. comparing both modalities, there was no significant difference in total intraoperative blood loss between patients that received epinephrine via injection of the greater palatine canal versus lateral nasal wall [42]. With regard to dosage, the available literature suggests that injectable epinephrine at concentrations of 1:200,000 and 1:100,000 are equivalent in terms of safety and efficacy [43]. While a transient increase in MABP was noted in the first 2 min following injection in the higher concentration group (1:100,000), the MABP returned to a normal range after 5 min.

Although there are instances of contradicting findings in the literature, the overwhelming majority of evidence suggests that injected epinephrine may have a negligible effect when compared to a control (saline injection or nil) and no significant benefit over topical vasoconstrictors.

Topical Sinonasal Vasoconstrictors

Topical sinonasal vasoconstrictors employed in sinus surgery have included various aqueous or paste-based formulations of cocaine, epinephrine, phenylephrine, and oxymetazoline [44].

Overall, these are an effective means of optimizing the intraoperative visual field. However, the safety of their use has been called into question based on a relatively small sample of cases of serious adverse events associated with their using during sinus surgery [44]. While it is difficult to establish causality in many of these cases due to study design and the small sample sizes involved, one can appreciate that caution should be exercised in higher risk patients, such as those with comorbid cardiovascular disease.

Given that an overwhelming proportion of the cases of adverse events related to topical sinonasal vasoconstrictor use during FESS are associated with cocaine-based formulations, many otolaryngologists have opted to discontinue topical intranasal cocaine use, in favor of topical intranasal epinephrine [45]. Any benefit derived from the use of topical intranasal cocaine as a hemostatic agent must also be weighed against the added potential for substance abuse and the administrative burden of storing and requisitioning this agent. Given that RCT's comparing the efficacy of common topical formulations of cocaine (4%) to epinephrine (1:1000) [46] and phenylephrine (0.5%) [47] have demonstrated non-inferiority, it would be reasonable to preference the use of either agent over topical intranasal cocaine [46].

The safety of epinephrine has not been documented in pediatric cases, thus, practitioners may prefer the use of oxymetazoline under normal bleeding conditions [48]. A set of recommendations for the use of topical sinonasal vasoconstrictors in FESS were proposed (Table 2) based on a meta-analysis of 42 articles, including 19 case reports, nine RCT's, seven non-randomized studies, five survey studies, and two guidelines articles [44].

In essence, the discerning sinus surgeon may use topical sinonasal vasoconstrictors to optimize intraoperative conditions during FESS, employing 1:2000 or 1:1000 epinephrine in adults and 0.05% xylometazoline in pediatrics, while observing safe-handling protocols for the operating room and exercising caution in patients with cardiovascular comorbidities [44].

Table 2 Recommendations for the use of topical sinonasal vasoconstrictors in FESS proposed by Higgins et al. [44]

1. Do not use topical intranasal phenylephrine if possible.
2. Use caution with topical intranasal cocaine.
3. Avoid β-blockers for intraoperative hypertension after topical vasoconstrictor use.
4. Avoid halogenated hydrocarbon anesthetic agents (i.e., Halothane) when using topical sinonasal vasoconstrictors.
5. If possible, avoid using concentrated topical intranasal cocaine or epinephrine in patients with history of cardiovascular disease.
6. For neonate to 85 lbs or 12 years old (child), consider using 0.05% topical intranasal oxymetazoline first. If adequate visualization or hemostasis is not achieved, consider 1:2000 topical intranasal epinephrine with judicious use.
7. For 85 lbs to 17 years old (adolescent), use topical intranasal oxymetazoline or 1:2000 topical intranasal epinephrine with judicious use.
8. ≥ 18 years old (adults), use 1:2000 or 1:1000 topical intranasal epinephrine with judicious use.

Positioning of Patients Intraoperatively

While topical and injectable vasoconstrictors are effective for achieving hemostasis and optimizing the surgical field of view, the use of these agents is not without risks and caution should be taken when employed in patients with comorbid cardiovascular disease. For decades, surgeons have taken advantage of the ability to alter vascular supply to their operative field by adjusting the angle of the operating room table to their advantage. In the context of head and neck surgery, placing a subject in the reverse Trendelenburg position (RTP) creates a situation where venous return and cardiac output is decreased, and thus, arterial pressure is decreased [49].

Ko et al. first demonstrated the efficacy of the RTP, set at a 10° angle, to improve endoscopic field of view and reduce blood loss during endoscopic sinus surgery (ESS) when compared to control (supine position) [49]. In an RCT comparing the 15-degree RTP against supine positioning, RTP significantly reduced TBL (426 mL vs 247 mL), blood loss per minute (4.26 vs 2.68 mL/min), and Boezaart score (2.33 vs 1.66). Subgroup analysis demonstrated that significant improvements in total blood loss and endoscopic field of view were observed even in cases of CRSsNP that tended to have less intraoperative blood loss on average [50].

The optimal RTP angle was investigated in a subsequent RCT employing the 5-, 10-, and 20-degree RTP position on intraoperative outcomes during FESS [50, 51]. Total blood loss and VSF (via Boezaart score) were significantly improved in the 20-degree position above all others. The literature cautions positioning patients beyond a 30-degree RTP as this could result in decreased cerebral perfusion pressure [51]. The use of this technique during FESS also comes with the caveat that, should excessive bleeding occur, these patients should be re-positioned supine because the RTP, under such circumstances, could theoretically potentiate the risk of hypotensive shock [49].

The 15–20-degree RTP position offers a safe and highly effective technique for optimizing surgical conditions during FESS.

Hot Saline Irrigation

Hot water irrigation (HWI) was first described by Guice in 1884 in the management of intractable cases of epistaxis [52]. Several studies demonstrated its efficacy in controlling cases of posterior epistaxis [53–55]. Strangerup and Thomsen found that exposing rabbit nasal mucosa to hot water at temperatures between 48C and 52 °C led to mucosal edema, narrowing of the nasal cavity and vasodilatation without any demonstrable toxic effects [55]. It was then postulated that these findings can aid in hemostasis as edema can facilitate tissue compression on a bleeding vessel and vasodilatation decreases the intravascular pressure inducing stasis of blood.

Gan et al. randomized 62 CRS patients undergoing FESS to either receive room temperature or hot (49 °C) saline nasal irrigation every 10 min throughout the procedure [56]. HSI led to a significant decrease in TBL (mean difference = 70.7 ml, $p = 0.04$) but VSF (via Boezaart score) and OT did not differ between groups. Further analysis of cases extending beyond 2 h showed a statistically significant improvement in VSF in the group receiving HSI (mean difference = 0.4 points, $p = 0.04$). However, the clinical significance of this small improvement (less than one point) is not clear. This study exemplifies the possible hemostatic effect of HSI in FESS which could be more pronounced in cases with advanced disease requiring lengthier surgeries.

Anesthesia Technique

Sinonasal mucosal bleeding is a function of the mean arterial blood pressure (MABP) which is determined by the systemic vascular resistance (SVR), cardiac output (CO), and central venous pressure (CVP) [4, 57•]. Decreasing the MABP to levels between 50 and 70 mmHg (deliberate or controlled hypotension) has been associated with improvement in the sinonasal surgical field but methods vary. To assess the density of the microcirculation in sinuses, expression of CD34 antigen was reported in 30 cases of CRS. As CD34 expression increased, intense reduction of MABP levels was required to achieve a bloodless field [12]. Although considered to be generally safe, deliberate hypotension to a MABP below 60 mmHg can decrease the cerebral perfusion significantly and has been linked to neurological and systemic adverse events in some cases [58, 59].

To alter MABP levels, the CVP can be manipulated through positioning of the patient and this was tackled in the above section [60]. Alternatively, hypotension can be achieved by decreasing the SVR through vasodilation (e.g., using sodium nitroprusside). This has been shown to be inferior to other techniques in improving the sinonasal surgical field owing to the reflex tachycardia that occurs to maintain the CO [7, 57•]. Decreasing the heart rate (HR) and cardiac contractility using β-blockers (e.g., esmolol or metoprolol) has been associated with a significant improvement in VSF and a decrease in the average blood loss in FESS [5, 61]. Even in the absence of β-blockers, a significant correlation between the HR and VSF was recognized with significantly worse VSF if the HR goes above 60 beats/min [5]. Achieving hypotension by infusing $MgSO_4$ in anesthesia for FESS has been associated with significantly better VSF and TBL [62]. However, it can prolong emergence time due to potentiation of neuromuscular drugs and opiates [63].

For induction and maintenance of general anesthesia, volatile agents (e.g., sevoflurane) are commonly used. Their use results in hypotension through vasodilation which in turn increases the nasal mucosal perfusion. This can lead to a hypothetical rise in bleeding during FESS. In 1993, Blackwell et al. introduced total intravenous anesthesia (TIVA) in FESS cases as an alternative to achieve controlled hypotension with a decreased occurrence of peripheral vasodilation. It also reduces the cerebral perfusion which can potentially decrease the flow in the ethmoid arteries feeding the nasal cavity [64]. Propofol alone or in combination with a short acting opioid such as remifentanil that are given intravenously achieve the desired level of anesthesia with less variability in MABP and HR [4]. Over the last 25 years, the additional benefits of using TIVA in ESS have been debated. Three systematic reviews were published in addressing this issue [60, 65, 66]. Inconsistencies in sampling techniques, outcome measures, anesthetic protocols, and lack of power due to small sample sizes were significant limitations that led to a dispute in interpreting the pooled data. All three reviews have shown a small improvement in VSF favoring TIVA with no significant changes seen in TBL or OT and definitive recommendations could not be made due to the limitations mentioned above. Little et al. addressed some of these methodological issues in a recent randomized trial comparing TIVA vs inhaled desflurane in FESS [67]. Powered to detect a difference of 1 on the 10-point Wormald bleeding scale proposed by Athanasiadis et al., 28 participants were included, and the depth of anesthesia was standardized using a bispectral index (BIS) monitor [8]. The TIVA group demonstrated a statistically significant improvement in VSF compared to desflurane (4.21 vs 5.53, $p = 0.024$) with no significant changes in OT or TBL. In a larger randomized trial of 72 participants, Brunner et al. focused on the possible additional benefits of TIVA in FESS for high-grade CRS (defined as having nasal polyps or a preoperative Lund-Mackay score of ≥ 12) [68•]. This recently reported study has shown that TIVA improved the VSF significantly compared to sevoflurane (3.5 vs 4.1, $p = 0.0089$). Contrary to the other studies mentioned above, the TBL has significantly decreased in the TIVA group compared to the sevoflurane group (200 mL vs 300 mL, $p = 0.046$).

Another promising drug used to achieve controlled hypotension in anesthesia is dexmedetomidine. It is a highly selective α_2-adrenoceptor agonist with powerful central nervous system sympatholytic activity. Its use would lead to a decrease in blood pressure and heart rate, with sedative and vasoconstrictive effects making it an appealing choice in anesthesia during FESS [69]. A systematic review of five randomized controlled trials (254 participants collectively) reported its efficacy in improving the operative field in FESS [70]. When compared to placebo or no treatment (three trials), the VSF and intraoperative bleeding improved significantly with its use with no effect on OT. Compared to esmolol and remifentanil, dexmedetomidine groups showed similar VSF scores, TBL, and OT. Similar results were reported in a more recent systemic review on the use of α_2-adrenergic agonists in FESS [71]. It also showed that dexmedetomidine produced superior results in operative field variables compared to clonidine, another α_2-adrenergic agonist, in one trial. The benefits of combining dexmedetomidine with TIVA have also been investigated in a recent randomized placebo-controlled trial [72]. The dexmedetomidine group showed significant improvement in the VSF and TBL. The infusion rate of propofol and remifentanil was also lower due to a significant decrease in HR and MABP in the participants receiving dexmedetomidine.

In choosing an appropriate anesthetic agent, their cost should be weighed as well. Compared to inhaled anesthetics, TIVA agents possess a significantly higher cost which can lead to significant financial implications if used liberally [73–75]. Dexmedetomidine is even more expensive than other sedatives (including propofol) in some countries [76]. However, cost-efficacy trials of using these agents in ESS are currently lacking. Thus, it would be difficult to generate strong recommendations on their usage at this point in time.

In summary, controlled hypotension achieved with inhaled anesthetics and short-acting opiates should be adequate in most CRS cases in addition to other methods mentioned in this article. The usage of TIVA and/or dexmedetomidine could be reserved for advanced cases of CRS. It is crucial to also mention that excellent communication throughout the procedure with the anesthetist is the key to achieving the best and safest surgical conditions possible during FESS.

Use of Tranexamic Acid

Tranexamic acid (TXA) is a synthetic, anti-fibrinolytic agent derived from the amino acid, lysine. It binds to the lysine-binding sites of plasmin and plasminogen, causing separation of plasmin from superficial fibrin and effectively preventing fibrinolysis [77]. TXA has been widely used as a potent hemostatic agent for a variety of head and neck surgeries, and more recently has been employed in FESS. A systematic review and meta-analysis of TXA, including topical and systematic modalities, demonstrated that TXA was both safe and effective to use during FESS [78]. In an RCT published after that meta-analysis, TXA was shown to significantly improve the endoscopic field of view and reduce total blood loss when compared to normal saline in both CRS with and without nasal polyposis [77]. Although total operating time also trended towards a decrease in the TXA group, this difference was not statistically significant.

While very uncommon, the main side effects associated with TXA treatment are nausea, diarrhea and vomiting [26]. There were no significant adverse events (i.e., thromboembolic events) reported in any of the trials included in the meta-analysis by Pundir et al. and no significant difference in minor post-operative adverse events (e.g., vomiting and nausea) when compared to saline control groups [78].

Notably, a recent RCT of topical TXA administered via TXA-soaked pledgets (5% TXA with 0.5% phenylephrine compared to pledgets with just 0.5% phenylephrine) for 10 min in bilateral nasal cavities prior to surgery provided effective hemostasis for the first 30 min, after which the effect began to wane [77]. Thus, serial applications of TXA, either topically or via intravenous infusion, may be required to sustain an optimal endoscopic field of view during FESS [78].

Conclusions

Multiple pre- and intraoperative methods can be combined to optimize the surgical field of view in FESS. At our respective centers, we prepare all patients for FESS with a preoperative course of topical nasal steroid sprays and reserve the use of oral corticosteroids for CRSwNP cases after ruling out relevant contraindications. Intraoperatively, the authors do not locally inject vasoconstrictors during FESS based on the best available evidence and rely primarily on topically applied vasoconstrictors (mainly xylometazoline 0.1%) in both spray and pledget forms. Another important yet, simple measure to optimize the surgical field in FESS is to position the patients in a 15- to 20-degree reverse Trendelenburg position which is routinely done in our centers. We found that HSI is beneficial in improving the surgical field in FESS, especially in advanced cases of CRS. We believe that continuous communication with the anesthetist is more important than the choice of specific anesthetic regimens in FESS as the current evidence is showing conflicting results and larger studies are still needed. It is of critical importance to consider stopping the procedure if bleeding becomes difficult to control and is compromising visualization in order to avoid devastating complications. To date, significant gaps exist in the literature on this topic. Standardization of trial design and larger multi-center studies are needed to generate international standard protocols in optimizing CRS patients for FESS.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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Papers of particular interest, published recently, have been highlighted as:
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