

Total intravenous anaesthesia versus inhaled anaesthesia for endoscopic sinus surgery: a meta-analysis of randomized controlled trials*

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Abstract

Background: Total intravenous anaesthesia (TIVA) with propofol, compared to inhaled anaesthesia (IA), has been proposed to reduce bleeding and improve surgical field quality during endoscopic sinus surgery (ESS), but prior meta-analyses have not been conclusive. We performed an updated meta-analysis to determine the benefit of TIVA versus IA during ESS.

Methodology: PubMed, EMBASE, and Cochrane Library were searched for randomized controlled trials (RCTs) comparing TIVA versus IA. Demographic and outcome data were extracted from articles meeting selection criteria and analysed.

Results: We included 12 RCTs for a total of 560 patients. Preoperative characteristics were similar between the two groups. Compared to IA, TIVA improved surgical visibility, estimated blood loss (EBL), and operative time. In a subgroup analysis with remifentanyl as the short-acting opioid, TIVA improved surgical visibility, EBL, and operative time. These benefits were not seen with fentanyl as the short-acting opioid.

Conclusions: TIVA with propofol, in comparison to IA, may improve surgical field quality, reduce blood loss, and decrease operative time for ESS. Remifentanyl is the preferred short-acting opioid for TIVA in ESS.

Key words: endoscopic sinus surgery, inhaled anaesthesia, meta-analysis, propofol, total intravenous anaesthesia

Introduction

Endoscopic sinus surgery (ESS) is now the established modality through which a variety of pathologies of the paranasal sinuses and anterior skull base are surgically addressed. Successful and safe ESS relies upon a mastery of anatomy, the study of specific patient imaging, and maintaining a clear surgical field while operating. Blood loss during ESS obscures important landmarks the surgeon relies upon for navigation and safe dissection. Consequently, optimizing the surgical field by minimizing blood loss is an important component of ESS. Surgical principles and techniques that limit or reduce blood flow in the operative field are of the utmost importance for the surgeon to understand and master. Anaesthetic techniques and agents can also have an impact on surgical conditions and have been the topic of many discussions and investigations.

Anaesthetic agents affect the patient's systemic blood pressure as well as the local capillary beds of the surgical field. The anaesthetic technique that has shown the most promise in obtaining controlled hypotension during ESS is total intravenous anaesthetic (TIVA), rather than the more traditional and routine practice of using inhaled anaesthetics (IA). Many studies have specifically evaluated the use of propofol and a short acting opioid versus a volatile inhalational anaesthetic and a short acting opioid. Some randomized controlled trials (RCTs) on the topic have shown that TIVA is superior to IA with regards to the quality of the surgical field⁽¹⁻⁴⁾. Studies have also suggested that blood loss is lower with TIVA compared to IA^(1,3,5). However, other RCTs have not shown TIVA to be superior to IA for surgical field quality and/or blood loss⁽⁶⁻¹²⁾.

Systematic reviews and meta-analyses on the topic have inclu-

ded a limited number of RCTs and are inconclusive. In 2012, Kelly et al. conducted a systematic review, but did not perform a meta-analysis due to a lack of power and study heterogeneity⁽¹³⁾. A Cochrane meta-analysis published in 2013 and updated in 2016 found TIVA improved the surgical field but did not decrease estimated blood loss (EBL) or operative time. However, the authors defined deliberate hypotension narrowly as a mean arterial pressure (MAP) between 50 and 65 mm Hg and limited the meta-analysis to studies with that specific range as the target MAP. Only four studies met this strict criteria while an additional 10 studies were excluded for specifying a different blood pressure goal⁽¹⁴⁾. Finally, a meta-analysis of nine studies by DeConde et al. in 2013 found similar results of superior visibility scores with TIVA, but no difference in EBL or operative time⁽¹⁵⁾. A number of additional RCTs have been published after this meta-analysis, and a few previously-published RCTs were not captured by their search strategy. As no prior meta-analysis had incorporated these RCTs, we set out to perform an updated meta-analysis comparing TIVA with IA for ESS. Furthermore, our meta-analysis is the first to include a subgroup analysis on both the short acting opioid and the inhaled anaesthetic.

Methods

Eligibility criteria

We analysed randomized controlled trials comparing total intravenous anaesthesia to inhalational anaesthesia in patients undergoing endoscopic sinus surgery. TIVA was defined as a combination of propofol and a short acting opiate, while IA was defined as a combination of a volatile anaesthetic and a short acting opiate. Trials which utilized a different short acting opiate in the TIVA and IA groups were excluded. Trials could include patients of any age. Trials were not restricted by publication date or status, but were limited to those available in the English language.

Search criteria

Electronic searches were conducted of the PubMed, EMBASE, and Cochrane Library databases. The search was performed on September 18, 2018 and updated on April 14, 2019. The exact search query utilized was "(endoscopic sinus surgery) AND propofol AND random* AND (desflurane OR isoflurane OR sevoflurane)". No additional search filters were utilized in any database. The title and abstract of the search results were independently reviewed by both authors (NRK and LM) to determine if they satisfied our inclusion and exclusion criteria. Any discrepancies between the authors were resolved by consensus. Duplicate results among the three database searches were removed. The full-text manuscripts of all remaining studies were obtained and further reviewed for eligibility. The reference lists of included articles were also searched for additional studies.

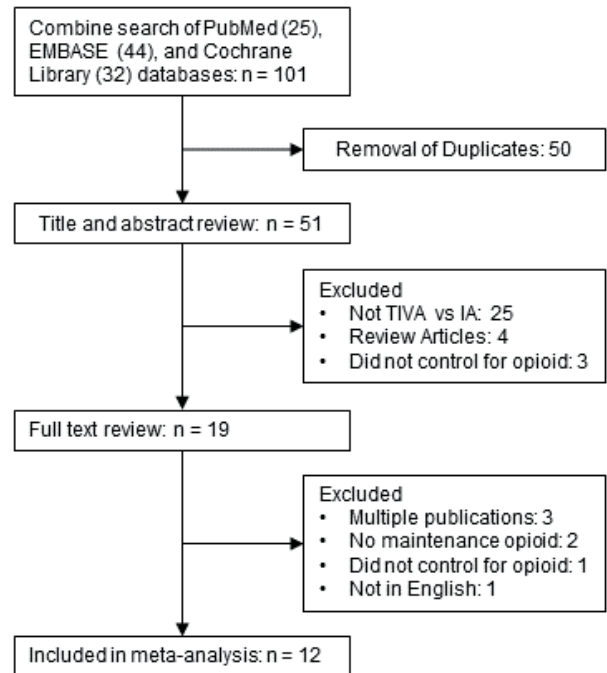


Figure 1. Flow diagram of study selection process.

Data extraction

Data was extracted from the articles by both authors independently using a data spreadsheet template. Differences were resolved by consensus. The primary outcomes were surgical field quality and EBL. The secondary outcomes were operative time, anaesthesia time, MAP, and heart rate. In addition to the characteristics of each study, demographic information was also extracted, including age, gender, weight, and preoperative Lund-Mackay score.

Quality analysis

Each included study was qualitatively evaluated for the risk of bias in seven domains: random sequence generation, allocation concealment, blinding of participants and personal, binding of outcome assessment, incomplete outcome data, selective reporting, and other. The risk of bias across studies with evaluated with a forest plot for the primary outcomes.

Statistical analysis

The principal summary measure was the mean difference in outcomes comparing TIVA to IA. The median was used as an approximation of the mean when studies did not report the mean. For the study by Pavlin et al.⁽¹⁰⁾, the mean was calculated from a histogram assuming a uniform distribution within the histogram groups. If the standard deviation was not reported, it was either calculated from the interquartile range or from the p-value, with the assumption the data followed a normal distribution. For the study by Yoo et al.⁽¹²⁾, we received standard deviation data from personal communications with the authors. Their study had

Table 1. Study characteristics.

Author, Year	Visibility Scale	BP Goal (mmHg)	Opioid	Inhaled Anaesthetic	Group	N	Age (years)	Male	Weight (kg)	LM Score
Pavlin et al. 1999 ⁽¹⁰⁾	Custom: 1-4 per sinus	MAP 65-80	Alfentanil	Isoflurane	IA	26	43	42%	78	
					TIVA	30	42	60%	84	
Sivaci et al. 2004 ⁽¹¹⁾	None	None	Fentanyl	Sevoflurane	IA	16	33		70	
					TIVA	16	32		68	
Beule et al. 2007 ⁽⁷⁾	VAS	SBP 70-140 DBP 50-90	Fentanyl	Sevoflurane	IA	22	46	64%	80	15
					TIVA	24	43	67%	79	15
Ahn et al. 2008 ⁽¹⁾	VAS	MAP 70-80	Remifentanyl	Sevoflurane	IA	18	41	83%	69	14
					TIVA	20	49	70%	70	14
Yoo et al. 2010 ⁽¹²⁾	Boezaart	MAP 65	Remifentanyl	Sevoflurane/ Desflurane	IA	40	43	55%	65	6
					TIVA	20	37	75%	65	7
Ankichetty et al. 2011 ⁽⁶⁾	Boezaart	MAP 60-70	Fentanyl	Isoflurane	IA	20	34	65%	62	
					TIVA	20	32	55%	54	
Cho et al. 2012 ⁽²⁾	Boezaart	MAP 70-80	Remifentanyl	Desflurane	IA	32	42	53%	67	13
					TIVA	36	44	50%	63	13
Gomez-Rivera et al. 2012 ⁽⁹⁾	Boezaart	MAP 70-80	Remifentanyl	Sevoflurane	IA	11	50	55%		15
					TIVA	12	51	58%		7
Chaaban et al. 2013 ⁽⁸⁾	None	SBP < 100	Fentanyl	Sevoflurane	IA	15	43	53%		13
					TIVA	18	41	50%		14
Marzban et al. 2013 ⁽³⁾	VAS	MAP 70-80	Remifentanyl	Isoflurane	IA	22	34	55%		
					TIVA	22	32	64%		
Milonski et al. 2013 ⁽⁵⁾	VAS	MAP 60-70	Remifentanyl	Sevoflurane	IA	30		70%		
					TIVA	30		57%		
Little et al. 2018 ⁽⁴⁾	Wormald	MAP 60-70	Remifentanyl	Desflurane	IA	15	51	73%		
					TIVA	15	45	40%		

LM = Lund-Mackay; BP = Blood Pressure; DBP = Diastolic Blood Pressure; MAP = Mean Arterial Pressure; SBP = Systolic Blood Pressure; IA = Inhaled Anaesthetic; TIVA = Total Intravenous Anaesthesia; VAS = Visual Analog Scale.

two IA groups and one TIVA group. The data from the two IA groups were combined for comparison against the TIVA group. As different scales were used by different studies to grade the surgical field, the standardized mean difference (SMD) was used as the summary statistic for surgical field visibility. For all other outcomes, the mean difference (MD) was used as the summary statistic. Data analysis was performed with Review Manager (RevMan) 5 by The Cochrane Collaboration, using a random effects model.

Results

Study selection

A search of PubMed, EMBASE, and Cochrane Library databases yielded a total of 101 results, 51 of which were unique. After title and abstract review, 19 citations qualified for full-text review. However, this only represented 16 unique studies as three studies had a second citation for an abstract published independently prior to manuscript publication. One study was excluded

as it was not written in English. Two studies were excluded as it did not meet our definition of TIVA because a short acting opioid was not used as a part of maintenance anaesthesia. One study was excluded because it did not control for the short acting opioid used in the TIVA and IA groups. Thus 12 studies satisfied the inclusion and exclusion criteria and were included in the meta-analysis ⁽¹⁻¹²⁾. No additional studies were identified by checking the references of relevant papers. A flow diagram for study selection is presented in Figure 1.

Study characteristics

Study characteristics and demographic data are summarized in Table 1, while outcome data is summarized in Table 2. The included studies involved a total of 560 patients. Average age of patients varied from 32 to 51 years old. When reported, average Lund-Mackay scores generally ranged from 13 to 15. Two studies had patient groups with an average Lund-Mackay score of 6 or 7 ^(9, 12). Sivaci et al. was the only study not to specify an intraope-

Table 2. Study data.

Author, Year	Group	Visibility Score	EBL (mL)	Operative Time (min)	Anaesthesia Time (min)	Mean Arterial Pressure (mmHg)	Heart Rate (bpm)
Pavlin et al. 1999 ⁽¹⁰⁾	IA	1.9	147	130		71	
	TIVA	1.7	189	136		74	
Sivaci et al. 2004 ⁽¹¹⁾	IA		297	68			
	TIVA		128	63			
Beule et al. 2007 ⁽⁷⁾	IA	3.7	300	73		70	64
	TIVA	4.3	277	71		72	65
Ahn et al. 2008 ⁽¹⁾	IA	4.8	211	99	127	73	70
	TIVA	2.9	26	83	119	73	62
Yoo et al. 2010 ⁽¹²⁾	IA	2.1		83	109	67	74
	TIVA	2.1		83	107	69	75
Ankichetty et al. 2011 ⁽⁶⁾	IA	1.6	133	131			
	TIVA	1.3	109	98			
Cho et al. 2012 ⁽²⁾	IA	2.7		32		73	66
	TIVA	2.3		33		73	65
Gomez-Rivera et al. 2012 ⁽⁹⁾	IA	1.8	355	216	282		
	TIVA	2.1	152	144	198		
Chaaban et al. 2013 ⁽⁸⁾	IA	7.1	131	117	164	81	75
	TIVA	6.8	194	135	181	88	72
Marzban et al. 2013 ⁽³⁾	IA	3.0	291	124			
	TIVA	1.9	155	96			
Milonski et al. 2013 ⁽⁵⁾	IA		340	79	113		
	TIVA		225	67	104		
Little et al. 2018 ⁽⁴⁾	IA	5.5	285	106		63	65
	TIVA	4.2	245	112		68	76

EBL = Estimated Blood Loss, IA = Inhaled Anaesthesia; TIVA = Total Intravenous Anaesthesia; bpm = beats per minute.

rative blood pressure goal as part of their protocol ⁽¹¹⁾, though there was variability among the other studies in what the goal was and how it was specified. Most studies used either fentanyl or remifentanyl as the short acting opioid agent, while one study used alfentanil. For the inhaled anaesthetic, half of the studies used sevoflurane, while the other half were split evenly between isoflurane and desflurane.

Risk of bias

Our analysis of the risk of bias in individual studies is summarised in Figure 2. The risk of selection bias was unclear in some studies because not enough detail was provided on how random sequence for allocation was generated or concealed. Similarly, with regards to performance and detection bias, some studies did not specify if and how surgeons were blinded to the type of anaesthesia administered. We found only one instance of a high risk of bias across all studies. Ahn et al. excluded two patients from the IA group from analysis because they were con-

verted to TIVA intraoperatively upon surgeon request because of poor surgical conditions. However, since this introduces a risk of bias favouring IA, and would only result in an underestimation of the benefit of TIVA, the study was not excluded.

Results of individual studies

Overall effects estimates are reported in Table 3. There was variability in the demographic and outcome data that was reported in each study and available for analysis. In terms of demographic data, 11 studies reported on age, while 11 reported on gender, 7 on weight, and 6 on preoperative Lund-Mackay score. There was no difference in any of these measures between the TIVA and IA groups pooled across all studies. Of the 12 studies, 10 graded visibility of the surgical field. Of these, 1 study reported both a Wormald score ⁽¹⁶⁾ and a Boezaart score ⁽¹⁷⁾, while 4 reported only a Boezaart score, 4 reported on a Visual Analog Scale, and one study used a custom 1-4 ordinal scale graded per sinus. All 12 studies reported operative time, while 9 studies reported on

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Ahn 2008	?	?	+	+	-	+	+
Ankichetty 2011	+	+	?	?	+	+	+
Beule 2007	+	+	+	+	+	+	+
Chaaban 2013	+	+	?	?	+	+	+
Cho 2012	?	?	+	+	+	+	+
Gomez-Rivera 2012	+	?	+	+	+	+	+
Little 2018	+	+	+	+	+	+	+
Marzban 2013	+	?	?	?	+	+	+
Milonski 2013	?	?	?	?	+	+	+
Pavlin 1999	+	?	+	+	?	+	+
Sivaci 2004	+	?	+	+	+	+	+
Yoo 2010	+	+	+	+	+	+	+

Figure 2. Summary of risk of bias assessment.

EBL, 5 on anaesthesia time, 7 on MAP, and 6 on heart rate.

Results of pooled analysis

In the pooled analysis, there was no difference between IA and TIVA regarding anaesthesia time or heart rate. There was a statistically significant difference with regards to surgical visibility, EBL, operative time, and MAP. Compared to IA, TIVA improved surgical visibility (SMD -0.4, 95% CI -0.6 to -0.2, p = 0.001), EBL (MD -61 mL, 95% CI -117 to -5 mL, p = 0.03), and operative time (MD -7.8 minutes, 95% CI -15.6 to -0.0 minutes, p = 0.05). With TIVA, the MAP was slightly higher than with IA (MD 1.9 mmHg,

95% CI 0.6 to 3.2 mmHg, p = 0.005). Summary data, effect estimates, confidence intervals, and weight for each study for surgical visibility and EBL are shown in Figures 3 and 4, respectively. There was low heterogeneity among the studies for the outcome of surgical visibility (I² = 31%), while there was greater heterogeneity with regards to EBL (I² = 73%). Funnel plots were created for the primary outcomes of surgical visibility (Figure 5), and EBL (Figure 6). Neither of these funnel plots demonstrated gross asymmetries.

Results of subgroup analysis

A subgroup analysis of inhalational agent was performed. The results of the subgroup analysis are shown in Table 4. Visibility was superior with TIVA compared to isoflurane (SMD -0.5, 95% CI -0.8 to -0.1, p = 0.01), and compared to desflurane (SMD -0.5, 95% CI -0.9 to -0.1, p = 0.02), but not compared to sevoflurane (SMD -0.2, 95% CI -0.6 to 0.2, p = 0.27). Conversely, EBL was lower with TIVA compared to sevoflurane (MD -101 mL, 95% CI -176 to -27 mL, p = 0.008), but not compared to isoflurane (MD -39 mL, 95% CI -129 to 51 mL, p = 0.40). There were an insufficient number of studies to compare TIVA to desflurane with regards to EBL. Operative time was not reduced with TIVA compared to any of the inhaled anaesthetics.

A subgroup analysis was also performed on short acting opioid. As alfentanil was used in only two studies, it was not included. The results of this subgroup analysis are shown in Table 5. TIVA with remifentanyl was superior to IA with regards to visibility (SMD -0.5, 95% CI -0.9 to -0.2, p = 0.001) and EBL (MD -125 mL, 95% CI -174 to -76 mL, p < 0.00001), but not operative time (MD -12.2 minutes, 95% CI -24.0 to -0.2 minutes, p = 0.05). TIVA with fentanyl was not superior to IA with regards to visibility (SMD -0.1, 95% CI -0.5 to 0.3, p = 0.55), EBL (MD -44 mL, 95% CI -146 to 59 mL, p = 0.4), or operative time (MD -7.1 minutes, 95% CI -21.7 to 7.5 minutes, p = 0.34).

Discussion

Summary of evidence

Our pooled analysis found that TIVA improved visibility of the surgical field. The premise is that a better surgical field allows for more thorough surgery and a lower risk of complications. These are two outcomes of interest but are difficult to study directly because: (1) The completeness of surgical dissection is difficult to measure, and (2) A very large number of patients would be needed to show statistical differences in complication rates due to their infrequent occurrence in sinus surgery.

The prevalent theory behind the benefit of TIVA compared to IA then is that the quality of the surgical field is improved by a reduction in blood loss. Our pooled analysis did find that TIVA reduced EBL compared to IA, although there was considerable heterogeneity in this outcome (I² = 73%) that is likely multifactorial. There was considerable variability in the sophistication

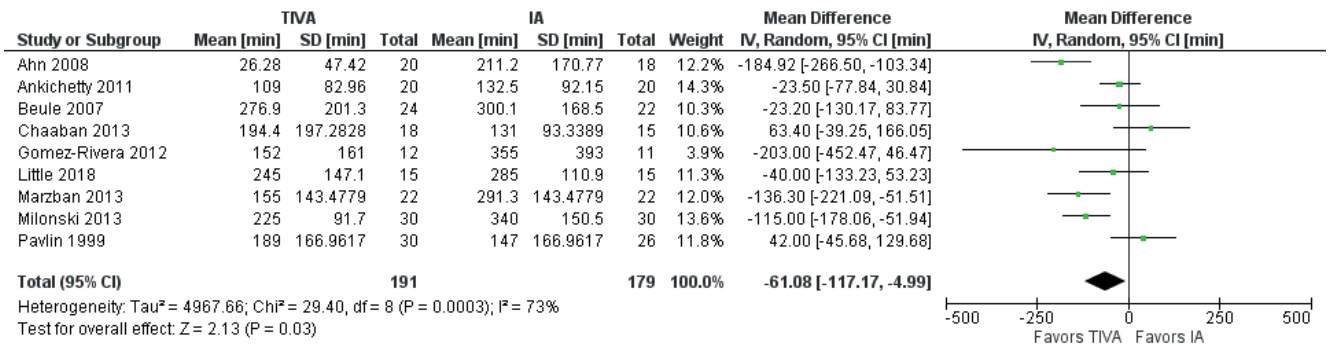


Figure 3. Visibility score forest plot.

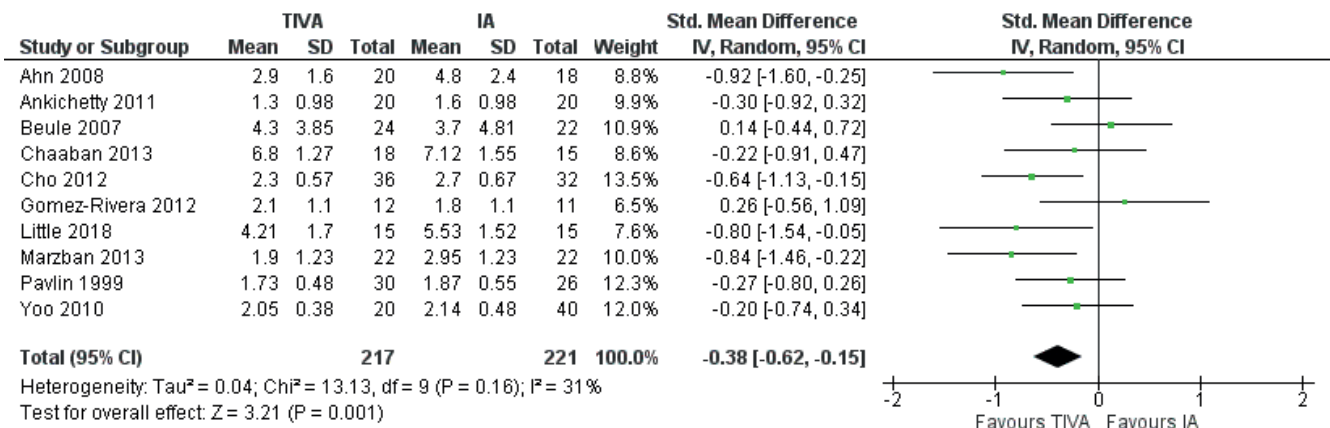


Figure 4. Estimated blood loss forest plot.

of the technique used to estimate blood loss, from simply subtracting the volume irrigated from the volume suctioned to measuring concentrations of haemoglobin to centrifuging out tissue parts from the suction canister. Nonetheless our results support the theory that TIVA improves surgical field quality by reducing blood loss.

The reduction in blood loss does not come from a difference in the patient’s systemic hemodynamics. In our meta-analysis there was no difference in heart rate between the TIVA and IA groups. With regards to MAP, the pooled analysis showed that MAP was actually statistically higher with TIVA than with IA, by 1.9 mmHg. This is a negligible clinical difference, but if patient hemodynamics accounted for the difference between TIVA and IA then we would expect, if anything, to see IA superior to TIVA.

The theoretical benefit of propofol for endoscopic surgery does have a physiological basis. The benefit of propofol over inhaled anaesthetic lies in how controlled hypotension is achieved, and specifically the differential effect of propofol on central and peripheral circulation compared to inhaled anaesthetics. IA and propofol both cause peripheral vasodilation. However inhaled anaesthetics do so by relaxing pre-capillary sphincters in the mucosa, thereby increasing blood flow to the surgical field (18). Propofol acts by depressing central sympathetic tone. Because it does not directly affect peripheral vasculature, local and topical

adrenergic medications can maintain pre-capillary sphincter tone and decrease blood flow to the surgical field (19). Propofol also has a favourable effect on central circulation. It depresses cerebral blood flow and thus decreases arterial flow to the ethmoids (20,21). In contrast, inhaled anaesthetics cause central vasodilation, again increasing blood flow to the ethmoids and surgical field (21). Compared to inhaled anaesthetics, propofol can theoretically achieve systemic hypotension with a vasoconstricted surgical field.

Our pooled analysis found that TIVA resulted in a reduction in operative time compared to IA, even though there was no significant difference in the severity of sinus disease by Lund-Mackay score. This is an important outcome, as it suggests that the improvement in the surgical field quality seen in TIVA may translate to reduced operative time. Improvement in surgical field quality may have allowed surgeons to work more efficiently by reducing the need for suctioning to clear blood from the surgical field. While an improvement by 7.8 minutes represents a small reduction in operating time, the significance of this and whether it translates to increased operational efficiency or lower cost may warrant further investigation.

Our subgroup analysis of inhaled anaesthetic agents demonstrated TIVA to be superior to isoflurane and desflurane in surgical visibility, and superior to sevoflurane in operative time.

Table 3. Overall effects.

	Studies	TIVA Participants	IA Participants	TIVA - IA Estimate [95% CI]	p
Covariates					
Age (years)	11	218	222	-1.2 [-3.6, 1.3] [#]	0.36
Gender	11	247	251	1.1 [0.8, 1.7]	0.48
Weight (kg)	7	166	174	-1.8 [-5.2, 1.6]	0.31
Lund-Mackay Score	6	130	138	-0.1 [-0.9, 0.8]	0.89
Outcomes					
Visibility Score	10	217	221	-0.4 [-0.6, -0.2]	0.001
Estimated Blood Loss (mL)	9	191	179	-61 [-118, -5]	0.03
Operative Time (min)	12	263	267	-7.8 [-15.6, -0.0]	0.05
Anaesthesia Time (min)	5	100	114	-6.9 [-19.1, 5.4]	0.27
Mean Arterial Pressure (mmHg)	7	163	168	1.9 [0.6, 3.2]	0.005
Heart Rate (bpm)	6	133	142	-0.1 [-5.2, 5.1]	0.98

IA = inhaled anaesthesia; TIVA = total intravenous anaesthesia; bpm = beats per minute; [#] Odds Ratio.

Table 4. Subgroup analysis by inhaled anaesthetic.

Outcome	Sevoflurane			Isoflurane			Desflurane		
	n	Effect	p	n	Effect	p	n	Effect	p
Visibility	5	-0.2 [-0.6, 0.2]	0.27	3	-0.5 [-0.8, -0.1]	0.01	3	-0.5 [-0.9, -0.1]	0.02
Estimated Blood Loss (mL)	6	-101 [-176, -27]	0.008	3	-39 [-129, 51]	0.40	1	-	-
Operative Time (min)	7	-7.0 [-14.4, 0.3]	0.06	3	-20.3 [-40.8, 0.4]	0.05	3	1.1 [-3.4, 5.7]	0.62

Table 5. Subgroup analysis by short acting opioid.

Outcome	Fentanyl			Remifentanyl		
	n	Effect	p	n	Effect	p
Visibility	3	-0.1 [-0.5, 0.3]	0.55	6	-0.5 [-0.9, -0.2]	0.001
Estimated Blood Loss (mL)	4	-44 [-146, 59]	0.40	5	-125 [-174, -76]	<0.00001
Operative Time (min)	4	-7.1 [-21.7, 7.5]	0.34	7	-12.2 [-24.1, -0.2]	0.05

With these mixed results, we are unable to conclude that TIVA is superior to only a particular IA agent. While TIVA was not statistically superior to any one of the IAs with regards to EBL in the subgroup analysis, it was superior to IA when the subgroups were combined. This suggests that a statistical difference was not seen for the subgroups individually because of a lack of power.

The subgroup analysis based upon the short acting opioid provided more consistent results. Across all three of our primary outcomes, TIVA was superior to IA when remifentanyl was used as the short acting opioid, but not when fentanyl was utilized. Remifentanyl may be superior to fentanyl as a short acting opioid adjunct regardless of whether propofol or IA agents

are being used. The combination of propofol and remifentanyl has been shown to reduce intraoperative bleeding compared to propofol and fentanyl in sagittal split osteotomies⁽²²⁾ and endoscopic pituitary surgery⁽²³⁾. As an adjunct to sevoflurane, remifentanyl has been shown to be better than fentanyl in reducing intraoperative bleeding during spinal surgery⁽²⁴⁾. However, our results suggest that there is some synergist effect from the combination of propofol and remifentanyl that does not exist with remifentanyl and IA. This has previously also been shown for lumbar spine fixation surgery⁽²⁴⁾.

Our result for surgical field quality confirms a previous meta-analysis on this topic by DeConde et al., which found that TIVA improved surgical visibility score by 1.04 on a 10 point scale (p

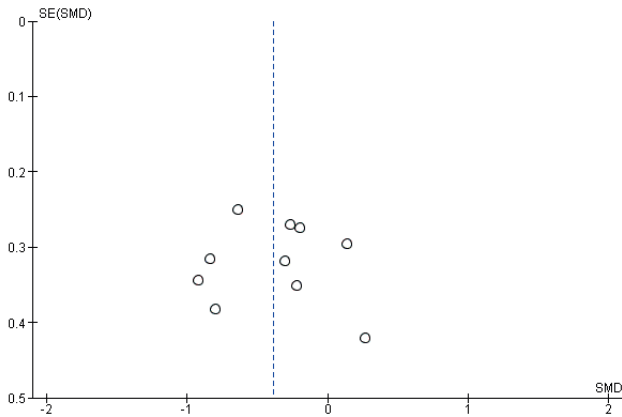


Figure 5. Visibility score funnel plot.

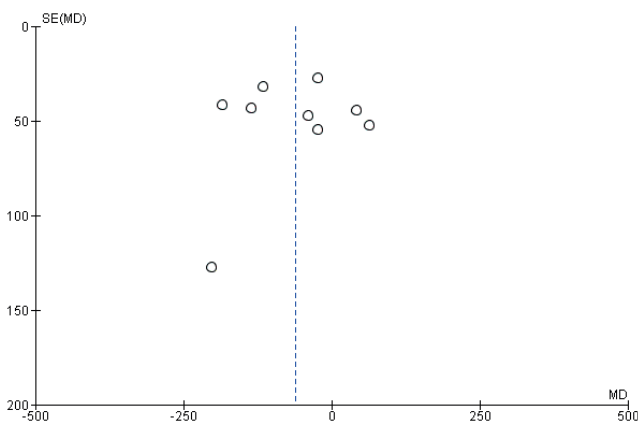


Figure 6. Estimated blood loss funnel plot.

< 0.001)⁽¹⁵⁾. However, our meta-analysis is the first to show a significant difference with regard to operative time or EBL. De-Conde et al. had a total of nine studies in their meta-analysis but included studies that did not control for the short acting opioid between the TIVA and IA groups. We excluded those studies, but also included one study not captured by their search strategy, and six additional RCTs published after their meta-analysis. Thus, we were likely able to demonstrate a significant difference in EBL and operative time because of the additional power that came with a greater number of studies and thus total subjects. While TIVA is a well-established technique, inhaled anaesthesia is more frequently utilized, and thus relative discomfort or inexperience with TIVA may be a potential disadvantage. Meta-analyses that studied the recovery profile of TIVA compared to IA have found reduced incidence of post-operative nausea and

vomiting with TIVA⁽²⁵⁾, and earlier recovery with IA, but overall no difference in time to discharge from the recovery room^(25, 26). A study comparing desflurane-remifentanyl to propofol-remifentanyl for septorhinoplasty found to no difference in recovery profile or cost⁽²⁷⁾.

Limitations

There was variability in the included studies that could have introduced confounding variables, such as use of topical vasoconstrictors and injected local vasoconstrictors. Also, the inhaled anaesthetics in these studies may have been titrated to higher dose than is common to maintain hypotension. The higher dose of inhalational anaesthetic may have led to greater blood loss and worse surgical field score by inducing vasodilation in the surgical field. There was also variability across studies in the scale used for surgical field assessment. Although this may be partially overcome with statistical techniques, a standardized and validated method of using these scales is not well-established, and reliability is low (<0.70) without standardization⁽¹⁶⁾. The severity of sinus disease was also not consistently evaluated in these studies and is another potential confounding factor. Overall the quality of the included studies was not high and sample sizes were small.

Conclusion

Our search found that many randomized controlled trials comparing TIVA vs IA in endoscopic sinus surgery have been published. A meta-analysis of the pooled results from 12 studies suggests that TIVA with propofol is superior to IA for endoscopic sinus surgery with regards to surgical field quality, EBL, and operative time. A subgroup analysis further demonstrated that there may be a benefit only when remifentanyl is used as the short acting opioid.

Author contribution

NRK: Designed the study, conducted the search, extracted data from each study, performed data and statistical analysis, and wrote the manuscript. LM: contributed to the design of the study, verified the search and data extraction, reviewed and edited the manuscript.

Conflict of interest

LM: Xhance Speaker’s Bureau.

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