

Comparison of surgical conditions during propofol or sevoflurane anaesthesia for endoscopic sinus surgery

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Background. Endoscopic sinus surgery (ESS) is often affected by intra-nasal bleeding, which can be influenced by various anaesthetics and preoperative conditions. This study compared the surgical condition and the amount of intra-nasal bleeding between patients given sevoflurane/remifentanyl (SR) and propofol/remifentanyl (PR) anaesthesia.

Methods. ASA I or II patients undergoing ESS were randomly assigned to group SR ($n=20$) or group PR ($n=20$). The extent of the preoperative surgical lesion was classified as high (>12) and low Lund–Mackay (LM) (≤ 12) scores according to the computed tomography findings. The amount of intraoperative blood loss was calculated from the patients' haemoglobin (Hb) and the amount of blood in the suction canister. The surgeons rated the visibility of the surgical field on a numeric rating scale (NRS).

Results. In the high-LM score patients, the median (1st/3rd quartiles) blood loss for the SR and PR groups was 135 (121/222) and 19 (8/71) ml h^{-1} , respectively ($P<0.01$), and the mean (SD) of NRS was 5.8 (2.3) and 2.3 (1.0), respectively ($P<0.05$). However, in patients with low-LM score, both blood loss and NRS scores were not different between groups SR and PR.

Conclusions. In the high-LM score patients, PR anaesthesia results in less blood loss and a better surgical conditions for ESS than SR anaesthesia.

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During endoscopic sinus surgery (ESS), mucosal bleeding often interferes with the optimal visualization of the intra-nasal anatomy, which not only hinders the operation but also increases the incidence of complications.¹ For an appropriate control of intraoperative bleeding, various manoeuvres such as an epinephrine injection into the nasal mucosa, elevation of the patients' head, or hypotensive anaesthesia have been adopted.²

Among the various manoeuvres, anaesthetic agents can also influence the amount of blood loss and the condition of the surgical field through their hypotensive or vasodilatory action.

There are only a few contradictory reports on this subject and the consensus is that propofol anaesthesia results in a better or similar surgical field^{2–6} and less or

similar amount of bleeding^{2,3,5–7} than isoflurane or sevoflurane anaesthesia.

However, previous studies gave no consideration for the extent of the preoperative lesion.^{2,3,5} Wormald and colleagues⁶ reported that a more extensive lesion is related to a poor surgical score. Therefore, classifying the patients based on the extent of the lesion and observing the effects of the anaesthetic techniques are essential.

Therefore, a prospective, randomized study was performed to compare the amount of blood loss and the surgical condition during ESS in patients under general anaesthesia with either propofol/remifentanyl (PR) or sevoflurane/remifentanyl (SR).

In this study, the patients were further classified according to the extent of the preoperative lesion [Lund–Mackay

(LM) score determined by computed tomography (CT)] and a more precise measurement of blood loss was obtained by correcting the amount of blood in the suction canister with the patients' haemoglobin concentration.

Methods

Patients

After receiving institutional review board approval and written informed consent, 40 patients (ASA I and II) with chronic sinusitis involving a minimum of two paranasal sinuses undergoing ESS were randomly assigned to receive either PR ($n=20$) or SR ($n=20$) anaesthesia. None of the patients were pre-medicated. Patients with the disease or medication related to coagulation or the cardiovascular system were excluded.

The otorhinolaryngological surgeons evaluated and scored the concentration of oedema and redness of the nasal mucosa endoscopically before operation (mild, 1; moderate, 1.5; severe, 2). In addition, the LM CT score (Table 1) of the paranasal sinuses was also obtained.⁸ Patients with a total LM score of >12 were called high-LM score patients and with a total LM score of ≤ 12 were called low-LM score patients.

Anaesthesia

The patients were monitored with ECG, non-invasive blood pressure, and pulse oximetry. The blood pressure was recorded every 3 min. Anaesthesia was induced with lidocaine 0.5 mg kg^{-1} , propofol 2 mg kg^{-1} , and rocuronium 0.6 mg kg^{-1} in both SR and PR groups. N_2O and O_2 were administered at a 1:1 ratio with a total gas flow rate of 2 litre min^{-1} . Sevoflurane 1–3% was administered in

group SR, and the infusion of propofol was changed from manual injection to TCI mode (Master TCI, Fresenius Vial, Brezins, France) in group PR. The effect site concentration of TCI was $1\text{--}3 \mu\text{g ml}^{-1}$, and Marsh model was adopted for pharmacokinetics. Both groups received a continuous remifentanyl infusion simultaneously at a rate of $0.2 \mu\text{g kg}^{-1} \text{ min}^{-1}$ (Medfusion Pump, MEDEX Inc., Duluth, GA, USA).

The target mean blood pressure (MBP) was maintained at 70–80 mm Hg by adjusting the sevoflurane or propofol concentration within their range (between 1–3 vol% for sevoflurane or $1\text{--}3 \mu\text{g ml}^{-1}$ for propofol) according to the anaesthesiologist's judgement. If this failed, the remifentanyl rate was adjusted by $0.05 \mu\text{g kg}^{-1} \text{ min}^{-1}$. End-tidal CO_2 was continuously monitored (Capnomac Ultima, Datex, Helsinki, Finland) and adjusted to target concentration (35 mm Hg) by controlling minute ventilation started from 10 ml kg^{-1} tidal volume and $10 \text{ cycle min}^{-1}$ respiration rate. Patients were positioned in the 20° reverse Trendelenburg and four squeezed gauzes soaked with a mixed solution of epinephrine and lidocaine (1:1000 epinephrine:lidocaine 2%=1:1) were applied topically to each nasal mucosa. For a single blind study, the TCI pump was also set in group SR without the infusion. The attending surgeons were not informed whether the TCI pump was actually running and unaware of the type of anaesthesia administered.

Measurement of blood loss and surgical condition

The amount of blood loss was determined by collecting all the blood and rinsed fluid from the surgical field in two suction canisters into which 5 ml of 1:250 000 heparin had already been placed. Haemoglobin concentration was measured from the suction canisters and the blood samples obtained from the patients.^{2,9} The amount of blood loss was calculated from the fluid volume of the suction canister (V), the haemoglobin (Hb) concentration of the suction canister, and the patient's mean haemoglobin concentration at the beginning and end of surgery (Hbm) using the following equation:

$$\text{Blood loss (ml)} = \text{Hb (g dl}^{-1}) \times V(\text{ml}) / \text{Hbm (g dl}^{-1})$$

Immediately after surgery, the surgeons rated the surgical conditions (mucosal bleeding and visibility of the surgical field) on a numeric rating scale (NRS) ranging from 0 to 10 (best, 0; worst, 10).

Statistical analysis

The amount of blood loss and the intraoperative mean remifentanyl infusion rate are described as the median (1st/3rd quartiles), and are analysed using a Mann–Whitney rank sum test. The parameters except for blood loss and the remifentanyl infusion rate were reported to be the mean (SD), and were analysed using Student's t -test. The categorical data were compared using a χ^2 -test.

Table 1 Lund–Mackay computed tomography staging system

	No abnormality	Partial opacification	Total opacification
Anterior ethmoid			
R	0	1	2
L	0	1	2
Posterior ethmoid			
R	0	1	2
L	0	1	2
Maxillary			
R	0	1	2
L	0	1	2
Frontal			
R	0	1	2
L	0	1	2
Sphenoid			
R	0	1	2
L	0	1	2
Ostiomeatal complex	Non-obstructed		Obstructed
R	0		2
L	0		2

A *P*-value of <0.05 was considered significant. The correlation of the parametric data is described using the Pearson's correlation coefficients, and the correlation of the non-parametric data is described using the Spearman's coefficients.

Results

Age, gender, height, weight, ASA classification, the total LM score, the number of high-/low-LM score patients, and preoperative endoscopic score were similar in both groups (Table 2). The duration of surgery and anaesthesia, average rate of the remifentanyl infusion, intraoperative fluid volume, number of operation sites, distribution of the two operators, and injection volume of local epinephrine (1:100 000) were also similar. The intraoperative MBP was similar in both groups, but the intraoperative heart rate was lower in group PR (Table 3).

Table 2 Patients characteristics. The values are reported as the mean (sd) or the number of patients. Group SR, sevoflurane/remifentanyl group; Group PR, propofol/remifentanyl group; LM, Lund–Mackay; High LM score, LM score >12; Low LM score, LM score ≤12. **P*<0.05

	Group SR (n=20)	Group PR (n=20)	<i>P</i> -value
Sex (M/F)	15/5	14/6	0.723
Age (yr)	41 (14)	49 (15)	0.091
Weight (kg)	68.6 (11.9)	70.4 (9.6)	0.616
Height (cm)	169.3 (10.1)	166.0 (7.1)	0.257
Body mass index (kg m ⁻²)*	23.8 (2.7)	25.6 (2.7)	0.048
ASA classification (I/II)	13/7	16/4	0.288
Total LM score	14 (6)	14 (6)	0.737
Patients of high/low LM score	13/7	11/9	0.736
Preoperative endoscopic score	1.3 (0.4)	1.2 (0.3)	0.370

Table 3 Intraoperative variables. The values are reported as the median (1st/3rd quartiles) or mean (sd) or the number of patients. Group SR, sevoflurane/remifentanyl group; Group PR, propofol/remifentanyl group; †data from two patients with high LM score in group SR were excluded because their anaesthetic method was changed to PR anaesthesia during operation; **P*<0.05

	Group SR (n=18 [†])	Group PR (n=20)	<i>P</i> -value
Duration of anaesthesia (min)	127 (44)	119 (35)	0.536
Duration of surgery (min)	99 (41)	83 (35)	0.197
Average endtidal concentration of sevoflurane (%)	2.1 (0.5)	–	–
Average concentration of propofol at effect site (µg ml ⁻¹)	–	2.3 (0.8)	–
Average rate of remifentanyl infusion (µg kg ⁻¹ min ⁻¹)	0.107 (0.03/0.27)	0.150 (0.09/0.23)	0.334
No. of operation sites	8 (2)	8 (3)	0.631
Operator 1/2	15/5	12/8	0.311
Injection volume of local epinephrine 1:100 000 (ml)	9.4 (4.9)	8.8 (5.6)	0.722
Intraoperative fluid administration (ml kg ⁻¹ h ⁻¹)	6.8 (1.3)	6.0 (2.4)	0.199
Intraoperative MAP (mm Hg)	73 (8)	73 (7)	0.858
Intraoperative HR (beats min ⁻¹)*	70 (11)	62 (7)	0.008

The median (1st/3rd quartiles) of blood loss was 19 (10/55) ml in group PR, but it was 128 (37/154) ml in group SR (Table 4). The median amount of blood loss in group PR was significantly lower than that in group SR (*P*=0.004).

The NRS of the surgical conditions (see Methods section) was lower in group PR than that in group SR [2.9 (1.6) vs 4.8 (2.4), *P*=0.021]. The surgical conditions of two patients with high LM score (13 and 18, respectively) in group SR became so bad (7.5 and 8) and hence, the anaesthetic agent was switched to the other (PR) at the surgeon's request. After changing the anaesthetic method, the NRS decreased to 5 and 4, respectively.

In the post-anaesthetic care unit, the incidence of nausea, vomiting, and the use of analgesics were similar in both groups (Table 5).

Correlations with LM score

There was a correlation between the LM score and the preoperative evaluation by endoscopy (mild, 1; moderate, 1.5; severe, 2) (*ρ*=0.566, *P*<0.01). However, only the LM score showed a positive correlation with the amount of blood loss (*ρ*=0.396, *P*<0.05). There was no correlation between the LM score and the NRS (*r*=0.316, *P*=0.078).

High- vs low-LM score patients

Thirteen patients in group SR and 11 patients in group PR had a high LM score, and 7 in group SR and 9 in group PR showed a low LM score.

In high-LM score patients, PR anaesthesia showed less blood loss and a better surgical condition than SR anaesthesia (Fig. 1). The median and 1st/3rd quartiles of blood loss were 19 and 8/71 ml h⁻¹ in the PR group but were 128 and 37/154 ml h⁻¹ in the SR group, respectively (*P*<0.01). The NRS scores were 2.9 (1.6) and 4.8 (2.4), respectively (*P*<0.05).

However, in patients low-LM score patients, the amount of blood loss and the surgical conditions with the two anaesthetic methods were similar (Fig. 1). The median and 1st/3rd quartiles of the blood loss were 19 and 12/57 ml h⁻¹ for the PR group, respectively, and 17 and 6/128 ml h⁻¹ for the SR group, respectively (*P*=0.775). The NRS scores were 3.4 (2.0) and 3.0 (1.5), respectively (*P*=0.942) (Fig. 2).

Discussion

These results show that in the patients with more extensive lesion (LM score >12), i.v. anaesthesia (IVA) using PR improves the endoscopic visualization of the surgical field and decreases the amount of blood loss compared with balanced anaesthesia using SR.

In a retrospective study, Blackwell and colleagues¹⁰ first suggested that propofol might reduce the amount of blood

Table 4 Blood loss and the rating of the lesion. The values are reported as median (1st/3rd quartiles) or mean (sd). Group SR, sevoflurane/remifentanyl group; Group PR, propofol/remifentanyl group; NRS, numeric rating scale for surgical condition (0, best; 10, worst); High LM score, LM score >12; Low LM score, LM score ≤12. †Data from two patients with high LM score in group SR were excluded because their anaesthetic method was changed to propofol/remifentanyl anaesthesia during operation. * $P<0.01$. ** $P<0.05$. ‡ $P<0.01$ with other three groups. §§ $P<0.05$ with other three groups

	Group SR ($n=18^{\dagger}$)		Group PR ($n=20$)	
	Low LM score ($n=7$)	High LM score ($n=11$)	Low LM score ($n=9$)	High LM score ($n=11$)
Blood loss (ml h^{-1})	17 (6/128)	128 (37/154)*	19 (12/57)	19 (10/55)
NRS	3.0 (1.5)	4.8 (2.4)**	3.4 (2.0)	2.9 (1.6)
		5.8 (2.3)‡§§		2.3 (1.0)

Table 5 Parameters in post-anaesthetic care unit (PACU). The values are the number of patients. Group SR, sevoflurane/remifentanyl group; Group PR, propofol/remifentanyl group. There was no difference between the two groups. †Data from two patients with high LM score in group SR were excluded because their anaesthetic method was changed to PR anaesthesia during operation

	Group SR ($n=18^{\dagger}$)	Group PR ($n=20$)	P -value
Nausea (yes/no)	2/16	2/18	0.911
Vomiting (yes/no)	0/18	1/19	0.336
Anaesthetics (yes/no)	4/14	8/11	0.239

loss for ESS compared with isoflurane. Subsequent prospective studies showed that propofol produced a better surgical condition than isoflurane. However, it was unclear whether IVA with propofol actually reduced the amount of bleeding compared with the balanced anaesthesia with isoflurane.^{2–5} In the case of a comparison between sevoflurane and propofol anaesthesia, two reports^{6–7} showed less blood loss or a better surgical score in patients given propofol than those given sevoflurane. However, Manola and colleagues⁵ reported a similar surgical score and blood loss between propofol and sevoflurane, which was superior to isoflurane.⁵ These controversial results might have been because of the less precise way of measuring the amount of blood loss, i.e. simple subtraction of the irrigation volume from the total volume collected in the canister.⁵ Therefore, in this study, an attempt was made to improve the measurement of blood loss by performing the calculation based on the Hb values and the total volume collected in the canister.^{2–9} The results showed less blood loss in the PR group than that in the SR group.

The use of vasoactive agents for controlled hypotensive anaesthesia in previous studies^{3–6} could mask or complicate the specific effect of the anaesthetic agents on the nasal vasculature³ and is another compounding factor in an evaluation of the surgical scores and bleeding. Traditionally, controlled hypotension is required to reduce the amount of blood loss and provide a dry surgical field for ESS. But, it can increase the risk of organ ischaemia and jeopardize the patients. Furthermore, a considerable amount of data has shown that the blood pressure and intraoperative bleeding are not necessarily related, and hypotension on its own does not necessarily improve the surgical field.^{11–14} In contrast, hypotension is often associated with peripheral vasodilation,

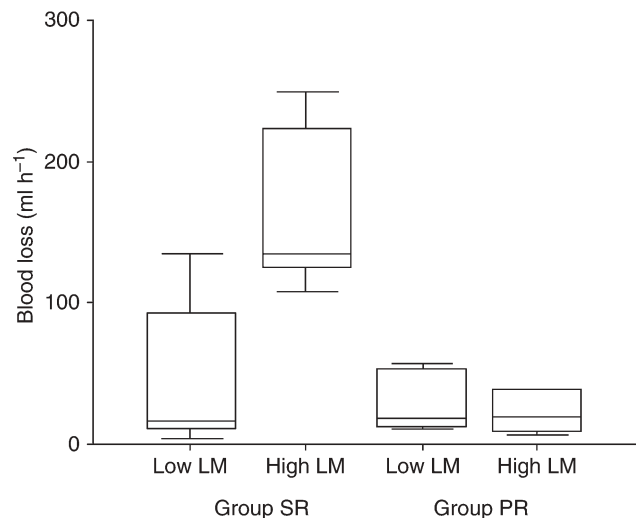


Fig 1 Blood loss in the high- and low-LM score patients in groups SR and PR. The horizontal bars show the maximum, 3rd quartiles, median, 1st quartiles, and the minimum. The amount of blood loss in the high-LM score patients was significantly higher in group SR than in group PR. * $P<0.01$. LM, Lund–Mackay; High LM, LM score >12; Low LM, LM score ≤12; Group SR, sevoflurane/remifentanyl group; Group PR, propofol/remifentanyl group.

which might increase the amount of bleeding.^{11–13} Indeed, the mucosal bleeding in ESS was even larger in the hypotensive group using sodium nitroprusside.¹⁴ Therefore, the MBP was maintained at 70–80 mm Hg, and the pure anaesthetic effect was examined.

Anaesthetic agents *per se* can affect the amount of blood loss through their various pharmacological effects on the degree of vasodilation and heart rate. Both propofol and inhalation agents have a vasodilatory effect in a concentration-dependent manner.^{15–16} However, the extent of reflex tachycardia is quite variable. Compared with the apparent reflex tachycardia in isoflurane, sevoflurane usually does not alter the heart rate.¹⁵ In contrast, propofol inhibits the baroreflex and can even result in bradycardia.¹⁶ Therefore, propofol suppresses the cardiac output more than sevoflurane.¹⁷ When the patients did not have a cardiovascular disease and the MBP was controlled within the same range such as in the present study, the heart rate was lower in the IVA than in the balanced anaesthesia (Table 3). Therefore, the lower intraoperative heart rate in

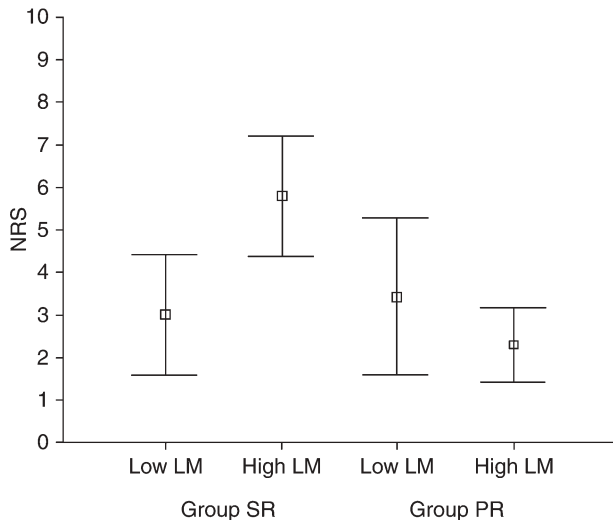


Fig 2 NRS of the high- and low-LM score patients in groups SR and PR. The point and horizontal bars show the mean \pm 2SE, respectively. The NRS of the high-LM score patients was significantly higher in group SR than in group PR. * $P < 0.01$. The NRS in the group SR was significantly higher in the high-LM score patients than in the low-LM score patients. * $P < 0.05$. NRS, numeric rating scale for the surgical condition (0, best; 10, worst). LM, Lund-Mackay; High LM, LM score > 12 ; Low LM, LM score ≤ 12 ; Group SR, sevoflurane/remifentanyl group; Group PR, propofol/remifentanyl group.

group PR might have reduced the amount of intraoperative blood loss, as previously suggested by Eberhart and colleagues.³ Consistent with these reports, Manola and colleagues⁵ reported that the surgical condition and bleeding for ESS has a worsening tendency in the order of propofol, sevoflurane, and isoflurane. A study using beta-blocker pre-medication also showed a correlation between the surgical scores and heart rate, but not MBP.¹⁸

In the present study, the bradycardia observed during IVA requires careful interpretation because remifentanyl had been infused continuously along with propofol. The suppressed heart rate might also have been because of opioids such as remifentanyl. However, the infused remifentanyl dose in both groups was the same, which suggests that the bradycardia in group PR was related to propofol.

In this study, there was no correlation between the extent of the lesions (LM score) and the surgical condition, and only a positive correlation between the LM score and the amount of blood loss. Interestingly, the benefit of IVA on the surgical condition and the amount of blood loss was significant only in the high-LM score (> 12) patients. The patients with a low-LM score (≤ 12) were not affected by the anaesthetic methods. This might have been caused by the more extensive inflammation and vasodilation in the high-LM score patients.

In summary, IVA results in less bleeding and a better surgical condition for patients undergoing ESS than conventional balanced anaesthesia, particularly in patients with a high-LM score who anticipate more blood loss.

Further studies will be needed to clarify the benefit of IVA in difficult ESS cases such as allergic fungal sinusitis, nasal polyposis, or revision surgery, in which a large amount of blood loss is expected.

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