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Study Analysis

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The Factors Related to Blood Loss during Endoscopic Sinus Surgery

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Abstract

Background: The safety and efficacy of endoscopic sinus surgery have improved with the development of new equipment and improved surgical techniques. However, it is accompanied by the risk of complications. Intra-operative blood loss is an important factor for the safe conduct of surgery. Therefore, we examined the factors associated with intra-operative blood loss.

Method: The amount of intra-operative bleeding experienced by 518 patients with sinonasal disease who underwent endoscopic sinus surgery under general anaesthesia at our hospital over 9 years was tabulated. Thirty-four variables were extracted after analysis of the patients' background, sinonasal pathology, and haematology results. Multivariate linear regression analysis was performed.

Results: Multivariate analysis revealed significant differences in the prothrombin time-international normalised ratio (PT-INR), Lund-Mackay score, operative time, and initial versus repeat surgery.

The degree of change between the 25% and 75% points was significant for the following variables: an increase from 5 to 14 points for the Lund-Mackay score at 73.0 mL.

Conclusions: Preoperative precautionary measures should be implemented in the event of re-operation, expected prolonged operative time, high Lund-Mackay score, and prolonged PT-INR. Intra-operative blood loss in patients with a high Lund-Mackay score requires meticulous attention.

Keywords

Blood loss, Endoscopic sinus surgery, ESS, Lund-Mackay score

Introduction

Endoscopic sinus surgery (ESS) is the gold standard for the treatment of chronic rhinosinusitis [1,2]. In recent years, the safety and efficacy of ESS have improved with the development of new equipment and improvement in surgical techniques [2]. However, there still exists an attendant risk of complications associated with orbital or skull base injury, such as spinal fluid fistula and optic nerve damage [3]. The success or failure of ESS depends on numerous factors, and contamination of the surgical field due to excessive bleeding constitutes one of the most important factors [4]. Excessive blood loss is sometimes difficult to predict and manage [5]. Intra-operative blood loss is an important factor for the safe performance of ESS [6], but few studies have conducted an extensive examination of the factors related to blood loss in ESS. In this study, we examined the factors associated with intra-operative blood loss during ESS at our hospital.

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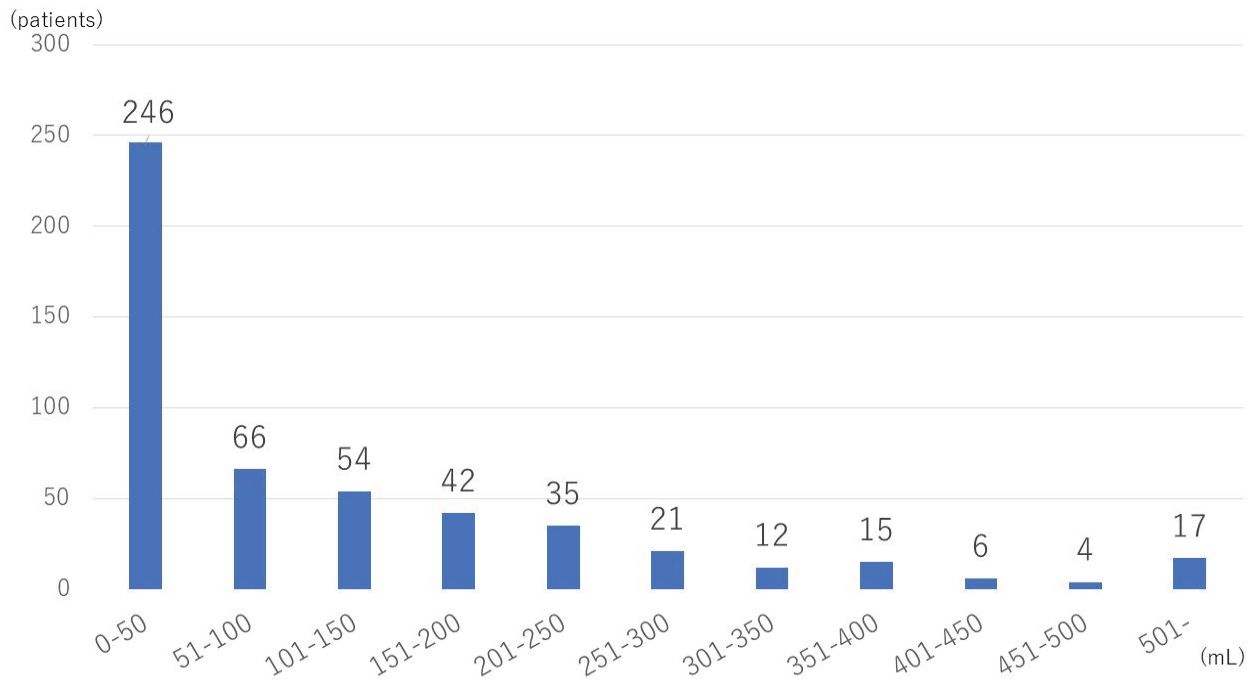

Figure 1: Intra-operative blood loss was measured and stratified in increments of 50 mL.

The horizontal axis indicates the amount of blood loss, and the vertical axis indicates the number of patients. Nearly half of the patients lost between 0 and 50 mL of blood. The number of patients in each group decreased gradually with the increase in blood loss, and rose in the heaviest bleeding group, i.e. blood loss of 500 mL or more.

Materials and Methods

Patients

The amount of intra-operative bleeding experienced by 518 patients with sinonasal disease who underwent ESS under general anaesthesia at Yokohama City University General Medical Centre between April 2012 and March 2020 was tabulated. Patients with neoplastic lesions and those who required extra-nasal incision were excluded.

The amount of bleeding was measured by subtracting the amount of saline solution sprayed into the nose to clean the surface of the lens from that aspirated by the suction tube and microdebrider during ESS.

Factors for analysis

A total of 34 variables were extracted for analysis in this study as follows: Patient background [age, sex, hypertension, asthma, antithrombotic medication, smoking habit, alcohol consumption, preoperative systolic blood pressure (sBP), and preoperative diastolic blood pressure (dBP)], nasal sinus pathology (sinus disease, Lund-Mackay score, number of inflamed sinuses, nasal polyps, preoperative macrolide use, preoperative steroid use, operative time, initial surgery or re-operation, unilateral or bilateral, and number of open sinuses), and blood test results [white blood cell (WBC), neutrophil/lymphocyte (Neu/Lym) ratio, eosinophils (Eos), haemoglobin (Hb), platelet (Plt), albumin (Alb), aspartate aminotransferase (AST), alanine aminotransferase (ALT), γ-glutamyl transpeptidase (γ-GTP), alkaline phosphatase (ALP), total bilirubin (T-bil), creatinine, C-reactive protein (CRP), prothrombin time-international normalised ratio (PT-INR) and activated partial thromboplastin time (APTT)].

Criteria for analysis

The participants were stratified into 11 groups according to bleeding volume in increments of 50 mL. The variance inflation factor was calculated for each study variable to confirm multicollinearity. Multivariate analysis by linear regression was performed, and standardised regression coefficients were calculated for each study variable. The confidence intervals and the amount of change between the 25% and 75% points were calculated.

The analyses were performed by a clinical statistician at our hospital. All statistical analyses were performed using the statistical analysis software R. P-values less than 0.05 were considered statistically significant.

This study was approved by the Research Ethics Review Committee of Yokohama City University General Medical Centre (B210500054).

Results

Bleeding volume and stratification

The distribution of patients according to bleeding volume (Figure 1) was as follows: 246 patients in the 0-50 mL group, 66 in the 51-100 mL group, 54 in the 101-150 mL group, 42 in

Table 1: The factors analysed in this study.

Variable	Value	n = 518	Variable	Value	n = 518
Age (years)	6-88	(med.53)	Sex (man)	343	(66.2%)
preoperative sBP (mmHg)	79-179	(med.122)	Hypertension (yes)	126	(24.3%)
preoperative dBP (mmHg)	32-116	(med.74)	Asthma (yes)	122	(23.5%)
Number of inflamed sinuses (pieces)	0-10	(med.6)	Antithrombotic medication (yes)	23	(4.4%)
Lund-Mackay score (points)	0-24	(med.8)	Smoking habit (yes)	261	(50.9%)
Operative time (minutes)	20-349	(med.154)	Alcohol consumption (yes)	282	(54.3%)
Number of sinuses opened (pieces)	1.-10	(med.8)	Sinus disease		
WBC (/μl)	2600-12830	(med.6005)	Odontogenic maxillary sinusitis	61	(11.8%)
Neu/Lym ratio	0.64-19.4	(med.1.82)	Fungal sinusitis	53	(10.2%)
Eos (%)	0.1-59.1	(med.3.65)	Eosinophilic chronic rhinosinuitis	65	(12.5%)
Hb (g/dl)	9.3-17.8	(med.14.3)	Cystic disease	24	(4.6%)
Plt (10^4/μl)	10.1-50.1	(med.23.6)	CRS with/without nasal polyps	315	(60.7%)
Alb (g/dl)	2.8-5.6	(med.4.5)	Nasal polyps (yes)	309	(59.5%)
AST (U/L)	9-164	(med.22)	Preoperative macrolide dose (yes)	162	(31.2%)
ALT (U/L)	6-169	(med.19)	Preoperative steroid dose (yes)	63	(12.1%)
γ-GTP (U/L)	8-213	(med.25)	Initial surgery or re-operation (Initial)	428	(82.6%)
ALP (U/L)	96-1837	(med.218)	Unilateral or bilateral (bilateral)	313	(60.4%)
T-bil (mg/dl)	0.3-2.7	(med.0.7)			
Creatinine (mg/dl)	0.34-12.61	(med.0.75)			
CRP (mg/dl)	0.001-11.319	(med.0.104)			
PT-INR	0.81-3.97	(med.0.97)			
APTT (seconds)	13.7-72	(med.30.3)			

WBC: White Blood Cell; Neu/Lym ratio: Neutrophil/Lymphocyte; Eos: Eosinophils; Hb: Haemoglobin; Plt: Platelet; Alb: Albumin; AST: Aspartate Aminotransferase; ALT: Alanine Aminotransferase; γ-GTP: γ-Glutamyl Transpeptidase; ALP: Alkaline Phosphatase; T-bil: Total Bilirubin; CRP: C-Reactive Protein; PT-INR: Prothrombin Time-International Normalised Ratio; APTT: Activated Partial Thromboplastin Time; CRS: Chronic Rhinosinusitis

the 151-200 mL group, 35 in the 201-250 mL group, 21 in the 251-300 mL group, 12 in the 301-350 mL group, 15 in the 351-400 mL group, 6 in the 401-450 mL group, 4 patients 451-450 mL group, and 17 patients in the 501 mL or more group.

Patient characteristics

The patient characteristics (Table 1) were as follows: The participants' ages ranged from 6 to 88 years (median: 53). The study population included 343 men and 175 women. The patients' medical history and habits were as follows: Hypertension, 126 patients; asthma, 122 patients, antithrombotic medication, 23 patients, smoking habit, 261 patients; and alcohol consumption, 282 patients. The preoperative sBP ranged from 79-179 mmHg (median: 122), and the preoperative dBP ranged from 32-116 mmHg (median: 74).

Sinonasal pathology

The sinonasal pathology (Table 1) was as follows: The sinus diseases included fungal sinusitis (n = 53, 10.2%), odontogenic maxillary sinusitis (n = 61, 11.8%), cystic disease (n = 24, 4.6%), eosinophilic chronic rhinosinusitis (ECRS) (n = 65, 12.5%), and chronic rhinosinusitis (CRS) (n = 315, 60.7%).

The number of inflamed sinuses ranged from 0-10 (median: 6), while the Lund-Mackay score ranged from 0-24 (median: 8); 309 (59.5%) patients had nasal polyps. A total of 162 (31.2%) patients took macrolides and 63 (12.1%) took steroids.

Surgical factors

The surgical factors (Table 1) were as follows: The operative time ranged from 20 to 349 min (median: 154). In this study, 428 patients underwent ESS for the first time, and 90 patients underwent re-operation. The sinus disease which the 90 patients of re-operation had included fungal sinusitis (n = 5, 5.6%), odontogenic maxillary sinusitis (n = 2, 2.2%), cystic disease (n = 21, 23.3%), ECRS (n = 20, 22.2%), and CRS (n = 42, 46.7%). Bilateral surgery was performed for 313 patients and unilateral surgery for 205 patients. The number of open sinuses ranged from 1-10 (median: 8).

Laboratory blood data

The laboratory blood data (Table 1) was as follows: The results (range) of blood testing were as follows: WBC, 2600-12830/μL (median: 6005); Neu/Lym ratio, 0.64-19.4 (median: 1.82). Eos, 0.1-59.1% (median 3.65); Hb, 9.3-17.8 g/dL

(median: 14.3); Plt, 10.1-50.1 × 104/μL (median: 23.6); Alb, 2.8-5.6 g/dL (median: 4.5); AST, 9-164 U/L (median: 22); ALT, 6-169 U/L (median: 19); γ-GTP, 8-213 U/L (median: 25); ALP, 96-1837 U/L (median: 218); T-bil, 0.3-2.7 mg/dL (median: 0.7); creatinine, 0.34-12.61 mg/dL (median: 0.75); CRP, 0.001-11.319 mg/dL (median: 0.104); PT-INR, 0.81-3.97 (median: 0.97); and APTT, 13.7-72 s (median: 30.3).

Variance inflation factors

The results of the analysis of the coefficient of variance are shown in Table 2. The values of the variance inflation factors for each variable were as follows: Age, 1.94, sex (female), 1.79; hypertension, 2.06; asthma, 1.51, antithrombotic medication; 1.19; smoking habit, 1.36; alcohol consumption, 1.28; preoperative sBP, 2.41; preoperative dBP, 1.12; odontogenic maxillary sinusitis, 3.08; cystic disease, 2.16; fungal sinusitis, 2.92; CRS, 3.62; Lund-Mackay score, 5.40; number of inflamed sinuses, 5.47; nasal polyps, 17.9; preoperative macrolide use, 1.16; preoperative steroid use, 1.34; operative time, 1.72; history of ESS (re-operation), 1.41; laterality (bilateral), 4.27; number of open sinuses, 7.15; WBC, 1.51; Neu/Lym ratio, 1.33; Eos, 1.41; Hb, 2.26; Plt, 1.48; Alb, 1.64; AST, 3.05; ALT, 3.73; γ-GTP, 1.60; ALP, 1.21; T-bil, 1.29; creatinine, 1.10; CRP, 1.50; PT-INR, 1.24; and APTT, 1.12.

Table 2: Variance inflation factors for the variables analysed in this study.

	n = 518
Sex (man)	1.79
Age (years)	1.94
Hypertension (yes)	2.06
Asthma (yes)	1.51
Antithrombotic medication (yes)	1.19
Smoking habit (yes)	1.36
Alcohol consumption (yes)	1.28
Preoperative sBP (mmHg)	2.41
Preoperative dBP (mmHg)	1.12
Sinus disease	
Odontogenic maxillary sinusitis	3.08
Fungal sinusitis	2.92
Cystic disease	2.16
CRS with/without nasal polyps	3.62
Number of inflamed sinuses (pieces)	5.47
Lund Mackay score (points)	5.4
Nasal polyps (yes)	1.79
Preoperative macrolide use (yes)	1.16
Preoperative steroid use (yes)	1.34
Operative time (minutes)	1.72
Initial surgery or re-operation (re)	1.41
Unilateral or bilateral (bilateral)	4.27
Number of sinuses opened (pieces)	7.15
WBC (/μl)	1.51
Neu/Lym ratio	1.33
Eos (%)	1.41
Hb (g/dl)	2.26
Plt (10^4/μl)	1.48
Alb (g/dl)	1.64
AST (U/L)	3.05
ALT (U/L)	3.73
γGTP (U/L)	1.6
ALP (U/L)	1.21
T-bil (mg/dl)	1.29
Creatinine (mg/dl)	1.1
CRP (mg/dl)	1.5
PT-INR	1.24
APTT (seconds)	1.12

None of the variables possessed sufficient multicollinearity to cause problems in the multivariate analysis.

sBP: systolic Blood Pressure; dBP: diastolic Blood Pressure; CRS: Chronic Rhinosinusitis; WBC: White Blood Cell; Neu/Lym ratio: Neutrophil/Lymphocyte; Eos: Eosinophils; Hb: Haemoglobin; Plt: Platelet; Alb: Albumin; AST: Aspartate Aminotransferase; ALT: Alanine Aminotransferase; γ-GTP: γ-Glutamyl Transpeptidase; ALP: Alkaline Phosphatase; T-bil: Total Bilirubin; CRP: C-Reactive Protein; PT-INR: Prothrombin Time-International Normalised Ratio; APTT: Activated Partial Thromboplastin Time

None of the variables possessed sufficient multicollinearity to cause problems in the multivariate analysis.

Multivariate analysis by linear regression

Multivariate analysis (Table 3) revealed significant differences ($p < 0.05$) in PT-INR, the Lund-Mackay score, operative time, and history of surgery. No significant differences were found for the other variables.

The confidence intervals and the degree of change between the 25% and 75% points are shown in Table 4. The four principal factors that showed significant differences were an increase of 1 in the PT-INR at 64.9 mL, increase in the Lund-Mackay Score from 5 to 14 points at 73.0 mL, increase in the operative time from 102 to 201 min at 28.2 mL, and increase in the frequency of re-operation versus initial surgery at 49.1 mL.

Discussion

Several studies have focused on excessive bleeding control in ESS, the endoscopic view, and methods for bleeding control. These studies examined the appropriate methods to reduce blood loss and make the procedure easier and safer [1-25]. We think that identifying the risk factors for excessive bleeding will help clinicians focus on bleeding concerns and plan and implement countermeasures in advance. The factors that showed significant differences were operative time, initial surgery versus re-operation, Lund-Mackay score, and PT-INR. Because the degree of the 25% and 75% points was the largest in the Lund-Mackay score at 73.0 mL, this score exhibited the strongest correlation with blood loss.

Table 3: Results of multivariate analysis by linear regression.

Factor	Estimate	Standardized	Std. Error	Pr(>|t|)	n = 518
Sex (woman)	-22.499	-0.085	14.183	0.11	
Age (years)	-0.551	-0.076	0.409	0.18	
Hypertension (yes)	-1.795	-0.0062	16.798	0.91	
Asthma (yes)	-16.839	-0.057	14.573	0.25	
Antithrombotic medication (yes)	-29.816	-0.049	26.499	0.26	
Smoking habit (yes)	7.467	0.030	11.711	0.52	
Alcohol consumption (yes)	-1.397	-0.0056	11.379	0.90	
Preoperative sBP (mmHg)	0.0072	0.0011	0.403	0.99	
Preoperative dBP (mmHg)	-0.148	-0.047	0.133	0.27	
Sinus disease					
Odontogenic maxillary sinusitis	15.940	0.041	27.463	0.56	
Fungal sinusitis	23.230	0.057	28.232	0.41	
Cystic disease	-30.639	-0.052	35.002	0.38	
CRS with/without nasal polyps	-13.456	-0.053	19.594	0.49	
Number of inflamed sinuses (pieces)	2.260	0.054	3.947	0.57	
Lund Mackay score (points)	-8.116	0.385	1.973	0.0001	***
Nasal polyps (yes)	1.807	0.0071	13.690	0.90	
Preoperative macrolide dose (yes)	1.688	0.0063	11.653	0.88	
Preoperative steroid dose (yes)	-13.475	-0.035	17.754	0.45	
Operative time (minutes)	0.286	0.145	0.104	0.0063	**
Initial surgery or re-operation (re)	49.098	0.150	15.690	0.0019	**
Unilateral or bilateral (bilateral)	-0.689	-0.0027	21.204	0.97	
Number of sinuses opened (pieces)	-2.680	-0.072	3.983	0.50	
WBC (/μl)	0.0070	0.096	0.004	0.05	
Neu/Lym ratio	1.321	0.015	4.181	0.75	
Eos (%)	-1.364	-0.052	1.254	0.28	
Hb (g/dl)	4.185	0.045	5.579	0.28	
Plt (10^4/μl)	-1.586	-0.075	1.038	0.13	
Alb (g/dl)	-16.818	-0.045	19.300	0.38	
AST (U/L)	-0.014	-0.0013	0.774	0.99	
ALT (U/L)	0.216	0.026	0.635	0.73	
γGTP (U/L)	-0.085	-0.020	0.211	0.69	
ALP (U/L)	-0.039	-0.040	0.043	0.36	
T-bil (mg/dl)	-22.763	-0.051	20.299	0.26	
Creatinine (mg/dl)	-0.906	-0.004	9.626	0.93	
CRP (mg/dl)	-3.138	-0.019	8.147	0.70	
PT-INR	64.883	0.090	32.356	0.046	*
APTT (seconds)	1.298	0.049	1.131	0.25	

Significant ($p < 0.05$) differences were observed in PT-INR, Lund-Mackay score, operative time, and initial surgery versus re-operation. No significant differences were found for the other items.

sBP: systolic Blood Pressure; dBP: diastolic Blood Pressure; CRS: Chronic Rhinosinusitis; WBC: White Blood Cell; Neu/Lym ratio: Neutrophil/Lymphocyte; Eos: Eosinophils; Hb: Haemoglobin; Plt: Platelet; Alb: Albumin; AST: Aspartate Aminotransferase; ALT: Alanine Aminotransferase; γ-GTP: γ-Glutamyl Transpeptidase; ALP: Alkaline Phosphatase; T-bil: Total Bilirubin; CRP: C-Reactive Protein; PT-INR: Prothrombin Time-International Normalised Ratio; APTT: Activated Partial Thromboplastin Time

$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

Table 4: Confidence intervals and the amount of change between the 25% and 75% points.

Factor	Low	High	Effect	95% CI			n = 518
Sex (woman)	1	2	-22.499	-50.369	to	5.370	
Age (years)	41	67	-14.194	-34.897	to	6.510	
Hypertension (yes)	1	2	-1.795	-34.802	to	31.210	
Asthma (yes)	1	2	-16.839	-45.474	to	11.800	
Antithrombotic medication (yes)	1	2	-29.816	-81.885	to	22.250	
Smoking habit (yes)	2	1	-7.467	-30.480	to	15.540	
Alcohol consumption (yes)	2	1	1.397	-20.963	to	23.760	
Preoperative sBP (mmHg)	109	136	0.195	-21.182	to	21.570	
Preoperative dBP (mmHg)	65	85	-2.961	-8.194	to	2.270	
Sinus disease (vs. CRSw/sNP)							
Odontogenic maxillary sinusitis	5	2	29.396	-9.074	to	67.870	
Fungal sinusitis	5	4	36.686	-4.150	to	77.520	
Cystic disease	5	3	-17.183	-75.246	to	40.880	
Eosinophillic chronic rhinosinuitis	5	1	13.456	-25.046	to	51.960	
Number of inflamed sinuses (pieces)	0	10	-18.759	-73.544	to	36.030	
Lund Mackay score (points)	5	14	73.047	38.151	to	107.940	
Nasal polyps (yes)	2	1	-1.807	-28.706	to	25.090	
Preoperative macrolide dose (yes)	1	2	1.688	-21.209	to	24.590	
Preoperative steroid dose (yes)	1	2	-13.475	-48.361	to	21.410	
Operative time (minutes)	102	201	28.229	8.013	to	48.450	
Initial surgery or re-operation (Initial)	1	2	49.098	18.268	to	79.930	
Unilateral or bilateral (bilateral)	2	1	0.689	-40.976	to	42.350	
Number of sinuses opened (pieces)	4	10	13.561	-32.971	to	60.090	
WBC (/μl)	5100	7293	15.407	-0.199	to	31.010	
Neu/Lym ratio	1.00	2.449	1.412	-7.369	to	10.190	
Eos (%)	1.00	6.400	-6.272	-17.604	to	5.060	
Hb (g/dl)	13.00	15.100	7.846	-12.708	to	28.400	
Plt (10^4/μl)	19.00	27.375	-12.013	-27.455	to	3.430	
Alb (g/dl)	4.00	4.700	-6.727	-21.897	to	8.440	
AST (U/L)	18.00	27.000	-0.124	-13.818	to	13.570	
ALT (U/L)	13.00	28.750	3.407	-16.244	to	23.060	
γGTP (U/L)	16.00	42.000	-2.198	-12.956	to	8.560	
ALP (U/L)	185.00	278.750	-3.685	-11.661	to	4.290	
T-bil (mg/dl)	0.00	0.800	-4.553	-12.530	to	3.420	
Creatinine (mg/dl)	0.00	0.860	-0.199	-4.360	to	3.960	
CRP (mg/dl)	0.00	0.223	-0.548	-3.346	to	2.250	
PT-INR	0.00	1.020	5.839	0.117	to	11.560	
APTT (seconds)	28.00	1.020	5.809	-4.135	to	15.750	

The four main items that showed significant differences were as follows: an increase of 1 in PT-INR at 64.9 mL, increase in the Lund Mackay score from 5 to 14 points at 73.0 mL, increase in operative time from 102 to 201 min to 28.2 mL, and the frequency of re-operation increased compared to initial surgery at 49.1 mL.

sBP: systolic Blood Pressure; dBP: diastolic Blood Pressure; CRS: Chronic Rhinosinusitis; WBC: White Blood Cell; Neu/Lym ratio: Neutrophil/Lymphocyte; Eos: Eosinophils; Hb: Haemoglobin; Plt: Platelet; Alb: Albumin; AST: Aspartate Aminotransferase; ALT: Alanine Aminotransferase; γ-GTP: γ-Glutamyl Transpeptidase; ALP: Alkaline Phosphatase; T-bil: Total Bilirubin; CRP: C-Reactive Protein; PT-INR: Prothrombin Time-International Normalised Ratio; APTT: Activated Partial Thromboplastin Time

Quantification of blood loss provides an objective method for measuring the amount of intra-operative bleeding [7,8]. Measurement of the suctioned content has garnered criticism as an inaccurate method of for quantifying the volume of blood loss, as tissue and rinsing saline are collected in the suction bottle meant for blood [9]. Nevertheless, most studies measured the amount of blood stored using the aspiration system [10-18]. In the present analysis, we reduced the influence of bias on the amount of blood loss in each case by dividing the patients into groups of 50 mL.

Operative time was found to be an independent factor that increased intra-operative bleeding. However, the operative time can only be evaluated retrospectively owing to its inherent nature. Therefore, it is difficult to determine whether the surgery takes longer because of excessive blood loss or whether a longer operative time results in greater blood loss. Previous studies reported that the total amount of bleeding depends directly on the duration of surgery [19,20]. We think that the fact that operative time was deemed to be an independent factor is important on this study's accuracy, since it coincides with the results of previous analyses.

PT-INR, which was found to be independently correlated with the amount of bleeding in this study, is an indicator of the coagulation capacity. It is obvious that the higher the PT-INR value, the greater the bleeding volume.

The amount of blood loss was greater in patients undergoing re-operation compared to those undergoing ESS for the first time. Surgical treatment is more difficult in recurrent cases due to scarring and changes in nasal morphology. Moreover, patients with ECRS are prone to recurrence [21] and some Japanese reports suggested that ESS of ECRS usually caused more blood loss than other sinus disease [22]. In the English literature, few studies exist that focus on the concept of ECRS, and some researchers have stated that the intensity of local inflammation affects bleeding during ESS [19]. Moreover, blood loss presents a substantial problem during ESS in patients with broad nasal polyps [19]. ECRS is characterised by prominent bilateral nasal polyps and intense eosinophilic inflammation [21]; thus, it can be inferred that patients with ECRS are prone to excessive bleeding during ESS.

The possible reasons for the high incidence of bleeding in recurrent cases include scar formation, post-operative changes, and high degree of local inflammation, especially in cases with frequent recurrence.

The Lund-Mackay score was independently correlated with the amount of bleeding. Previous reports have shown that CRS with extensive lesions are often associated with excessive bleeding [23,24], and this study is consistent. On the other hand, the number of sinuses opened by surgery, number of inflamed sinuses, and laterality of the operative site (bilateral or unilateral) were not independent factors. For example, in the case of a single sinus lesion of the sphenoid sinus, the intact ethmoidal or maxillary sinus may be opened if necessary. The present analysis suggests that opening sinuses with no or little inflammation do not or are unlikely to affect the amount of bleeding.

In summary, we found that the amount of bleeding is correlated with the severity of sinusitis and not with the extent of surgery, and that the Lund-Mackay score is a good system that reflects the severity of sinusitis.

The amount of bleeding did not differ significantly with respect to the type of sinus disease. As a tendency the amount of bleeding was lesser in cystic disease and greater in odontogenic maxillary sinusitis and fungal sinusitis. On the other hand, the proportion of recurrent cases was 22.6% in cystic disease with a higher frequency of post-operative maxillary cysts, 54.8% in CRS, and 19.4% in ECRS. The proportion of cystic disease and ECRS was large compared to overall, but it did not agree with the data on bleeding tendency by disease. In addition to the factors that re-operation itself has. There might be other factors that increase bleeding in a group of patients with recurrence. Analysis with a different study design is needed for the next.

None of the items related to hypertension were statistically significant. In addition to a history of hypertension, some patients presented with high blood pressure on the day before surgery, which was not correlated with excessive bleeding. We believe that the systemic management for general anaesthesia played a major role in these results. In our hospital, we often ask the anaesthesiologist to manage the sBP so that it does not exceed 100 mmHg. Previous studies have also shown that controlling the mean arterial pressure and heart rate facilitates management of bleeding and secures the visual field [25]. This result suggests the importance of good communication with the anaesthesiologist during surgery to maintain the blood pressure and heart rate under control.

WBC and CRP are widely used haematological indicators of inflammation. However, no significant differences were found in these factors with respect to intra-operative blood loss in the present analysis. In the case of chronic sinusitis, it is possible that the inflammation was only local and did not extend systemically. In fact, the WBC and CRP levels were within the normal range in most cases. The degree of inflammation on computed tomography and nasal examination may show a better correlation compared to the severity of inflammation on haematological testing.

Conclusion

We examined the factors correlated with the amount of blood loss during ESS at our hospital. The results showed that preoperative precautionary measures should be implemented in the event of re-operation, expected long operative time, high Lund-Mackay score, and prolonged PT-INR. Particular attention should be paid to intra-operative blood loss in patients with a high Lund-Mackay score.

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Author Contributions Statement

Y.O., H.H., K.H., S.Y., N.K., T.I., Y.M. and H.N. examined and treated the patient. Y.O., K.H., S.Y., N.K. and T.I. collected the data. K.Y. performed statistical analysis. Y.O. and H.H.

wrote the manuscript and made all the figures. K.N., Y.I., K.S., T.K. and N.O. supervised the manuscript. All authors have read and approved the manuscript for publication and the authorship.

Competing Interests

The authors declare no competing interests.

Data Availability

Data are available upon reasonable request from the corresponding author.

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