

## ORIGINAL ARTICLE

# Effect of removal of subglottic blood during endoscopic sinus surgery

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## ABSTRACT

**Objective:** Postoperative pulmonary complications may occur after endoscopic sinus surgery, secondary to leakage of blood into the trachea from the surgical field. We investigated the effects of removal of subglottic fluid, including blood, during endoscopic sinus surgery on the incidence of postoperative hypoxia and high fever.

**Methodology:** We first retrospectively confirmed whether the incidence of fever  $>38^{\circ}\text{C}$  and hypoxia ( $\text{SpO}_2 < 95\%$ ) in the first 24 h after endoscopic sinus surgery was higher than that after tympanoplasty (total  $n=99$ ). Next, the amount and characteristics of subglottic fluid were prospectively evaluated in the two groups, and the incidences of fever and hypoxia in the first 24 h postoperatively were compared between the two groups (total  $n=90$ ).

Data were analyzed using SPSS for Windows version 11.0 (SPSS Inc., Chicago, IL, USA). Normally distributed continuous data were analyzed using Student's *t*-test. Continuous data not normally distributed were analyzed using the Mann-Whitney *U*-test. Categorical data were analyzed using the  $\chi^2$  test. Statistical significance was defined as  $p < 0.05$ .

**Results:** The retrospective study showed that the incidences of fever and hypoxia were significantly higher after endoscopic sinus surgery than tympanoplasty (fever,  $p=0.001$ ; hypoxia,  $p=0.024$ ). The prospective study showed that the amount of subglottic secretions was significantly higher after endoscopic sinus surgery than tympanoplasty ( $p=0.006$ ). The pH values of subglottic and oral fluid were significantly higher after endoscopic sinus surgery than tympanoplasty (subglottic fluid,  $p=0.04$ ; oral fluid,  $p<0.001$ ). However, there were no significant differences between the two groups in the incidence of fever over  $38^{\circ}\text{C}$  and hypoxia in the first 24 h postoperatively.

**Conclusions:** An increase in subglottic fluid, including blood, during endoscopic sinus surgery might cause fever and hypoxia postoperatively. Removal of the fluid is likely an effective technique for preventing pulmonary complications.

**Key words:** Hypoxia; Pulmonary complications; Fever; Endoscopic sinus surgery; Subglottic fluid

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## INTRODUCTION

Hemoglobin or other blood components depress bacterial phagocytosis.<sup>1,2</sup> Tierney et al reported that blood components impair the function of alveolar surface-active material in rabbit lungs.<sup>3</sup> Therefore, endoscopic sinus surgery (ESS), a procedure that increases subglottic fluid, including blood from the surgical field, might cause postoperative pulmonary complications due to passage of the fluid into the lung.

To investigate whether adequate removal of subglottic fluid during ESS is an effective technique to suppress possible postoperative pulmonary complications, the following hypotheses were tested: (1) the incidence of

pulmonary complications (hypoxia and high fever) after ESS is higher than after other otolaryngological surgeries; and (2) removal of subglottic fluid reduces the incidence of pulmonary complications.

## METHODOLOGY

### 1. Retrospective study

First, patients who underwent tympanoplasty ( $n=49$ ), as representative of otolaryngological surgeries, and ESS ( $n=50$ ) from April 2009 to July 2011 at our hospital were selected for retrospective evaluation. The records of all patients under 18 years, patients with American Society of Anesthesiologists (ASA) physical status 3-6, and those who

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underwent emergency surgeries were excluded. Anesthesia in all patients was maintained with continuous infusion of propofol and remifentanyl, and bolus infusion of fentanyl. Patients were intubated with cylindrical cuffed endotracheal tubes. Age, sex, body mass index (BMI), current smoking, ASA physical status, duration of anesthesia, duration of operation, total infusion volume, total urine volume, total bleeding volume, and incidence of fever above 38°C and hypoxia (SpO<sub>2</sub> under 95%) in the first 24 h postoperatively were obtained from the anesthetic and postoperative records. Propensity score-matched analysis, which included patient characteristics and intraoperative variables (age, sex, BMI, current smoking, ASA physical status, duration of anesthesia) in the propensity score model, was selected to reduce preoperative confounding factors.<sup>4</sup> Patients who underwent tympanoplasty and whose propensity scores deviated by >0.02 from those of patients who underwent ESS were considered unmatched.

## 2. Prospective study

The study was conducted in accordance with the recommendations of the Ethics Committee of Fukui University Hospital (approved number; 22-118). After informed consent was obtained from each patient, 90 ASA physical status I or II patients, aged 18 to 85 years, scheduled for elective tympanoplasty (tympanoplasty group, n=45) or ESS (ESS group, n=45) under general anesthesia were enrolled in the study.

All patients were kept nil per os for 8 h before surgery. None of the patients was given premedication. In the operating room, anesthesia was induced with intravenous injections of remifentanyl and propofol, and maintained with continuous infusions of the same agents. After administration of rocuronium, all patients were intubated

with a special endotracheal tube (TaperGuard™Evac, Covidien Japan, Tokyo, Japan) that allowed drainage of subglottic fluid. The internal diameters of the endotracheal tubes selected were 7-7.5 mm for women and 8-8.5 mm for men. The cuff pressure was maintained between 20 and 30 cmH<sub>2</sub>O during surgery.

In both groups, subglottic and oral fluids were suctioned manually with a 10 ml syringe at the end of surgery, to measure the volume and pH of the fluid. The pH value was measured using the pH meter with two-point automatic calibration (B-213 Twin Compact pH Meter, HORIBA, Tokyo, Japan), which can measure pH using only a single drop (0.1 ml to a few µl) of the sample.

All patients were given 100% O<sub>2</sub> (flow rate 6L/min) using a face mask for up to 6 h after surgery. The incidence of fever over 38°C and the incidence of hypoxia (SpO<sub>2</sub> < 95%) in the first 24 h was investigated.

## 3. Statistical analysis

All values are reported as means ± SD. Data were analyzed using SPSS for Windows version 11.0 (SPSS Inc., Chicago, IL, USA). Normally distributed continuous data were analyzed using Student's *t*-test. Continuous data not normally distributed were analyzed using the Mann-Whitney *U*-test. Categorical data were analyzed using the  $\chi^2$  test. Statistical significance was defined as *p* < 0.05.

## RESULTS

### 1. Retrospective study

Propensity matching yielded 33 pairs of patients who underwent tympanoplasty and ESS. The characteristics of the propensity-matched patients were well matched between the tympanoplasty and ESS groups (Table 1).

**Table 1: Baseline patient characteristics and intraoperative variables before and after propensity matching (retrospective study)**

Characteristics	Before matching			After matching		
	Tympanoplasty (n=49)	ESS (n=50)	P-value	Tympanoplasty (n=33)	ESS (n=33)	P-value
Age (years)*	50.5±18.3	49.1±19.7	0.712	47.8±16.2	51.9±18.6	0.337
Females	21 (42.9%)	22(44.0%)	0.771	14(42.4%)	15(45.5%)	0.804
BMI (kg/m <sup>2</sup> )*	22.6±3.9	22.8±3.6	0.802	22.3±4.2	22.2±3.3	0.866
ASA 2	15(30.6%)	14(28.0%)	0.877	9(27.3%)	9(27.3%)	1.000
Current smoker	13(26.5%)	8(16.0%)	0.239	5(15.2%)	7(21.2%)	0.523
Duration of anesthesia (min)*	271.2±67.3	233.4±71.1	0.007	259.6±68.0	248.0±77.0	0.518
Duration of operation (min)*	199.5±66.0	152.1±61.2	<0.001	188.4±67.6	162.3±67.5	0.121
Total infusion volume (ml)*	1373.6±480.7	1483.8±751.9	0.386	1411.2±510.7	1673.5±809.4	0.12
Total bleeding volume (ml)*	3.2±12.2	123.0±209.5	<0.001	2.7±9.2	148.0±244.0	0.001

ESS= endoscopic sinus surgery. BMI= body mass index.

ASA= American Society of Anesthesiologists score

\*Mean ±SD.

After propensity matching, intraoperative variables (such as duration of operation and total infusion volume) also showed no significant differences between the two groups, except for total intraoperative bleeding volume (Table 1). The incidence of fever over 38°C in the first 24 h after surgery was significantly higher in the ESS group than

in the tympanoplasty group ( $p=0.001$ ). The incidence of hypoxia was also significantly higher in the ESS group than in the tympanoplasty group ( $p=0.024$ ) (Table 2).

## 2. Prospective study

Of the 90 eligible patients, three patients in the ESS group

**Table 2: Comparison of postoperative pulmonary complications between tympanoplasty and endoscopic sinus surgery groups (retrospective study)**

Surgery	Before matching			After matching		
	Tympanoplasty (n=49)	ESS (n=50)	P-value	Tympanoplasty (n=33)	ESS (n=33)	P-value
Incidence of fever >38°C in first 24 h postop	0	13(26.0%)	<0.001	0	9(27.3%)	0.001
Incidence of SpO <sub>2</sub> <95% in first 24 h postop	3 (6.1%)	10(20.0%)	0.034	1(3.0%)	7(21.2%)	0.024

**Table 3: Demographic data and intraoperative variables (prospective study)**

Parameter	Tympanoplasty (n=45)	ESS (n=42)	P-value
Age (years)*	55.0±14.5	55.7±21.6	0.852
Females	19 (42.2%)	24 (57.1%)	0.164
BMI (kg/m <sup>2</sup> )*	23.2±3.7	23.9±3.7	0.339
ASA 2	20(44.4%)	23 (54.8%)	0.339
Current smoker	14 (33.3%)	7 (16.7%)	0.116
Duration of anesthesia (min)*	280.3±58.4	228.1±65.7	<0.001
Duration of operation (min)*	213.1±59.5	143.3±59.4	<0.001
Total infusion volume (ml)*	1565.0±617.9	1381.4±634.2	0.175
Total urine volume (ml)*	665.4±417.3	548.6±371.4	0.173
Total bleeding volume (ml)*	20.0±43.6	102.8±143.6	<0.001

\*Mean ±SD.

**Table 4: Comparison of the amount and characteristics of subglottic secretions above the endotracheal tube cuff between tympanoplasty and endoscopic sinus surgery groups (prospective study)**

Secretions parameter	Tympanoplasty (n=45)	ESS (n=42)	P-value
The amount of subglottic secretions(ml)*	0.87±0.99	2.18±2.98	0.006
The amount of oral secretions(ml)*	3.44±2.50	2.83±1.97	0.212
pH value of subglottic secretions*	7.23±0.47	7.48±0.46	0.04
pH value of oral secretions*	6.60±0.49	7.24±0.49	<0.001
Incidence of subglottic secretions with blood	3(6.67%)	27(57.1%)	<0.001

\*Mean ±SD.

**Table 5: Comparison of postoperative pulmonary complications between tympanoplasty and endoscopic sinus surgery groups (prospective study)**

	Tympanoplasty (n=45)	ESS (n=42)	P-value
Incidence of fever >38°C in first 24 h postop	4 (8.89%)	8(19.0%)	0.17
Incidence of SpO <sub>2</sub> <95% in first 24 h postop	1 (2.22%)	4(9.52%)	0.144

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were excluded because of atropine use during surgery. Thus, the analysis included 87 patients (45 patients in the tympanoplasty group and 42 patients in the ESS group). The patients' characteristics and demographic data are summarized in Table 3. Duration of anesthesia and operation were significantly longer in the tympanoplasty group than in the ESS group. Bleeding during surgery was significantly less in the tympanoplasty group than in the ESS group. There were no significant differences between the groups in other intraoperative variables.

The amount of subglottic fluid was significantly greater in the ESS group than in the tympanoplasty group ( $p=0.006$ ) (Table 4), while the amount of oral fluid was similar in the two groups. The pH of subglottic fluid and that of the oral fluid were significantly higher in the ESS group than in the tympanoplasty group, ( $p=0.04$  and  $p<0.001$ , respectively). The incidence of bloody subglottic fluid was significantly higher in the ESS group than in the tympanoplasty group ( $p<0.001$ ). There were no differences between the groups in the incidence of both fever over  $38^{\circ}\text{C}$  and hypoxia in the first 24 h postoperatively.

## DISCUSSION

The major findings of our retrospective and prospective studies were as follows: (1) the incidence of  $\text{SpO}_2 < 95\%$  and fever  $> 38^{\circ}\text{C}$  in the first 24 h after ESS was significantly higher than after tympanoplasty; and (2) removal of subglottic fluid equalized the incidences after ESS and tympanoplasty.

Blood from the surgical field passes down into the oral and subglottic areas during ESS. In fact, in our prospective study, the amount of subglottic fluid was significantly greater in the ESS group than in the tympanoplasty group. Assessment of the amount of bloody fluid and its pH values indicated that most of the subglottic fluid in the ESS group must have been blood, since the pH of blood is neutral. Hemoglobin or other blood components depress bacterial phagocytosis,<sup>1,2</sup> while, reportedly, blood components might impair the function of alveolar surface-active material in rabbit lungs.<sup>3,4</sup> Therefore, we hypothesized that blood from the surgical field during ESS may pass

down into the lungs and cause subsequent pulmonary complications. Hence, we first retrospectively investigated the incidence of postoperative hypoxia and high fever after ESS. As a result, we confirmed that the incidence of  $\text{SpO}_2 < 95\%$  and fever  $> 38^{\circ}\text{C}$  in the first 24 h after ESS was significantly higher than after other otolaryngological surgeries, such as tympanoplasty. Crockett et al reported that increased pulmonary complications may occur after ESS even in children.<sup>5</sup>

Next, to ascertain whether possible leakage of blood into the lungs during ESS can lead to postoperative deterioration in  $\text{SpO}_2$  and body temperature, we cleared subglottic blood and prevented the leakage of it with a special endotracheal tube. This tube combines clearance of subglottic fluid with a tapered high-volume low-pressure cuff. The cuff, unlike a usual cylindrical cuff, does not create micro capillary channels within the longitudinal folds of the cuff wall. The channels allow to drip the subglottic fluid that accumulates above the endotracheal tube cuff into the lower respiratory tract. Several studies have suggested that leakage of fluid into the trachea during surgery causes microaspiration.<sup>6-8</sup> In the prospective part of this study with the special endotracheal tube, the incidence of  $\text{SpO}_2 < 95\%$  and fever  $> 38^{\circ}\text{C}$  in the first 24 h after ESS was equal to that after tympanoplasty. This suggests that removal of subglottic blood and prevention of its leakage might decrease the incidence of pulmonary complications.

Since an  $\text{SpO}_2$  of greater than 95% is generally considered to be normal,<sup>9</sup> we defined hypoxemia as an  $\text{SpO}_2$  of  $<95\%$ . A temperature of  $>38^{\circ}\text{C}$  is a diagnostic clinical criterion of ventilator-associated tracheobronchitis.<sup>10</sup> We believe that subglottic blood was one of the causes of the high fever after ESS in the retrospective study, because its incidence decreased with prevention of the leakage of blood into the lungs in the prospective study.

## CONCLUSION

In conclusion, accumulation of bloody fluid in the subglottic area might cause postoperative fever and hypoxia after ESS. Removal of this fluid is likely an effective technique for preventing pulmonary complications after ESS.

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