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Nocturnal episodic hypoxemia after ambulatory breast cancer surgery: comparison of sevoflurane and propofol-fentanyl anesthesia

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Abstract
Purpose. To study the incidence and severity of nocturnal episodic hypoxemia after ambulatory breast cancer surgery and its differences with sevoflurane and propofol anesthesia.
Methods. Sixty-one adult female patients (ASA PS I–II; age, 32–77 years) without an apparent history of sleep apnea and respiratory disease undergoing major breast cancer surgery on an outpatient basis and with planned overnight admission were randomized to one of two anesthesia maintenance groups: sevoflurane anesthesia (SEV, $n = 31$) or intravenous propofol, fentanyl, and vecuronium anesthesia (TIVA, $n = 30$). All patients were administered propofol 2 mg·kg^{-1} intravenously for anesthesia induction, had a laryngeal mask airway placed, and received rectal diclofenac and local infiltration anesthesia for pain relief. No opioid analgesic or oxygen was administered after discharge from the postanesthesia care unit (PACU). Oxygen saturation (S_{pO_2}) was recorded continuously during the first postoperative night. S_{pO_2} <90% that lasted >10 s was regarded as hypoxemia, and the percentage of effective recording time with S_{pO_2} <90% (%time with S_{pO_2} <90) was evaluated.
Results. Six patients (SEV3/TIVA3) had >1% of %time with S_{pO_2} <90 (S-hypoxemia group), 17 (SEV7/TIVA10) had >0% and ≤1% (M-Hypoxemia group), and 38 (SEV21/TIVA17) had 0% (no-hypoxemia group). There were no statistical differences in age, ASA PS, anesthesia technique, and duration of anesthesia among groups. The S-hypoxemia group had higher body mass index (BMI) and incidence of oxygen supplementation in the PACU than the no-hypoxemia group. No patient had major complications.
Conclusion. Nocturnal episodic hypoxemia occurs frequently after ambulatory breast cancer surgery. The incidence was not different between SEV and TIVA. Hypoxic patients had a higher BMI and needed oxygen therapy in PACU more frequently.

Key words Postoperative nocturnal episodic hypoxemia · Breast cancer surgery · Ambulatory anesthesia · Sevoflurane · Propofol

Introduction

Hypoxemia is a common problem after major inpatient surgery [1–5]. In the early postoperative period, constant or episodic hypoxemia often occurs after major surgery; therefore, all patients should be monitored with hemoglobin oxygen (O_2) saturation and receive O_2 therapy after major surgery in a postanesthesia care unit (PACU) [1]. Several studies have documented episodic hypoxemia during the first to fifth nights after major surgery [2–21]. It has been demonstrated that postoperative nocturnal hypoxemia may contribute to postoperative morbidity and mortality, such as impaired wound healing, wound infection, delirium, cerebral stroke, myocardial ischemia, infarction, and unexpected sudden death [2–5,13].

Recently, major breast cancer surgeries, such as mastectomy, have been performed as an ambulatory basis to decrease healthcare costs and improve patient emotional and psychological well-being [22,23]. Healthy patients undergoing a relatively brief and minor surgical procedure with general anesthesia have not necessarily been considered to be at risk of early and late postoperative hypoxemia [1–3,13,15,24]. However, very recently, it has been reported that postoperative nocturnal hypoxemia can occur, especially on the first postoperative night, even in ambulatory surgical patients with ASA PS (Physical Status Classification of the American Society of Anesthesiologists) class I [25]. To perform

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major breast cancer surgery safely as an ambulatory case, confirmation of the risk of postoperative nocturnal hypoxemia may be necessary, although morbidity and mortality associated with nocturnal hypoxemia are not clearly known [2–5].

The purpose of this study was to evaluate the incidence and severity of nocturnal hypoxemia after major breast cancer surgery and to identify its risk factors and outcome. In addition, we have compared the influences of two general anesthesia techniques, sevoflurane and propofol-based anesthesia, on postoperative nocturnal hypoxemia, because the influence of anesthesia technique on late postoperative hypoxemia is not fully understood, although it is well known that anesthesia technique affects the development of early postoperative hypoxemia [1,2,17,26].

Methods

Adult female patients (n = 61; age, 32–77 years), who were scheduled to undergo a major breast cancer operation (unilateral modified radical mastectomy or wide local excision with axillary lymph node dissection) under general anesthesia at the Day Surgery Unit (DSU), Kyoto University Hospital, were recruited between December 2002 and August 2004. Informed consent was obtained from each patient preoperatively, and the protocol was approved by the ethical committee of our institute. The operation was performed on an outpatient basis, with planned overnight observation (23-h admission). Exclusion criteria were ASA PS class III or IV, history of sleep apnea or pulmonary disease, use of opioid or sedative/hypnotic drugs, planned stay ≥2 nights, operation time <60 min, intraoperative blood loss >300 ml, and reoperation required because of postoperative hemorrhage.

Pulse oximetric arterial oxygen saturation ($S_{p_{O_2}}$) value was measured at the preoperative evaluation clinic several days before surgery. All patients were admitted to the DSU in the morning on the day of surgery, and anesthesia induction was scheduled at 9:00 A.M. No patient received sedative, antiemetic, and analgesic drugs before entry to the operation room. Patients were divided randomly into two anesthesia groups using a sealed envelope technique: SEV (sevoflurane anesthesia) and TIVA (total intravenous anesthesia). In all patients, anesthesia was induced with propofol 2 mg·kg^{-1} intravenously, and a laryngeal mask airway (LMA) was placed. All patients received a diclofenac suppository (total, 100 mg) and 0.5% lidocaine infiltration (total, 400 mg) into the surgical field for pain relief just before starting and ending the operation. In SEV patients (n = 31), anesthesia was maintained with sevoflurane in oxygen-air (inspiratory O_2 concentration = 45%), and they breathed spontaneously. In TIVA patients (n = 30), anesthesia was maintained with continuous infusion of propofol (4–10 mg·kg·h^{-1}) and divided doses of fentanyl (total, 0.1 mg) and vecuronium (total, <10 mg), and they received mechanical ventilation initially and then breathed oxygen-air spontaneously (inspiratory O_2 concentration = 45%). The dose of inhaled sevoflurane or intravenous propofol and use of other drugs were adjusted according to clinical variables by an attending anesthesiologist. No patients received an opioid antagonist or anticholineesterase drug. No urinary catheter or surgical drain was placed.

After surgery, the LMA was removed, and patients were transported first to the postanesthesia care unit (PACU) and then to a stepdown recovery area (SRA). Patients breathed room air initially at the PACU, but O_2 was given by face mask when $S_{p_{O_2}}$ episodes <92% persisted. O_2 supplementation was stopped before patients were transferred to the SRA. During the PACU/SRA stay, trained nursing staff who were blinded to the group allocation routinely recorded vital signs, interviewed patients, and documented adverse events, including postoperative nausea and vomiting (PONV), and drugs administered. The times at which patients drank fluids, walked, voided, and were discharged from the DSU (SRA) were recorded. Patients who requested an analgesic were given flurbiprofen axetil 50 mg intravenously and/or oral loxoprofen sodium 60 mg. Patients who requested an antiemetic were given metoclopramide 10 mg intravenously.

All patients were transferred to the overnight recovery area in the inpatient ward from the DSU before 5:00 P.M. All patients were given oral loxoprofen sodium 60 mg and cefcapene pivoxil 100 mg every 8 h, and no patients received O_2 therapy after DSU discharge. A hypnotic agent was prescribed when required by patients. The next morning, a trained DSU nurse interviewed each patient using a standardized 24-h follow-up questionnaire as previously described [27]. Patients were asked about adverse symptoms after DSU discharge, self-rated level (0–10) of resumption of normal activities (RNA), and the acceptability of their 23-h admission procedure [27].

On the first postoperative night at the ward, $S_{p_{O_2}}$ was measured and recorded continuously by a pulse oximeter (N-550; Nellcor Puritan Bennett, Pleasanton, CA, USA) with an adhesive probe applied to a finger (Oxisensor III D-25; Nellcor Puritan Bennett). The audible alarm was turned off to not disturb the patient's sleep. $S_{p_{O_2}}$ and pulse rate values were stored every 10 s. Each patient was taught that she could disconnect herself from the probe but should not turn off the oximeter if she wished to get out of bed, and should reconnect the probe when she returned to bed. After overnight re-

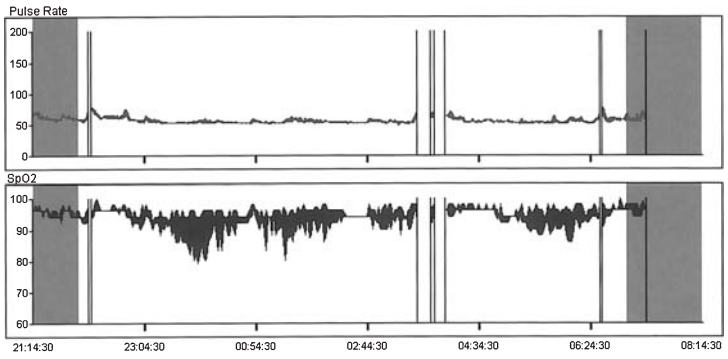

Fig. 1. Nocturnal pulse oximetric recording (pulse rate and Sp_{O_2} waveforms made using Score Software) in a 68-year-old woman on the first night after left mastectomy with axillary lymph node dissection under sevoflurane anesthesia. Data analysis was done only between 10 P.M. and 7 A.M.; *shaded areas* were excluded from the analysis. In this patient, hypoxemia and desaturation episodes occurred 56 and 151 times, respectively, and %time with effective recording, %time with sensor detached, %time with body movement, and %time with Sp_{O_2} <90 were 93.3% (503.8 min), 6.6% (35.7 min), 0.1% (0.5 min), and 5.0% (25.3 min), respectively

cording, the pulse oximetry data were downloaded into a personal computer and analyzed using Score Software 1.1 (Nellcor Puritan Benett) by an observer who was blinded to the patient allocation. Data between 10 P.M. and 7 A.M. (540 min) were used for analysis. Sensor detached period and motion-induced errors were excluded from the analysis. Hypoxemia was defined as Sp_{O_2} <90% for >10 s, and desaturation as 5% or more reduction in Sp_{O_2} from baseline (the average of the highest 10 data points in the previous 5 min) for >10 s [18,20,21]. Desaturation is related to significant respiratory events (apneas and hypopneas), and hypoxemia, which is influenced by duration of desaturation episodes and baseline Sp_{O_2}, represents the severity of episodic hypoxemia [2,18,21,28]. Percentages of total recording time with effective recording (%time with effective recording), sensor detached (%time with sensor detached) and body movement (%time with body movement), and percentage of effective recording time with hypoxemia (%time with Sp_{O_2} <90) were calculated (Fig. 1). Patients who had <400 min of recording time were excluded from the study.

Values are expressed as median (25th–75th percentile). Statistical analyses for two groups were performed using the Mann–Whitney *U* test. Statistical analyses for three groups were performed using the Kruskal–Wallis test followed by Wilcoxon's rank sum test based on joint ranking for detection of significant differences among groups. The Spearman rank order test was performed for correlation analysis. Differences at $P < 0.05$ were considered statistically significant.

Results

There were no significant differences between SEV and TIVA in preoperative patient characteristics, duration of operation and anesthesia, intraoperative blood loss, and perioperative intravenous fluid volume (Table 1). Surgical procedures were uneventful in all patients. After PACU admission, the two anesthesia groups had similar recovery profiles. Every patient was able to drink fluids, walk, and void while in the DSU.

Hypoxemia and desaturation episodes occurred in 38% and 93% of the study patients, respectively, during the nocturnal (10 P.M.–7 A.M.) recording. The profiles of pulse oximetric recordings including the incidence of hypoxemia episodes were identical, except for desaturation episodes in the two anesthesia groups (Table 2). All SEV patients, but a lower percentage (87%) of TIVA patents, had desaturation episodes.

The patients were reclassified arbitrarily into three groups according to %time with Sp_{O_2} <90: no-hypoxemia (%time with Sp_{O_2} <90 = 0; $n = 38$), M-hypoxemia (%time with Sp_{O_2} <90 >0% and ≤1%; $n = 17$), and S-hypoxemia (%time with Sp_{O_2} <90 >1%; $n = 6$) (Table 3). Patients in the M- and S-hypoxemia groups had more episodes of hypoxemia and desaturation, larger %time with Sp_{O_2} <90, and lower value of the lowest Sp_{O_2} than no-hypoxemia patients. The S-hypoxemia group had longer %time with sensor detached. Total recording time and mean pulse rate were not different among the three groups.

There were no significant differences among the three hypoxemia groups in ASA PS, history of smoking, duration of operation and anesthesia, intraoperative blood loss, perioperative intravenous fluid volume, times required from PACU admission to drinking, ambulation, voiding, and actual discharge from DSU, PONV ratio, and perioperative medication (data not shown). S-hypoxemia patients had higher body mass index (BMI), and higher incidence of O_2 supplementation at PACU (see Table 3). Statistically significant correlations were found between BMI and %time Sp_{O_2} <90 [Spearman rank correlation coefficient (R_s) = 0.355, $P = 0.0376$, $n = 61$].

At the 24-h postoperative interview, symptoms after DSU discharge, hypnotic drug use on the first postoperative night, RNA level, and acceptability were

Table 1. Clinical characteristics in the two anesthesia groups

Anesthesia group	SEV (n = 31)	TIVA (n = 30)	Mann–Whitney test
Age (years)	58 (54–69)	56 (51–61)	ns
Height (cm)	156 (152–159)	155 (153–160)	ns
Body weight (kg)	53 (48–60)	53 (48–58)	ns
BMI (kg/m^2)	21 (20–25)	21 (20–25)	ns
ASA PS (I/II) (n)	12/19	16/14	ns
Smokers (%)	6	17	ns
Sp_{O_2} at preanesthesia evaluation clinic (%)	97 (96–98)	97 (96–98)	ns
Duration of operation (min)	123 (106–154)	127 (99–150)	ns
Duration of anesthesia (min)	165 (149–193)	173 (146–196)	ns
Intraoperative blood loss (ml)	49 (30–79)	46 (24–80)	ns
Intravenous fluid volume (ml)[a]	800 (700–900)	700 (650–865)	ns
Patients with O_2 supplementation at PACU (%)	19	16	ns
Patients with PONV at PACU/SRA (%)	23	10	ns
Time required from PACU admission to:			
Drinking (min)	125 (83–148)	115 (81–134)	ns
Ambulation (min)	125 (85–143)	95 (65–134)	ns
Voiding (min)	115 (75–145)	90 (65–128)	ns
Discharge from DSU (min)	222 (188–248)	230 (200–260)	ns
Intravenous fluid volume at PACU/SRA (ml)	375 (293–515)	425 (313–590)	ns
Drugs used at PACU/SRA			
Antiemetic drug (%)	6	7	ns
Analgesic drug (%)	55	60	ns
Nicardipine (%)	3	0	ns

Values are median (25th–75th percentile), number (n) or %; ns = not significant
SEV, sevoflurane anesthesia; TIVA, total intravenous anesthesia; BMI, body mass index; ASA PS, Physical Status Classification of the American Society of Anesthesiologists; Sp_{O_2} = oxygen saturation measured by pulse oximetry; PACU, postanesthesia care unit; PONV, postoperative nausea and vomiting; DSU, day surgery unit; SRA, stepdown recovery area
[a]Volume at preoperative preparation room plus volume at the operating room

Table 2. Summary of nocturnal pulse oximetric recordings in anesthesia groups

Anesthesia group	SEV (n = 31)	TIVA (n = 30)	Mann–Whitney test
Total recording time (min)	540 (540–540)	540 (540–540)	ns
%Time with effective recording (%)	98.4 (96.4–99.2)	98.2 (97.2–98.7)	ns
%Time with sensor detached (%)	1.51 (0.69–3.03)	1.70 (1.25–2.60)	ns
%Time with body movement (%)	0.06 (0.00–0.17)	0.03 (0.00–0.09)	ns
Mean pulse rate (bpm)	62 (57–68)	64 (56–65)	ns
Mean Sp_{O_2} (%)	96 (95–96)	96 (95–97)	ns
Lowest Sp_{O_2} (%)	90 (87–92)	89 (85–92)	ns
Patients with hypoxemia episodes (%)	32	43	ns
Patients with desaturation episodes (%)	100	87	$P < 0.05$
Hypoxemia episodes (n)	0 (0–1.5)	0.5 (0–2)	ns
%Time with Sp_{O_2} <90 (%)	0 (0–0.11)	0.02 (0–0.15)	ns
Desaturation episodes (n)	10 (4.5–23.5)	9.5 (2–37.5)	ns

Values are median (25th–75th percentile) or %; ns = not significant
%Time with effective recording, percentage of total recording time with effective recording; %time with sensor detached, percentage of total recording time with sensor detached; %time with body movement, percentage of total recording time with body movement; hypoxemia, Sp_{O_2} <90% for >10 s; desaturation, ≥5% decrease in Sp_{O_2} from baseline for >10 s; %time with Sp_{O_2} <90, percentage of effective recording time with hypoxemia

similar in two anesthesia groups (data not shown), and in the three hypoxemia groups (Table 4). All patients were discharged uneventfully from the hospital in the morning on postoperative day 2.

Discussion

The present study demonstrated that postoperative nocturnal hypoxemia and desaturation episodes were

Table 3. Nocturnal pulse oximetric recordings and summary of patient characteristics reclassified by hypoxemia extent

Hypoxemia group	No-hypoxemia ($n = 38$)	M-hypoxemia ($n = 17$)	S-hypoxemia ($n = 6$)	Kruskal–Wallis test
Total recording time (min)	540 (540–540)	540 (540–540)	540 (540–540)	ns
%Time with effective recording (%)	98.3 (97.1–99.1)	98.4 (98.2–98.9)	94.9 (94.3–96.8)	ns
%Time with sensor detached (%)	1.60 (0.85–2.78)	1.42 (0.80–1.73)	4.62 (2.99–5.08) *,**	$P < 0.05$
%Time with body movement (%)	0.03 (0.00–0.09)	0.06 (0.00–0.22)	0.12 (0.10–0.22)	ns
Mean pulse rate (bpm)	63 (59–67)	60 (53–65)	63 (61–69)	ns
Mean Sp_{O_2} (%)	96 (95–97)	96 (95–97)	94 (94–94)*,**	$P < 0.01$
Lowest Sp_{O_2} (%)	92 (90–92)	86 (84–88)*	81 (74–84)*	$P < 0.01$
Hypoxemia episodes (n)	0 (0–0)	2 (1–3)*	21 (19–48)*	$P < 0.01$
%Time with Sp_{O_2} <90 (%)	0 (0–0)	0.16 (0.12–0.28)*	2.50 (1.84–4.46)*	$P < 0.01$
Desaturation episodes (n)	5 (2–9)	38 (15–50)*	57 (47–89)*	$P < 0.01$
Age (years)	56 (50–68)	57 (53–61)	64 (59–68)	ns
Height (cm)	156 (153–159)	156 (154–160)	154 (149–160)	ns
Body weight (kg)	52 (48–56)	55 (47–59)	61 (56–70)	ns
BMI (kg/m^2)	21 (20–23)	23 (19–25)	26 (23–28)*,**	$P < 0.05$
Sp_{O_2} at preanesthesia evaluation clinic (%)	97 (96–98)	97 (96–98)	96 (95–97)	ns
Anesthesia, SEV/TIVA (n)	21/17	7/10	3/3	ns
Patients with O_2 supplementation at PACU (%)	8	24	67*	$P < 0.01$

Values are median (25th–75th percentile), number (n) or %; ns = not significant
BMI, body mass index
* $P < 0.05$ vs. no-hypoxemia
** $P < 0.05$ vs. M-hypoxemia (Wilcoxon's rank sum test)

Table 4. Postoperative interview 24 h after operation

Hypoxemia group	No-hypoxemia ($n = 38$)	M-hypoxemia ($n = 17$)	S-hypoxemia ($n = 6$)	Kruskal–Wallis test
Symptoms after DSU discharge				
Sleepiness (%)	32	41	17	ns
Dizziness (%)	16	18	17	ns
General malaise (%)	22	41	0	ns
Fever (%)	29	53	0	ns
Sleeplessness (%)	42	35	33	ns
Bleeding (%)	8	0	17	ns
Pain (%)	55	65	67	ns
Headache (%)	18	6	0	ns
Muscle pain (%)	11	24	0	ns
Sore throat (%)	68	53	83	ns
Hoarseness (%)	16	24	17	ns
Nausea and/or vomiting (%)	3	6	17	ns
Appetite loss (%)	13	12	0	ns
Thirst (%)	29	29	67	ns
Urinary disturbance (%)	3	0	0	ns
Hypnotic agent use (%)	18	6	0	ns
RNA score at interview	8.0 (6.6–9.0)	7.0 (6.5–8.0)	6.8(5.0–8.9)	ns
Preference (%)	74	77	83	ns

Values are % or median (25th–75th percentile); ns = not significant
RNA, resumption of normal activity (score 0 = no activity, 10 = back to normal activity)
Preference, preference to outpatient basis and 23-h admission procedures, the ratio of positive answers to all (positive, negative, and no) answers

observed at least once in 38% and 93%, respectively, of the apparently healthy patients (ASA PS I or II; $n = 61$) receiving general anesthesia and major breast cancer surgery on the first postoperative night. Six patients (10%) had >1% of recording time with Sp_{O_2} <90%, or considerably severe hypoxemia. They had 4.7–45.3 min (median, 13.0 min) of hypoxemia during approximately 9-h recording time. Because total recording time was presumably greater than total sleep time, severity of hypoxemia (%time with Sp_{O_2} <90) during sleep might be

underestimated. Sporadic S_{pO_2} value at a preanestheisa evaluation clinic could not predict postoperative nocturnal hypoxemia.

Our study may be criticized because of the lack of preoperative nocturnal oximetry data and baseline values. We could not deny the possibility that the hypoxemic patients were merely those with unrecognized obstructive sleep apnea [29] or other related diseases and that major breast cancer surgery and general anesthesia per se did not affect the frequency and severity of nocturnal hypoxemia episodes. Even if it were true, however, it is obvious that postoperative nocturnal hypoxemia can occur in a certain group of apparently healthy patients undergoing ambulatory breast surgery.

A number of reports have demonstrated that episodic nocturnal hypoxemia develops or is aggravated after open abdominal surgery [6,7,9,13–15,17], abdominal vascular surgery [11,12,20], major orthopedic surgery [6,10,16,19], thoracotomy [21], cesarean section [8], laparoscopic surgery [18], and video-assisted thoracic surgery [21]. It is reported that no significant nocturnal hypoxemia episodes developed after ophthalmic (lens extraction) or middle ear surgery (tympanoplasty) under general anesthesia and suggested that general anesthesia alone or minimally invasive surgery itself is not a risk factor of postoperative nocturnal hypoxemia [13,15,24]. However, Bowdle has recently reported that some patients who underwent ambulatory surgery including cataract surgery or tympanoplasty developed significant postoperatrive nocturnal hypoxemia [25]. Considering these reports, it may be valid that major breast cancer surgery can exacerbate nocturnal hypoxemia in a certain group of patients.

In our study, nocturnal recording was performed only on the first postoperative night, because nocturnal oximetry at a patient's home is difficult in an outpatient setting. It is reported that significant increase in percentage of recording time with S_{pO_2} <90% was observed on the first postoperative night, but not on the second night, compared with the preoperative night, in ambulatory surgical patients who had abnormal breathing during at least one of three (preoperative, first and second postoperative) study nights [25]. Episodic nocturnal hypoxemia may last up to a week after inpatient major surgery, and its degree is greater on the second and third nights than on the first night after operation [2,11,14,20]. There is an undeniable possibility that a profound nocturnal hypoxemia may develop after discharge home in a "risky" outpatient. Further studies are needed to ensure whether nocturnal hypoxemia develops during a later postoperative phase after discharge.

Postoperative hypoxemia is thought to be associated with postoperative delirium, cerebral stroke, impaired wound healing, wound infections, myocardial ischemia, infarction, arrhythmias, and sudden death [2–5,13]. However, little evidence suggests that nocturnal pulse oximetry improves patient outcomes [3,5]. A brief period of moderate hypoxemia may not be harmful to healthy patients. It was reported that outpatient surgical patients with obstructive sleep apnea did not have an increased incidence of perioperative adverse events and unanticipated hospital admissions compared with control patients [30], but the rate of unplanned admission (24%) was considerably higher than those in usual reports (1–2%) [27,31]. Supplemental O_2 therapy improved the severity of nocturnal hypoxemia, although it did not alter the occurrence of episodes of sudden S_{pO_2} decrease in patients who received major surgery [10]. A same-day surgical patient is back home soon after surgery without monitoring and availability of O_2 therapy. Patients with high risk of severe postoperative nocturnal hypoxemia as well as obstructive sleep apnea may be recommended to be in the hospital overnight with S_{pO_2} monitoring and receiving "prophylactic" O_2 therapy [29].

Risk factors of postoperative nocturnal hypoxemia reported were preoperative nocturnal hypoxemia [11,14,18], apnea witnessed by others [18], heavy snoring [16], obesity [12,18], higher age [6,25], pharyngeal hypertrophy [12], and opioid analgesia [6]. In our study, larger BMI and O_2 supplementation during the PACU stay were associated with severity of nocturnal hypoxemia. Age tended to be higher in our hypoxemic patients. We did not ask patients routinely about history of snoring or witnessed apnea in this study. To identify a high-risk outpatient, preoperative questions about assessing daytime sleepiness, apnea, or snoring during sleep may be important [29]. Because the use of opioid analgesics may delay postoperative recovery and discharge due to its adverse effects, such as emetic and sedative symptoms, in ambulatory surgery [31], we tried to use opioid-free or opioid-sparing analgesia, including the use of nonsteroidal anti-inflammatory drugs and local anesthesia [32,33]. Our study demonstrated that nocturnal hypoxemia could occur without opioid use.

In our study, frequency and severity of nocturnal hypoxemia were not different between SEV and TIVA on the first night after major breast cancer surgery. A previous report demonstrated that the incidence and degree of hypoxemia were significantly higher in patients who received nitrous oxide-isoflurane anesthesia than in patients with propofol anesthesia and oxygen-air ventilation on the first postoperative night after open cholecyctectomy [17]. The difference of general anesthetics may be partly involved in the disparity of hypoxemia development between our study and theirs. It is well known that isoflurane has a potent inhibitory action on airway ciliary motility [34,35]. However, sevoflurane has a weak [35] and propofol has no

cilioinhibitory action [36, 37]. Nitrous oxide may contribute to absorption atelectasis [38].

Every patient in our study reached the "home-readiness" criteria [27,31] on the day of surgery and had no serious morbidity. S-hypoxemia patients had significantly longer sensor detached time, suggesting that their sleep was short or disturbed, although there was no difference in frequency of sleeplessness and other complaints among groups at the 24-h postoperative interview.

In conclusion, the present study demonstrates that nocturnal episodic hypoxemia occurs frequently after uncomplicated major breast cancer surgery under general anesthesia on the first postoperative night. Hypoxemic patients had larger BMI and required more episodes of O_2 supplementation at the PACU. Additional studies are necessary to clarify the significance of postoperative nocturnal episodic hypoxemia in ambulatory care practice.

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