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Original Article

Is Postoperative Orotracheal Intubation Necessary in Patients Who Underwent Transoral Robotic Surgery due to Obstructive Sleep Apnea Syndrome?

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ABSTRACT

Objective: In this study we investigated whether postoperative changing nasotracheal to orotracheal intubation is necessary after trans-oral robotic surgery (TORS) for obstructive sleep apnea syndrome (OSAS).

Methods: A total of 151 patients who underwent TORS between 2011 and 2023 with the diagnosis of OSAS were included. All patients were transferred to post anaesthesia intensive care unit (PACU) after operation with orotracheal (group O: 73 patients, operated between 2011 and 2017) or nasotracheal tubes (group N: 78 patients, operated between 2017 and 2023). Age, gender, American Society of Anesthesiologists scores, Mallampati scores, PACU stay, pH in arterial blood gas samples taken during this period (1—first hospitalization, 2—12 hours later, 3—before extubation), PCO_2, PO_2, Base excess (BE), lactate values, total amount of fluid administered, presence of complications, and discharge times were collected from the patients files. Statistical analyses were done between the groups.

Results: There was no statistical difference between groups regarding patient's demographic data. The distribution of Mallampati scores of the patients was 52% in group O and 55% in group N ($P = .97$). Complication rate was 16% in group O (6 bleeding, 4 vomiting, 1 need for reintubation) and 19% in group N (6 bleeding, 7 vomiting, 2 need for reintubation). The length of stay in the PACU in both groups was 24.9 hours ($P = .92$). The amount of fluids given in PACU was not statistically different ($P = .14$). The length of hospital stay was the same in both groups (7 days). No statistical difference was observed between the 2 groups in any measurement period of arterial blood gas values, pH, PO_2, PCO_2, BE, and lactate.

Conclusion: Our results support that nasotracheal intubation itself is safe both during surgery and postoperative period in OSAS patients who underwent TORS, and there is no need to change it to orotracheal intubation at the end of the operation. We believe that our study will contribute to the management of the early postoperative process in this patient group.

Keywords: Anesthesia, endotracheal, robotic surgical procedures, obstructive sleep apnea

Introduction

The development of obstructive apnea and hypopnea due to repetitive collapse of the upper airway during sleep is called obstructive sleep apnea (OSA).[1] It has been shown that there are 936 million people aged 30-69 years worldwide with mild-to-severe OSA and 425 million with moderate-to-severe OSA.[2] The rate is slightly higher in adult men. The prevalence appears to be increasing, either due to increasing obesity or an increase in diagnostics.[3,4]

Surgical treatment is indicated as the primary treatment for OSA when a fixed, surgically correctable airway obstruction is responsible for apnea. Surgical treatment of OSA includes a wide variety of procedures and approaches that dilate and/or stabilize the upper airway.[5] To deal with tongue root obstruction, transoral robotic surgery (TORS) and coblation-assisted tongue root reduction surgery are 2 of the most published tongue root tissue reduction procedures. The first applications of robot-assisted surgical techniques in upper airway pathologies began in 2005 at the University of Pennsylvania.[6]

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In 2009, the U.S. Food and Drug Administration approved the use of TORS in benign and malignant lesions of the oropharynx and larynx.[7] In 2010, Vinci et al[8] initiated a preliminary study on the use of TORS in OSAS and reported that it was practical and well tolerated. The most recent systematic review and meta-analysis by Meccariello et al (2017) concluded that TORS appears to be a promising and safe technology for the management of OSAS, with a mean failure rate of 34.4% (29.5%-46.2%).[9] Trans-oral robotic surgery offers minimally invasive access to the oropharynx and hypopharynx with advantages such as maneuverability beyond the limits of human hand movement, high sensitivity and 3-dimensional image, use of angled endoscopes, tremor reduction, and a wide range of surgical instrument options.[10]

In patients with OSAS, anesthesia and surgery have known inherent risks.[11,12] Obstructive sleep apnea increases the risk of perioperative complications and should be well planned in the perioperative period to minimize postoperative morbidity and mortality.[13,14]

Management in terms of anesthesia should start with a comprehensive preoperative evaluation and should be comprehensive with a follow-up plan, considering their postoperative processes from their perioperative management. The difficulty of initial intubation, the benefits of shared use of the operating field, the potential for postoperative swelling or bleeding, and extubation planning should be formulated with the surgical team. Because of this, nasotracheal intubation is replaced by orotracheal intubation at the end of the operation, with the latter being usually the preferred method.

In our study, we investigated if postoperative orotracheal intubation is necessary in these OSAS cases who underwent TORS. For this purpose we compared the clinical data of the OSAS patients followed with nasotracheal intubation alone and the patients whose nasotracheal tubes were replaced with orotracheal intubation at the end of the TORS procedure.

Method

After the approval of the local ethics committee of our hospital (2023-326/2023-15-01), patients over the age of 18 who underwent TORS between 2011 and 2023 with the diagnosis of OSA syndrome, patients with American Society of Anesthesiologists (ASA) scores I-III, were included. Data of the patients collected from hospital's electronic Database (Probel, İzmir, Turkey) and ImdSoft-Metavision/Q linICU clinical decision support system (Israel). Of the 158 patients whose data were collected, 7 patients were excluded from the study (blood gas values could not be reached in 3, reoperation in 2, and postoperative extubation in 2). Age, gender, ASA scores, Mallampati scores, post anaesthesia intensive care unit (PACU) stay of the remaining 151 patients, pH in arterial blood gas samples taken during this period (1—first hospitalization, 2—12 hours later, 3—before extubation), PCO_2, PO_2, BE, lactate values, total amount of fluid administered, presence of complications (bleeding, vomiting, reintubation, other), and discharge times were recorded. The patients were divided into 2 groups according to their postoperative intubation route. The patients who were followed up in the PACU with oral intubation after the surgery were grouped as group O (73 patients operated between 2011 and 2017) and the patients followed up with nasal intubation were grouped as group N (78 patients operated between 2017 and 2023).

A routine general anesthesia protocol was applied to all patients undergoing TORS. All patients were monitored according ASA standards. In order to prepare for possible difficult intubation in OSA cases, preoxygenation was performed in all cases for 5-8 minutes with a 100% O_2 mask. Invasive arterial monitoring was routinely performed on all patients for blood gas monitoring. After entering nasal cavity with the intubation tube, nasotracheal intubation was completed quickly by seeing the tube in the mouth with videolaryngoscopy. At the end of the operation, all patients were taken to the PACU under deep sedation.

Post anaesthesia Intensive Care Unit Follow-Up Process

All patients in the PACU were hospitalized with their heads 45° up. All patients were given antiedema treatment, including methylprednisolone (250 mg), which was given the same day, and dexamethasone (8 mg) the next morning. Fluid infusion was administered at 25 mL/kg/h, and antibiotic and analgesic treatments (Parol 1 g, tramadol 100 mg) were also routinely given. A deep sedation was maintained with remifentanil 0.03-0.2 µg/kg/min, midazolam 0.01-0.1 mg/kg, propofol 0.1-3 mg/kg/h, and dexmedetomidine 0.2-1 µg/kg/min. Gradual reduction of sedatives ensured the awakening of the patient around 24 hours after the operation. Prophylactic antiemetic was administered to all patients. And all patients were ventilated with an O_2–air mixture in Continious Positive Airway Pressure (CPAP) mode with no muscle relaxant. Preparation and extubation of patients were done together with the ear, nose, and throat (ENT) team the day after the operation. After the extubation process, patients were monitored in the PACU for 1 hour with an O_2 mask and room air and then transferred to the ward.

Statistical Analysis

Categorical data were given as numbers and percentages. Normally distributed numerical data were shown with mean and standard deviation values. Kolmogorov–Smirnov test was used to test the normal distribution of numerical data. Student's *t*-test was used to compare normally distributed numerical data. The frequencies of categorical variables were compared with Pearson chi-square and Fisher's exact test. A *P*-value below .05 was considered statistically significant. Statistical analysis was performed using the Statistical Package for the Social Sciences Statistics software, version 21 (IBM Corp., Armonk, NY, USA).

Results

A total of 151 patient data, 73 oral intubation and 78 nasal intubation, were analyzed. The mean age of the patients in group O was 47 years, 43 years in group N, and the mean ASA score was II in both groups. There was no statistical difference between groups regarding patients ages ($P = .012$). Of the patients in group O, 60 (82%) were male and 13 (17%) were female. Of the patients in group N, 70 (89%) were male and 8 (10%) were female. The distribution of Mallampati scores of the patients was 38 (52%) in group O and 43 (55%) in group N ($P = .97$). The highest Mallampati scorewas seen in both groups (Table 1). Complications were seen in 11 patients (16%) in group O (6 bleeding, 4 vomiting, 1 need for reintubation) and 15 patients (19%) in group N (6 bleeding, 7 vomiting, 2 need for reintubation). Complications are summarized in Table 2. The length of stay in the PACU in both groups was 24.9 hours ($P = .92$). No patient had to stay in the PACU longer. They received the same treatment during this time, and the amount of fluids given was not statistically different (1246 mL in group O and 1359 mL in group N, $P = .14$). The length of hospital stay was the same in both groups (7 days) (Table 1).

Arterial blood gas values of the groups are shown in Table 3, and no statistical difference was observed between the 2 groups in any measurement period of pH, PO_2, PCO_2, BE, and lactate values (Table 3).

Discussion

Obstructive sleep apnea syndrome is a sleep disorder characterized by intermittent cessation or reduction of airflow during sleep due to complete or partial obstruction of the upper airway. As in all cases of

Table 1. Demographic and Follow-Up Findings

	Group O n = 73 (mean ± SD)	Group N n = 78 (mean ± SD)	*P*
Age (years)	47 ± 8.7	43.6 ± 8	.012
Gender n (%)			.240
1 (male)	60 (82.2)	70 (89.7)	
2 (female)	13 (17.8)	8 (10.3)	
ASA	73 (100)	78 (100)	
Mallampati score n (%)			.974
1	23 (31.5)	22 (28.2)	
2	38 (52.1)	43 (55.1)	
3	8 (11)	9 (11.5)	
4	4 (5.5)	4 (5.1)	
Complication	12 (16.5)	15 (19.2)	.476
PACU	24.9 ± 3.8	24.9 ± 4.6	.928
Total crystalloid (mL)	1246.6 ± 441.9	1359 ± 497.1	.145
Length of stay (days)°	7.1 ± 1.3	7.1 ± 1.4	.810

ASA, American Society of Anesthesiologists scores; PACU, postoperative intensive care unit.

Table 2. Complications

	Group O	Group N
Bleeding (n)	6	6
Vomiting (n)	4	7
Reintubation (n)	1	2

TORS, it is important to determine an uneventful extubation strategy for the most common surgical procedure, uvulopalatopharyngoplasty, and its modification for OSA treatment.

Since 2011, when our TORS experience began, to avoid possible bleeding and edema as well as tracheotomy, in all patients, we routinely used "planned extended intubation" for postoperative 24-48 hours, and extubation was performed 24-48 hours later in the PACU while patients were under deep sedation.

In these patients, cardiovascular disease is a common complication and/or a comorbidity,[15] which has been associated with an increased risk of ischemic stroke as an independent of vascular risk factors.[16] The incidence of perioperative cardiorespiratory complications is higher in patients with OSA.[17] Thus, the OSA syndrome itself and its additional comorbidities are associated with an increased risk of complications from procedures involving sedation or anesthesia. In addition, head and neck surgery is associated with higher complication rates during and immediately after planned extubation compared to other elective surgeries.[18]

Table 3. Blood Gas Values

	Group O	Group N	*P*
pH			
First bedtime	7.35 ± 0.08	7.35 ± 0.08	.713
12 hours later	7.36 ± 0.07	7.36 ± 0.07	.843
Before extubation	7.4 ± 0.06	7.4 ± 0.06	.951
PO_2			
First bedtime	124.1 ± 42.2	122.2 ± 42.9	.792
12 hours later	110.4 ± 34.2	111.9 ± 34.8	.783
Before extubation	107.5 ± 26.1	108.4 ± 26.8	.841
PCO_2			
First bedtime	47.2 ± 12.4	47.5 ± 12.5	.886
12 hours later	45.4 ± 8	43.9 ± 7.6	.261
Before extubation	40 ± 5.8	39.1 ± 7.3	.393
BE			
First bedtime	0.2 ± 1.8	0.08 ± 1.8	.597
12 hours later	0.6 ± 1.7	0.5 ± 1.7	.644
Before extubation	0.9 ± 1.7	−0.1 ± 7	.208
Lactate			
First bedtime	1.5 ± 0.5	1.5 ± 0.5	.954
12 hours later	2 ± 0.6	1.9 ± 0.6	.872
Before extubation	2 ± 0.6	2.1 ± 0.6	.919

Due to the unique difficulties of robotic surgery, surgical team and anesthesia team have to share the same anatomical area in treatment of OSA that makes the procedure more complex. It is necessary to perform a comprehensive preoperative examination and to plan the entire preoperative and postoperative process in advance. This planning process should be done together with the anesthesia and otolaryngologist. Patients should be fully informed about the procedure and possible complications that mostly (>80%) occur in the first 24 hours after the operation.[17]

In an observational study conducted in patients with sleep apnea, the deterioration in sleep was found at the highest level on the first postoperative night, and it was determined that (REM) sleep improved on the third postoperative night.[19] Therefore, careful monitoring is very critical in these patients, especially in the early postoperative period.

Factors such as increased volume of soft tissue surrounding the upper airway are associated with a higher risk of apnea.[20] Vascular volume increase in the neck, i.e., rostral fluid shift, may increase upper airway obstruction. This has been demonstrated experimentally by vasoconstriction and vasodilation.[21,22]

Another important factor is patient position. It is known that the supine position worsens upper airway obstruction, and it is safer to keep these patients in an upright or semi-upright position during postoperative period, unless contraindicated by the surgical team.[23]

In addition to the position, this is the reality underlying restrictive fluid therapy and targeted strategy for antiedema therapy and antiemetic therapy. We have been using a restricted fluid regime (25 mL/kg/h) and routine antiedema and antiemetic treatment in OSA cases from the beginning. The fact that urine outputs were not recorded is a limiting situation for our study.

During the intensive care processes of these patients, the main goal is to achieve a controlled and safe extubation. The ASA, the American Academy of Sleep Medicine, and the Society of Anesthesiology and Sleep Medicine have issued guidelines[24] on this subject.

Besides the many advantages of TORS, the most important disadvantage is that the mouth opening is narrow for the robot's endoscopes and instruments.[25] For this reason, nasal intubation is often preferred.[26] Thus, the surgical field is relieved. In addition, a safer perioperative process is aimed without the need for invasive procedures to fix the tube.[27]

It is also known that the probability of otitis media with effusion increases, especially in nasally intubated patients.[28] In nasotracheal intubation, the development of sinusitis has been associated with an inflammatory response due to the presence of the tube. Sinus infection is common, with sinus effusion being more common with intubation for a few days.[29,30]

Besides the abovementioned facts, concerns about the increased possibility of leakage caused by choosing a small nasal tube diameter, increased peak pressures, and the risk of hypercarbia and even hypoxia with insufficient ventilation all together defined our

anesthesia strategy at the beginning. Therefore, in the first years of our experience, we performed a nasal intubation in the operating room with a larger-diameter oral intubation before transferring the patients to the PACU at the end of the operation. Believing that we provide a safer ventilation strategy by replacing nasotracheal tube with a larger orotracheal one. In a patient who had to be reoperated due to bleeding occurring in the early postoperative period, it was observed that switching to oral intubation aggravated the difficult intubation conditions. After this experience, we changed our strategy and started to keep the nasotracheal tube in place postoperatively.

Close monitoring of the ventilation quality of these patients is essential. When quantitative assessment is required, arterial blood gas measurement provides the most precise measure of ventilation. In our retrospective evaluation, we found that there were no differences in arterial blood gas values in both groups during any measurement period between the 2 groups. In addition, we have never encountered results such as acidosis, hypercapnia, and hypoxia. These results suggested that tube replacement is not necessary in line with the standards in the PACU treatment process.

The demographic data of the patients were almost the same in the 2 groups. The male population was 82%. Contrary to the prediction that these patients had high Mallampati score values, it was only around 5% with 4 patients in Group O and Group N. We think that the reason why the complication rates and distributions are the same is that the PACU treatment process was the same in both groups and the operation was performed by the same surgical team.

In conclusion, TORS needs experienced and collaborative ENT and anesthesia teams, and careful preoperative, perioperative, postoperative follow-up is essential. Our results support that nasotracheal intubation is a safe method and orotracheal intubation is not neccessary at the end of the operation. We believe that our study will contribute to the management of the early postoperative process in this patient group.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Health Sciences University Istanbul Bakırköy Dr Sadi Konuk Training and Research Hospital (Approval no: 2023-15-01, Date: 07.08.2023).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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References

1. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of sleep-disordered breathing among middle-aged adults. *N Engl J Med*. 1993;328(17):1230-1235. [CrossRef]
2. Benjafield AV, Ayas NT, Eastwood PR, et al. Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. *Lancet Respir Med*. 2019;7(8):687-698. [CrossRef]
3. Peppard PE, Young T, Barnet JH, Palta M, Hagen EW, Hla KM. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol*. 2013;177(9):1006-1014. [CrossRef]
4. Senaratna CV, Perret JL, Lodge CJ, et al. Prevalence of obstructive sleep apnea in the general population: A systematic review. *Sleep Med Rev*. 2017;34:70-81. [CrossRef]
5. Epstein LJ, Kristo D, Strollo PJ Jr, et al. Clinical guideline for the evaluation, management and long-term care of obstructive sleep apnea in adults. *J Clin Sleep Med*. 2009;5(3):263-276. [CrossRef]
6. Hockstein NG, Nolan JP, O'Malley BW Jr, Woo YJ. Robotic microlaryngeal surgery: a technical feasibility study using the daVinci surgical robot and an airway mannequin. *Laryngoscope*. 2005;115(5):780-785. [CrossRef]
7. Rinaldi V, Pagani D, Torretta S, Pignataro L. Transoral robotic surgery in the management of head and neck tumours. *Ecancermedicalscience*. 2013;7:359. [CrossRef]
8. Vicini C, Dallan I, Canzi P, Frassineti S, La Pietra MG, Montevecchi F. Transoral robotic tongue base resection in obstructive sleep apnoea-hypopnoea syndrome: a preliminary report. *ORL J Otorhinolaryngol Relat Spec*. 2010;72(1):22-27. [CrossRef]
9. Meccariello G, Cammaroto G, Montevecchi F, et al. Transoral robotic surgery for the management of obstructive sleep apnea: a systematic review and meta-analysis. *Eur Arch Otorhinolaryngol*. 2017;274(2):647-653. [CrossRef]
10. Kayhan FT, Kaya KH, Yilmazbayhan ED. Transoral robotic approach for schwannoma of the larynx. *J Craniofac Surg*. 2011;22(3):1000-1002. [CrossRef]
11. Gross JB, Bachenberg KL, Benumof JL, et al. Practice guidelines for the perioperative management of patients with obstructive sleep apnea: a report by the American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. *Anesthesiology*. 2006;104(5):1081-1118. [CrossRef]
12. Vasu TS, Doghramji K, Cavallazzi R, et al. Obstructive sleep apnea syndrome and postoperative complications: clinical use of the STOP-BANG questionnaire. *Arch Otolaryngol Head Neck Surg*. 2010;136(10):1020-1024. [CrossRef]
13. Abdelsattar ZM, Hendren S, Wong SL, Campbell DA Jr, Ramachandran SK. The impact of untreated obstructive sleep apnea on cardiopulmonary complications in general and vascular surgery: A cohort study. *Sleep*. 2015;38(8):1205-1210. [CrossRef]
14. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA*. 2002;288(14):1723-1727. [CrossRef]
15. Yeghiazarians Y, Jneid H, Tietjens JR, et al. Obstructive sleep apnea and cardiovascular disease: a scientific statement from the American Heart Association. *Circulation*. 2021;144(3):e56-e67. [CrossRef] Erratum in: *Circulation*. 2022;145(12):e775. [CrossRef]
16. Hermann DM, Bassetti CL. Role of sleep-disordered breathing and sleep-wake disturbances for stroke and stroke recovery. *Neurology*. 2016;87(13):1407-1416. [CrossRef]
17. Pivetta B, Sun Y, Nagappa M, Chan M, Englesakis M, Chung F. Postoperative outcomes in surgical patients with obstructive sleep apnoea diagnosed by sleep studies: a meta-analysis and trial sequential analysis. *Anaesthesia*. 2022;77(7):818-828. [CrossRef]
18. Cavallone LF, Vannucci A. Review article: extubation of the difficult airway and extubation failure. *Anesth Analg*. 2013;116(2):368-383. [CrossRef]
19. Chung F, Liao P, Yegneswaran B, Shapiro CM, Kang W. Postoperative changes in sleep-disordered breathing and sleep architecture in patients with obstructive sleep apnea. *Anesthesiology*. 2014;120(2):287-298. [CrossRef]
20. Schwab RJ, Pasirstein M, Pierson R, et al. Identification of upper airway anatomic risk factors for obstructive sleep apnea with volumetric magnetic resonance imaging. *Am J Respir Crit Care Med*. 2003;168(5):522-530. [CrossRef]
21. Wasicko MJ, Leiter JC, Erlichman JS, Strobel RJ, Bartlett D Jr. Nasal and pharyngeal resistance after topical mucosal vasoconstriction in normal humans. *Am Rev Respir Dis*. 1991;144(5):1048-1052. [CrossRef]
22. Wasicko MJ, Hutt DA, Parisi RA, Neubauer JA, Mezrich R, Edelman NH. The role of vascular tone in the control of upper airway collapsibility. *Am Rev Respir Dis*. 1990;141(6):1569-1577. [CrossRef]

23. American Society of Anesthesiologists Task Force on Perioperative Management of Patients with Obstructive Sleep Apnea. Practice guidelines for the perioperative management of patients with obstructive sleep apnea: an updated report by the American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. *Anesthesiology*. 2014;120(2):268-286. [CrossRef]
24. Memtsoudis SG, Cozowicz C, Nagappa M, et al. Society of anesthesia and sleep medicine guideline on intraoperative management of adult patients with obstructive sleep apnea. *Anesth Analg*. 2018;127(4):967-987. [CrossRef]
25. Miller MC. Tongue base exposure during TORS without the use of a mouth prop. *J Robot Surg*. 2016;10(4):347-352. [CrossRef]
26. Justin GA, Chang ET, Camacho M, Brietzke SE. Transoral robotic surgery for obstructive sleep apnea: a systematic review and meta-analysis. *Otolaryngol Head Neck Surg*. 2016;154(5):835-846. [CrossRef]
27. Weinstein GS, O'Malley BW Jr, Snyder W, Hockstein NG. Transoral robotic surgery: supraglottic partial laryngectomy. *Ann Otol Rhinol Laryngol*. 2007;116(1):19-23. [CrossRef]
28. Christensen L, Schaffer S, Ross SE. Otitis media in adult trauma patients: incidence and clinical significance. *J Trauma*. 1991;31(11):1543-1545. [CrossRef]
29. Stein M, Caplan ES. Nosocomial sinusitis: a unique subset of sinusitis. *Curr Opin Infect Dis*. 2005;18(2):147-150. [CrossRef]
30. Cavaliere F, Masieri S, Liberini L, Proietti R, Magalini SI. Tympanometry for middle-ear effusion in unconscious ICU patients. *Eur J Anaesthesiol*. 1992;9(1):71-75.