RESEARCH ARTICLE

Effectiveness of computed tomography-guided nasotracheal intubation procedure on predicting tube advancement difficulty and preventing epistaxis: A prospective case-control study

Seher Orbay Yasli[1], Dilek Gunay Canpolat[2], Ebru Baydan[3], Ahmet Emin Demirbas[4]

Abstract

Objective: To evaluate the effectiveness of computed tomography-guided nasotracheal intubation procedure in predicting tube advancement difficulty and preventing epistaxis.

Methods: The prospective study was conducted at Erciyes University Faculty of Dentistry from April 2018 to June 2019 and comprised maxillofacial surgery patients of either gender aged 18-50 years who were due to undergo bimaxillary orthognathic surgery, which was defined as American Society of Anaesthesiology grade I or II. The space where the tube was to be passed in the internal nasal valve region was measured horizontally and vertically using computed tomography. A single experienced anaesthesiologists intubated all the patients who were later divided into 'easy' group A and 'difficult' group B on the basis of the effort required to advance the tube through the nasal passage. Data was analysed using JASP version 0.14.1.0).

Results: Of the 60 patients, 42(70%) were females and 18(30%) were males. The overall mean age was 29.0±10.5 years and the mean body mass index value was 23.6±4.0 kg/m^2 (p>0.05). There were 28(46.6%) patients in group A, and 32(53.3%) in group B. Median distances were significantly shorter and epistaxis was significantly higher in group B compared to group A (p<0.001). The cut-off values to reveal the distance at which difficulty may be experienced while advancing the tube, determined through receiver operating characteristic analysis, were 1.09 cm for vertical and 0.39cm for horizontal distances.

Conclusion: The nasotracheal intubation procedure under the guidance of computed tomography could help predict the difficulty of tube advancement, and could thus prevent epistaxis and other related nasal intubation complications. Clinical trial number: NCT05525754.

Keywords: Tomography, X-Ray Computed, Epistaxis, Orthognathic surgical procedures, Intubation.

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Introduction

Nasotracheal intubation in maxillofacial surgery is essential because the surgeries are primarily realised in the intraoral region. This procedure can be traumatic due to the narrow size of the nasal passage, the rich vascular structure, and the fragility of the nasal mucosa. It can lead to severe complications, like epistaxis with excessive bleeding.[1] Tube advancement difficulty during nasal intubation is one of the fundamental causes of these complications. Epistaxis, which frequently appears with varying severity, is the most common complication of nasotracheal intubation.[2]

Regarding predicting the tube advancement difficulty through the nasal passage, the general recommendation is to perform nasal endoscopy before intubation which is a time-consuming and equipment-requiring procedure.[3,4]

The higher rate of success and the shorter operation time in surgeries have come to be achieved by the guidance of many radiological imaging devices, like ultrasonography (USG), magnetic resonance imaging (MRI), computed tomography (CT) imaging and others. CT technique is among the most important of those devices. Besides, CT is used for surgical planning in the preoperative period and surgical guidance in the intraoperative period.[5-7]

The internal nasal valve (INV) is the narrowest area of the nasal cavity.[8] Anatomically, the INV is located roughly 1.3cm from nares. The borders of INV can be listed as septum medially, upper lateral cartilages laterally, anterior end of inferior turbinate inferiorly, and the nose floor, which consists of the hard palate.[9]

The current study was planned to evaluate the usefulness of CT in predicting the difficulty of advancing the tube through the nasal passage and related nasal intubation complications by measuring the INV region. It was hypothesised that evaluating of the nasal passage from a CT scan might provide valuable information about the appropriate side of the nasal passage for nasotracheal

[1,2]Department of Anaesthesiology, Erciyes University, Turkey;
[3,4]Department of Dentistry, Erciyes University, Turkey.
Correspondence: Seher Orbay Yasli. e-mail: sehersin81@hotmail.com
ORCID ID. 0000-0001-5163-3893

intubation and may eliminate the need of pre-intubation nasal endoscopy.

Patients and Methods

The prospective study was conducted at Erciyes University Faculty of Dentistry from April 2018 to June 2019 and comprised maxillofacial surgery patients of either gender aged 18-50 years who were due to undergo bimaxillary orthognathic surgery, which was defined as American Society of Anaesthesiology (ASA) grade I or II. Approval was obtained from the ethics review committee of Erciyes University Faculty of Medicine, and written informed consent was taken from all the patients. The lack of preoperative CT scans, airways evaluated and considered difficult by the anaesthesiologists, airways assessed and considered inappropriate for right angle endotracheal (RAE) tube with 7.0 mm internal diameter, history of sinusitis or head trauma, and anticoagulant therapy constituted the exclusion criteria. Detailed patient history was taken, including nasal trauma history, smoking, breathing difficulties and other nasal symptoms.

Premedication with midazolam was administered to the patients before the operation. Pulse oximetry, electrocardiography (ECG), and non-invasive blood pressure (BP) monitoring were performed in a standard manner. CT scan images of the nasal passage coronal sections were examined to determine the appropriate side of the passage, which was wide and open (Figure 1).

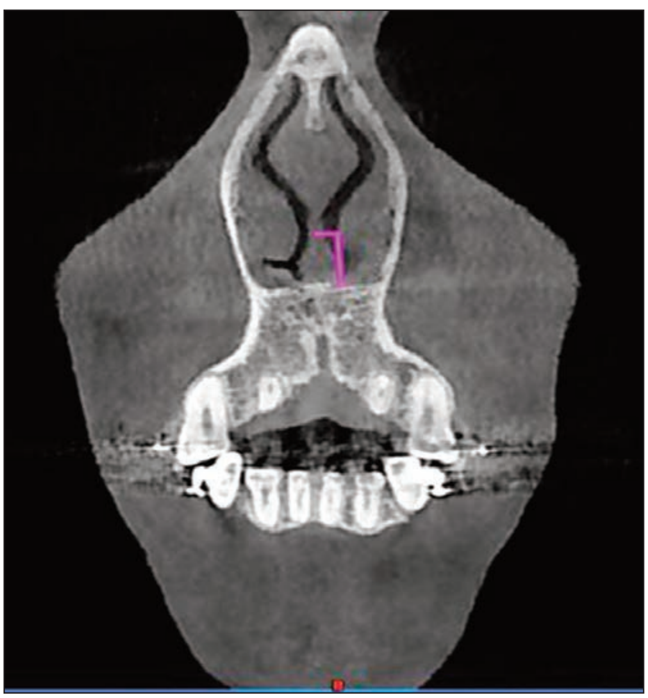

Figure-1: Nasal passage coronal computed tomography (CT) scans showing the wider side of the passage, and the distances between the septum and the inferior turbinate and between the hard palate (floor of the nose) and the inferior turbinate, measured in the internal nasal valve region.

For anaesthesia induction, 2mg/kg propofol (Propofol 1% Fresenius, Fresenius Kabi Deutschland, Bad Homburg, Germany), 1mcg/kg fentanyl (Fentanyl 0.05mg/mL, 10mL ampoule, Johnson&Johnson, Belgium), and 0.5 mg/kg rocuronium (Esmeron; GlaxoSmithKline, United Kingdom) were administered. Topical anaesthesia and vasoconstriction of the nasal cavity were performed using 4 ml of 4% lidocaine and 1ml of 1% phenylephrine in a mixture of 3.2% lidocaine and 0.2% phenylephrine. A syringe filled with 2-4ml of lidocaine/phenylephrine solution was directly applied into the nasal cavity. A single experienced anaesthesiologist performed all the intubations.

On the basis of CT scan images, nasal intubation was performed through the wider side of the nasal passage. RAE tubes made of polyvinyl chloride (PVC) material and an internal diameter of 7.0mm were used in all patients.

Based on an earlier study,[10] the tip of the nose was brought up, and the intubation tube was advanced through the passage caudally and parallel to the hard palate by the anaesthesiologist. Using this approach, nasal intubation was completed through the lower route where the intubation tube was not in contact with the middle turbinate.

Before intubation, the lower part of the nasal valve region, which is the narrowest area of the nasal passage, was measured by calculating the distance between the anterior border of the inferior concha and the septal cartilage.[8,11,12] Additionally, using the same section of the CT image, the distance between the inferior concha and the hard palate was measured. The senior surgical assistant, who mastered the CT application, made the measurements. The measurements were not relayed to the anaesthesiologist until after the intubation. Later, the difficulty in advancing the intubation tube through the nasal passage was recorded as either "easy" and "difficult" considering the applied force onto the tube. And the patients were divided into "easy" group A and "difficult" group B. No patient was left without intubation.

All CT scans were obtained before the surgery using cone-beam computed tomography (CBCT) (New Tom 5G, Verona, Italy). The measurements were carried out from the coronal sections at 0.25 intervals.

Since no study similar to the current one was found in the literature, the large effect size suggested by Cohen was used to determine the sample size.[13] Specifically, the sample size for our study was calculated using the statistical software G*Power[14] Version 3.1.9.2 (Franz Faul, Universitat Kiel, Germany). To determine the distance difference obtained from the measurements of the patients in the groups, with an effect size of d=0.80, based on the difficulty level of tube advancement through the nasal passage, the smple was calculated with type 1 error 0.05 and power 0.90.

Data normality was checked using Shapiro-Wilk, Kolmogorov-Smirnov and Anderson-Darling tests. Either independent samples t-test or Mann-Whitney U test was used, as appropriate, for comparing the groups.

To compare the differences between categorical variables, Pearson's chi-square test was used in 2x2 tables with expected cell counts of 5 and above. Fisher's exact test was used in tables with expected cell counts <5 and Fisher Freeman Halton test was used in row x column (RxC) tables where expected cell counts were <5. Receiver operating characteristic (ROC) curve analysis was used to evaluate the effects of obtained measurements on the differentiation of tube advancement difficulty degree. MedCalc statistical software and DeLong method were used to calculate the optimal cut-off value with Youden's index, 95% confidence interval (CI), and area under the curve (AUC).

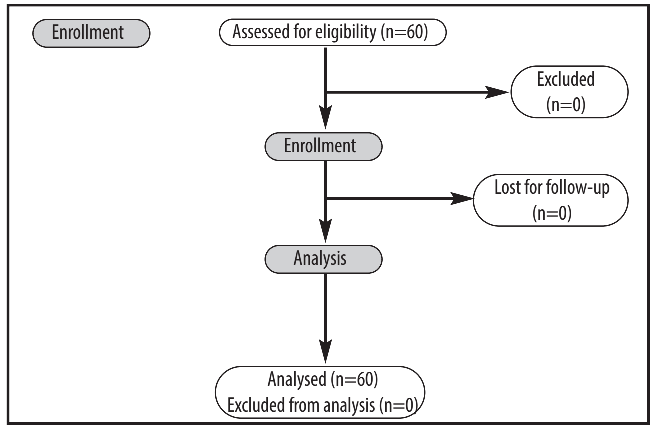

Figure-: Study flow diagram.

Statistical analyses were performed using Jamovi version 1.6.13.0, and JASP version 0.14.1.0.

Results

Of the 60 patients, 42(70%) were females and 18(30%) were males, and the study was completed by all those who were initially enrolled (Figure 2). The overall mean age was 29.0±10.5 years and the mean body mass index (BMI) value was 23.6±4.0 kg/m^2 (p>0.05). There were 28(46.6%) patients in group A, and 32(53.3%) in group B. Median distances were significantly shorter and epistaxis was significantly higher in group B compared to group A (p<0.001) (Table 1).

The median distance between the hard palate and inferior concha and between inferior concha and septum was shorter in patients with epistaxis compared to patients with no epistaxis (Table 2).

Cut-off values obtained from ROC analysis were 1.09 cm between the hard palate and inferior turbinate, and 0.39 cm between the inferior turbinate and septum. The measurements obtained were equal to or less than the cut-off values determined in group A, while the opposite was the case for group B (Table 3).

Table-1: Demographic and clinical variables of the patients.

	Overall patients	**Easy Group** (n=28)	**Difficult Group**(n=32)	***p*-value**
Mean Age (year)	27.0±10.5	28.1±11.0	26.1±10.1	0.450*
Mean Body mass index (BMI) (kg/m^2)	23.6±4.0	24.1±4.5	23.2±3.5	0.423*
Gender (%)				
Female	42 (70.0)	20 (71.4)	22 (68.8)	0.999**
Male	18 (30.0)	8 (28.6)	10 (31.2)	
Number of attempts for intubation	1.0 [1.0-4.0]	1.0 [1.0- 2.0]	2.0 [1.0- 4.0]	<0.001***
Epistaxis after intubation (%)				
No bleeding	20 (33.3)	19 (67.9)	1 (3.1)	<0.001¶
Bleeding fills half of the nelaton catheter	15 (25.0)	9 (32.1)	6 (18.8)	
Bleeding fills all of the nelaton catheter	21 (35.0)	0 (0.0)	21 (65.6)	
Severe bleeding	4 (6.7)	0 (0.0)	4 (12.5)	
The distance between hard palate and inferior concha (cm)	1.1 [0.7- 1.6]	1.2 [0.8- 1.6]	1.0 [0.7- 1.3]	<0.001***
The distance between inferior concha and septum (cm)	0.4 [0.2- 0.8]	0.5 [0.2- 0.8]	0.3 [0.2- 0.7]	<0.001***

*: Independent Samples t test; **: Pearson Chi-square Test ; ***: Mann Whitney U test; ¶: Fisher Freeman Halton Test

Table-2: Comparison of clinical variables according to the presence of epistaxis.

	Epistaxis after intubation		
	Absent patients (n=20)	**Present patients** (n=40)	***p*-value**
The level of tube advancement difficulty (%)			
Easy	19 (95.0)	9 (22.5)	<0.001*
Difficult	1 (5.0)	31 (77.5)	
Distance between hard palate and inferior concha (cm)	1.2 [0.8- 1.6]	1.0 [0.7- 1.3]	0.004**
Distance between inferior concha and septum (cm)	0.5 [0.2- 0.8]	0.4 [0.2- 0.7]	0.011**

*: Fisher Exact Test; **: Mann Whitney U test

Discussion

Nasotracheal intubation is widely performed, especially in the field of maxillofacial surgeries. CT is a reliable and widely used technique for obtaining nasal measurements.[12,15] The current

Table-3: Receiver operating characteristic (ROC) analysis to calculate the cut-off values of the distance values at which difficulty may be experienced while advancing the tube.

Prediction Model	AUC	Sensitivity	Specificity	Cut-off	95% CI	*p*-value
The distance between the hard palate and inferior concha	0.770	75.00	71.43	≤1.09	0.643- 0.868	<0.001
The distance between inferior concha and septum	0.773	68.75	85.71	≤0.39	0.646- 0.871	<0.001

AUC: Area under the curve, CI: Confidence interval.

results indicated that getting specific measures from the INV region on CT in the preoperative period in the operating room were a valuable, practical and time-saving way of determining the appropriate side of the nasal passage for smooth transit of the tube.

The most common complication in nasal intubation is epistaxis, which has an incidence of 14-80% and can range from minimal to severe. It was shown that the risk for epistaxis increased with excessive force to advance the endotracheal tubes (ETTs) into the oropharynx, larger ETTs, repeated unsuccessful attempts, and intranasal abnormalities.[4,16]

In a previous study,[17] smooth transit of the tube through the nasal passage was shown to play a significant role in avoiding the epistaxis, which suggested that the most effective method for reducing the incidence of epistaxis might be the straightforward navigability of the tube through the passageway. The current study demonstrated that the side where the tube can pass through the nasal passage properly and easily can be found under the guidance of CT while still in the operating room. At the end of the study, the distance cut-off values related to the easy and difficult tube passage from the appropriate nasal passage were revealed.

A study[18] demonstrated that the frequency and severity of epistaxis depended on the types of tubes, and revealed that silicone-based tracheal tubes were superior to PVC-based tubes. In another study,[19] all nasotracheal intubations were performed with PVC-based tubes, and it was found that thermosoftening of the tubes reduced the severity of epistaxis. In the present study, the same material RAE tubes were used in all patients for standardisation. It was found that obtained measurements from CT differed significantly between epistaxis and no-epistaxis groups. The median distances between the hard palate and inferior concha and between inferior concha and septum were shorter in the epistaxis patients than the rest.

Determining the appropriate nasal cavity before nasal intubation as a part of the preoperative evaluation is a critical approach to minimising the complications that might arise, while nasal endoscopy and rhinological evaluations, separately or together, have been recommended for this purpose in the literature.[20.-24] Among rhinological evaluations, rhinomanometric and rhinometric measurements were recommended as objective methods that evaluate nasal obstruction especially. Both measurement techniques objectively provide information about the stenosis of the nasal passage as obtained from the data transferred to the computer environment.[24] However, these procedures require an experienced otolaryngologist, particular types of equipment with additional costs, and more time. The current study demonstrated that the appropriate nasal cavity for nasal intubation could be determined with the measurements taken from CT without requiring other equipment.

In a previous study, 360 patients were divided into three groups. In the first group, nasal intubation was performed preoperatively through the nostril through which the breathing was most comfortable; in the second group, nasal intubation was performed through the nostril identified by the preoperative CT scan; and in the third group, a rhinologist evaluated preoperative CT scans, while rhinological examination and nasal endoscopy were done, and rhinological treatment was applied, if necessary. Subsequently, nasal intubation was performed to the side that was finally deemed appropriate. At the end of the study, the frequency of epistaxis and nasal mucosal damage was statistically higher in the first group. There was no difference between the second and third groups. The adequacy of preoperatively evaluated CT scans in determining the appropriate side for nasal intubation was demonstrated.[26] The present study revealed the cut-off values for the distances evaluated. These values may be used as reference values to gain insight into the difficulty of nasal intubation procedures.

There is only one study similar to the current research, evaluating tube advancement difficulty with CT scan measurements. In this retrospective study,[27] the diameter of the circle drawn between the hard palate-inferior concha and inferior concha-septum, parallel to the hard palate, was taken as the reference. After the study, the reserachers began to apply it as a routine procedure to take measurements from CT before each nasal intubation procedure to determine the right nasal passage side that can be easily advanced relative to the diameter of the tube. The described method[27] is not a short procedure and is hard to perform in the operating room during the preoxygenation and induction processes. Moreover, according to the study results, preoperative CT scans should be evaluated in another department, such as radiology. In the current study, the nasal passage side for intubation was quickly assessed in the operating room in a time-saving manner.

The current study has limitations. First, nasal mucosal damage was not demonstrated by nasal endoscopy after intubation, so the relationship between nasal mucosal damage and difficulty of the tube advancement through the nostril could not be determined. Second, using a vasoconstrictor in the nostril was neglected during the measurement as its effect on the mucosa was not determined. However, the same vasoconstrictor was administered to each patient with the standard dose and manner. In this way, standardisation was achieved in the measurements.

Despite the limitations, however, the study may guide other surgical fields, such as plastic and ear-nose-throat (ENT) surgery, in which nasal intubation is performed, provided that the head and neck region CT scans have been completed before surgery for medical reasons.

Further studies with larger sample size are recommended to verify the current findings.

Conclusion

CT-guided nasotracheal intubation procedure was found effective in preventing epistaxis as it allowed the tube to be advanced by the most appropriate nasal passage.

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Conflict of Interest: None.

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