Original Article

Neck fat volume as a potential indicator of difficult intubation: A pilot study

ABSTRACT

Background: Direct laryngoscopy is the gold standard of the airway management in patients without predicted difficulties. If unpredicted difficulties are encountered instead, different algorithms to follow have been developed. To date, no single predictor is sufficiently valid. In clinical practice, it is used a combination of them to enhance the estimate, and despite the variety of parameters used, not all the difficult intubations are predicted. The aim of this work is to retrospectively analyze neck computed tomography scans of 37 patients who have had tracheal intubation and search for anatomic neck fat compartments that correlate with the intubation difficulty, and eventually find a suitable, clinical parameter that can potentially enhance the prediction of a difficult airway when used in combination of the preexisting scores.

Materials and Methods: the patients are divided by direct laryngoscopy view into two groups: Group A (n = 31): Normal airway, with a Cormack Lehane, Score I or II; Group B (n = 6): Difficult airway, with a Cormack Lehane Score III or IV. In the zone of interest, it was measured the neck volume parameter and other subparameters.

Results: Despite a positive trend is shown for anterior fat volume (AFV) (P = 0.23) and fat volume (FV) (P = 0.28), statistically significant differences (P < 0.05) were not found between Group A and B in any of the measurements acquired.

Conclusions: According to the literature, our results confirmed that there is still no single element that can predict a difficult intubation. Although no statistical significance was found, the AFV and FV have shown to have a potential predictive role for difficult intubation. Further studies with bigger samples are advisable to confirm this encouraging result.

Key words: Computed tomography; difficult intubation; intubation; neck fat volume

Introduction

Airway management has always been a trending topic because its failure is one of the biggest fears in anesthesiology. Since the first attempts and the developing of endotracheal intubation in the early past century, many new devices have been introduced into the airway management armamentarium, ranging from different versions of endotracheal tubes to extraglottic devices, and combination of them. However, direct laryngoscopy still is the gold standard of airway management in patients without predicted difficulties.[1,2] If unpredicted difficulties are encountered instead, different algorithms to follow have been developed.[3]

Several scores have been proposed to predict difficult tracheal intubation in the preoperative clinical examination. Every clinical element alone is insufficient to precisely and

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accurately predict a difficult intubation, so a combination of them is required.[4]

The most comprehensive score used is the one suggested by el-Ganzouri *et al*. in 1996.[5] In this score, several criteria have been included: The mouth opening,[6,7] Mallampati *et al*. classification,[8] head/neck movement,[9] ability to prognath,[10] thyromental distance,[11] body weight,[12] and previous history of difficult intubation. Other indexes such as palm prints have been suggested to be used along.[13]

From a large cohort study of 188,064 cases from the Danish Anaesthesia Database came out that of 3391 difficult intubations (1.8% of total), 93% were unanticipated, and when the difficult intubation was anticipated, 25% of them had an actual difficult intubation.[14] This data show that the largest number of difficult intubations is undetected during the preoperative airway assessment.

To date, no single predictor is sufficiently valid. In clinical practice, it is used a combination of them to enhance the estimate, and despite the variety of parameters used, not all the difficult intubations are predicted.

The aim of this work is to retrospectively analyze neck computed tomography (CT) scans of patients who have had tracheal intubation and search for anatomic neck fat compartments that correlate with the intubation difficulty, and eventually find a suitable, clinical parameter that can potentially enhance the prediction of a difficult airway when used in combination of the preexisting scores.

Materials and Methods

We retrospectively selected patients who underwent neck CT scan (for diagnosis or follow up reasons) and general anesthesia with direct laryngoscopy followed by tracheal intubation.

Inclusion criteria were: age: 18–99 years; sex: male and female; American Society of Anesthesiologist (ASA) Physical Status I-IV; general anesthesia with tracheal intubation performed; neck CT-scan available (performed at a maximum of 2 months before or after the surgery with endotracheal intubation). The exclusion criteria were patients who did not have tracheal intubation, patients who did not receive neck CT scans, and patients with laryngeal or neck disease that can affect el-Ganzouri score.

Overall, a total of 37 patients were included in this study [Table 1].

Table 1: Demographic data

	n	Mean age	Mean weight	Mean height	Mean BMI
Females	16	65.88	67.13	1.63	25.13
Males	21	62.71	78.57	1.73	26.5
Total	37	64.08	73.62	1.68	25.91

BMI: Body mass index

General anesthesia

All the selected patients have had a clinical preoperative assessment, according to the last Practice Guidelines for Management of the Difficult Airway of the ASAs Task Force and recording height, weight, body mass index (BMI), sex, age, and el-Ganzouri score. All patients then underwent general anesthesia with tracheal intubation, performed by direct laryngoscopy with a Macintosh curved blade and the Cormack Lehane score was recorded.

Group assignment

The patients are divided by direct laryngoscopy view into two groups:

- Group A ($n = 31$): Normal airway, with a Cormack Lehane, Score I or II
- Group B ($n = 6$): Difficult airway, with a Cormack Lehane, Score III or IV.

We would like to notice that the patients in Group B are all Cormack III since no Cormack IV was found in our database with the inclusion criteria for this study.

Statistical analysis

The CT volumes and the percentage scores were compared by the Student's *t*-test between the two groups. The level of statistical significance was considered $P < 0.05$.

Computed tomography scan

All the individuals included underwent a CT examination on clinical scanners (Somaton, Sensation 64, Siemens, Forcheim, Germany). CT studies were performed either before or after surgery.

CT scanning was performed with the patient awake, supine, during one-breath-hold at the end of a normal inspiration (35 patients during contrast medium injection and 2 patients without contrast medium injection).

The images were acquired in DICOM format and transferred to a workstation. CT measurements of neck tissues were assessed using 3 mm (7 patients), 2 mm (5 patients), and 1 mm (25 patients) slice thickness images. Volumes are measured and expressed in cm^3. All measurements were quantified semiautomatically with the "grow region (two-dimensional [2D]/3D segmentation)" function in Pixmeo, Geneva, Switzerland.

The zone of interest analyzed ranges from the axial slice corresponding to the most inferior tip of the soft palate to the one corresponding to the most inferior tip of the epiglottis [Figure 1].

In the zone of interest was measured the neck volume (NV) parameter, comprehensive of all the anatomical structure and tissue volumes, from which are derived all the other subparameters. NV was semi-automatically obtained measuring the volume of all the tissues of the slices examined [Figure 2].

The derived subparameters are:

- Fat Volume (FV): The volume of all the fat tissue included in NV [Figure 3]
- Anterior FV (AFV): The volume of fat that is ventral to the anterior border of each vertebral body, excluding the adipose tissue that is posterior to that border [Figure 4]
- Submental FV (SMFV): The volume of fat that ranges from the chin and the floor of mouth superiorly, to the hyoid bone posteriorly and to the thyroid cartilage inferiorly. SMFV was automatically measured in the sagittal plane, isolating the region of interest from the remnant of the neck [Figure 5]
- Airway volume (AWV): The volume of air within the airways included in the NV [Figure 6]
- These subparameters were also related to the NV of the same patient and normalized into percentage
- FV/NV (%): The percentage of the NV that corresponds to the FV
- AFV/NV (%): The percentage of the NV that corresponds to the AFV
- SMFV/NV (%): The percentage of the NV that corresponds to the SMFV
- AWV/NV (%): The percentage of the NV that corresponds to the AWV.

Results

Thirty-seven patients were included in the study: Thirty-one patients in Group A (Cormack Score ≤II) and six patients in Group B (Cormack Score ≥III).

The results are summarized in Table 2. Statistically significant differences ($P < 0.05$) were not found between Group A and B in any of the measurements acquired.

Discussion

Before analyzing the data obtained, there are some elements that need to be discussed. It is a common behavior of the anesthesiologist to "fear" the obese patient or the one presenting with a big or fat neck that is undergoing sedation or general anesthesia. If this may be true regarding the correlation between BMI and difficult mask ventilation,[15,16] this evidence was not confirmed by the studies correlating BMI or neck circumference with difficult laryngoscopy.[17-19]

Our hypothesis initially was that there could be a relation between the FV of the neck or one of its subparts (e.g., submental fat pad only) and the difficult airway, justifying that "fear" of the anesthesiologist. The CT volumetry was judged to be more precise than clinical findings

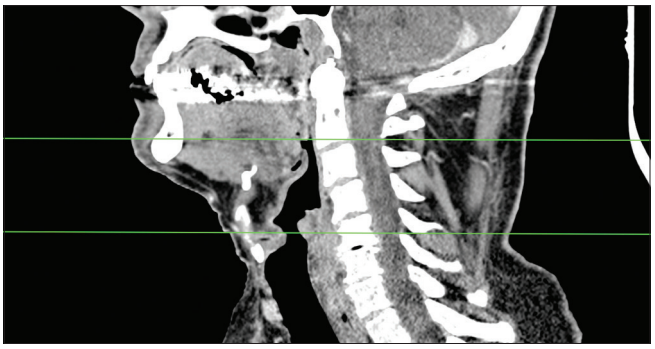

Figure 1: Computed tomography sagittal scan show zone of interest between the most inferior tip of the soft palate and the most inferior tip of the epiglottis

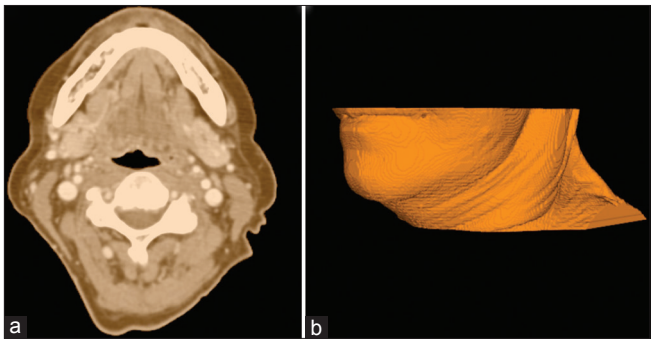

Figure 2: Computed tomography axial scan (a) and the respective volumetric reconstruction (b) of the neck volume

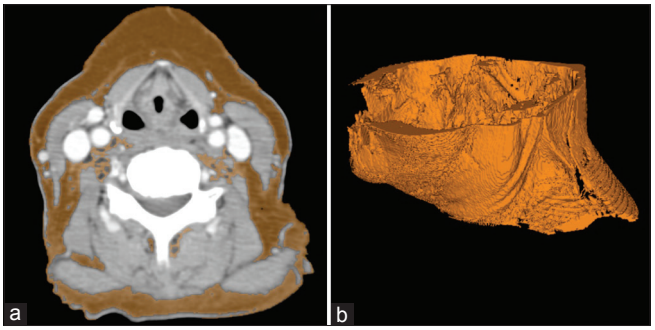

Figure 3: Computed tomography axial scan (a) and the respective volumetric reconstruction (b) of the fat volume

Table 2: Mean of the two groups and Student's *t*-test results

	NV (cm^3)	FV (cm^3)	AFV (cm^3)	SMFV (cm^3)	AWV (cm^3)	FV/NV (%)	AFV/NV (%)	SMFV/NV (%)	AWV/NV (%)
Group 1 mean	1242.5	352.33	161.83	51.33	10.22	28.64	12.37	4.13	0.85
Group 2 mean	1152.52	282.32	118.13	51	12.52	28.39	10.76	4.59	1.42
P	0.6	0.28	0.23	0.99	0.53	0.98	0.52	0.73	0.39

NV: Neck volume; FV: Fat volume; AFV: Anterior fat volume; SMFV: Submental fat volume; AWV: Airway volume

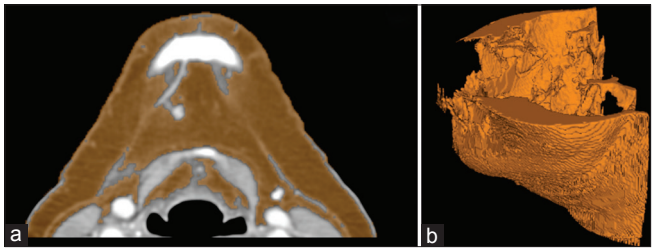

Figure 4: Computed tomography axial scan (a) and the respective volumetric reconstruction (b) of the anterior fat volume

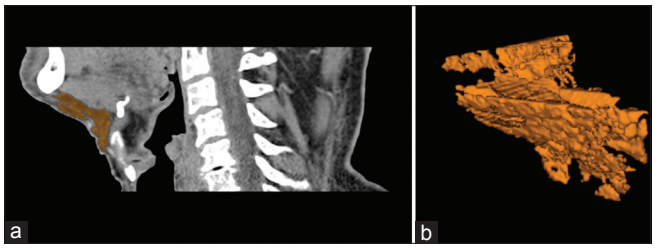

Figure 5: Computed tomography sagittal scan (a) and the respective volumetric reconstruction (b) of the submental fat volume

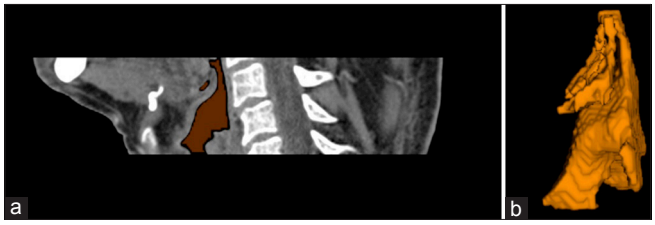

Figure 6: Computed tomography sagittal scan (a) and the respective volumetric reconstruction (b) of the airway volume

such as neck circumference or BMI in the measurements of neck FV and distribution.

However, this hypothesis was not confirmed by the results. It comes to attention that none of the measurements reached the statistical significance, defined as $P < 0.05$ at the Student's *t*-test [Table 2]. Moreover, for some "key" elements, there is almost a statistical independence (*P* value close to 1): Those elements are the SMFV ($P = 0.99$) and the FV/NV % ratio ($P = 0.98$).

Then, we found no correlation between a double chin and difficult intubation, and between the percentage of FV of the neck and a difficult intubation. These "key" elements of the anesthesiologist's fear are not supported by CT data.

The smallest p-scores obtained regard the AFV ($P = 0.23$) and FV ($P = 0.28$). Even though there is no statistical significance, this could suggest that the fat present in the anterior part of the neck is more related to a difficult intubation rather than the entire neck fat or the overall neck volume, even though it is an unreliable element when considered alone.

The AWV has also little statistical significance, but it is possible that could have been a bias related to the supine position.

The limits of our work are first the size of the two groups: Further studies with bigger sample sizes are advisable to confirm this encouraging result.

Another limit is the low percentage of patients that undergone neck CT: Indicate a neck CT for prediction of a difficult intubation is not proposable. Thus, neck FV can be evaluated only in already existing CT scans.

Conclusions

All the patients included in this paper received the CT scan examination in a period close to the general anesthesia for other reasons.

According to the literature, our results confirmed that there is still no single element that can predict a difficult intubation. Although no statistical significance was found, the AFV was the parameter most related to difficult intubations. This study involved 37 patients only; it is possible that a larger sample size may be required to achieve statistical significance.

Based on our results, we cannot routinely recommend to perform a neck CT scan or to measure the volume of anatomic neck fat compartments in patients who performed a CT scan of the neck for other reasons. If a further and bigger study will find a correlation between the difficult intubation and a specific neck fat compartment, it would be useful to measure the neck fat volumetry in patients who have had a neck TC scan for any reason. However, we would not recommend to perform a TC scan with the sole purpose of measuring the neck volumes. Nowadays, there are other noninvasive emerging

techniques that help to predict a difficult intubation,[20,21] making the high ionizing radiation dosages of a TC scan not advisable at the moment.

Answering to the title main question, the current scores are still valid for the preoperative assessment of difficult intubations, even though most of the really difficult cases remain undetected. We suggest to keep following international guidelines for preoperative anesthesiological assessment.

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Conflicts of interest
There are no conflicts of interest.

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