Short Neck, a new criterion for airway assessment: A pilot, cohort single blind study

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Abstract

Purpose

Short Neck is a term used by anesthesiologists to describe one of the risk factors for difficult airway management. However, the term Short Neck is very subjective and has not been standardized. We attempt to quantify Short Neck.

Methods

A pilot prospective single blinded study was conducted at Hamad General Hospital, Doha, Qatar between March 2018 and October 2018. 97 adult patients scheduled for elective surgery under general anesthesia were recruited. Measurements of airway assessment, including neck length, were documented prior to anesthesia. The operators (anesthesiologists) were blinded. Intubation Difficulty Scale was used. All data were documented and analysed afterwards. Patients were of three groups according to Intubation Difficulty Scale (IDS): Group A: IDS 0, Group B: IDS >0 - ≤5 and Group C: IDS >5.

Results

Five patients (5.2%) with intubation difficulty score >5 have a mean neck length 7.6 cm. Short Neck was found to have a significant p value 0.022 within the three groups.

Conclusions

Patient's features relevant to airway assessment are rather difficult to quantify. This is the first reported attempt to obtain an objective value for Short Neck in routine airway assessment.

1. Introduction
The term commonly used by anesthesiologists when preoperatively assessing a patient’s airway is Short Neck (SN). This term indicates a possibility of difficult airway management. Most of the airway management guidelines \cite{1, 2}, audits \cite{3}, books and articles \cite{4, 5, 6, 7, 8, 9, 10} refer to SN as one of the criteria of difficult airway management. Unfortunately, the term is very subjective and none of these references have addressed it in a scientific way. There is no consensus on neck length measurement, and thus SN has not been standardized \cite{11}. However, some medical and non-medical specialties have tried to define it in their own way, without clear reference \cite{12, 13, 14}.

Given the lack of clear consensus, our main objective is to quantify SN with a special reference to obese patients. We hypothesize that SN is associated with high body mass index (BMI) and, therefore, that it is linked with high Intubation Difficulty Scale (IDS) as well.

2. Methods

In our study, our aim was to establish a quantity value of SN. We prospectively identified and recruited obese adult patients of both sexes scheduled for elective surgery with BMI > 30. Exclusion criteria were the following: congenital anomalies, thyroid nodule, tumor of the neck and face, or cervical injury or limitation of movement that may cause SN or interfere with measurement, overall assessment, or intubation.

All classical airway assessment parameters were considered. These parameters include Mouth Opening (MO), Thyromental Distance (TMD), Mallampati Score (MMP), Neck Circumference (NC) at the cricoid level, Prognathism (PRO) for under or
overbite. Dentition (Full, Loose and Edentulous), and Neck Length (NL).

After discussing the procedure with the patients and attaining their written consent, the neutral position of the head was determined using the most comfortable erect position of the head with the eyes looking forward. We used a measuring tape to identify MO, TMD, NC and NL, and other variables were visually observed. NL was assessed by measuring the distance between the tip of the Mastoid, as it agrees with the level of the First Cervical Vertebrae (Atlas) (15), to the meeting point between the neck and the shoulder. We call this distance “apparent neck,” which reflects where flexion and extension technically occur. The data were then documented in a dedicated recording sheet. Other demographics, such as age, sex, height, weight, and BMI, were documented as well.

All investigators were not involved in the oral intubation procedure. The operator, who was a senior anesthesiologist, was blinded in the study. However, the operator was given the Intubation Difficulty Scale (IDS) recording sheet to be completed (16). The IDS score was calculated by an investigator and entered into a coded Microsoft Excel spreadsheet. These sheets were then combined into one final table.

2.1 Statistical Analysis

The primary objective and main focus of the data analysis in this pilot study is to assess and quantify the significance of neck length in the airway assessment. The statistical analysis is categorical and continuous values will be expressed as frequency (percentage), mean ± SD or median and interquartile range (IQR), as appropriate. Descriptive statistics will be used to summarize demographic, clinical, and other parameters related to airway assessment. The Kolmogorov-Smirnov (K-S) test or Q-Q Plot will be used, as appropriate, to test for normality of the data.
Associations between two or more qualitative variables will be assessed using chi-square (χ²) test and/or Fisher Exact test, as appropriate. Quantitative data between the two and more than two independent groups will be analysed using an unpaired ‘t’ test and one way analysis of variance (ANOVA). Where an overall group difference is found to be statistically significant, pair-wise comparisons will be made using appropriate post-hoc test. Relationships between two quantitative variables will be examined using Pearson’s correlation coefficients.

In addition, appropriate univariate and multivariate regression analysis (linear or logistic regression methods) will be used to assess and quantify the effect of different factors (such as neck length, neck circumference, age group, etc.) on the outcome of the difficult airway assessments. The results will be presented with the associated 95% confidence interval. Pictorial presentations of the key results will be made using appropriate statistical graphs. All P values presented will be two-tailed, and P values < 0.05 will be considered as statistically significant. All statistical analyses will be done using statistical packages SPSS 22.0 (SPSS Inc. Chicago, IL) and Epi-info (Centers for Disease Control and Prevention, Atlanta, GA) software.

3. Results

Ninety-nine patients were enrolled in this study. Two patients were excluded from the study due to incorrect documentation and intubation by a junior anesthetist. We completed our study with 97 patients in the final analysis.

In this pilot study, we found that five patients (5.2%) with the age range 45-64 years have a mean NL of 7.6 cm (SD ± 0.9) and IDS >5 (Group C), which reflects moderate to major difficulty in intubation. There is a statistically significant p value 0.022, considering the correlations between the groups (Table 1). Fifty-five patients
have an IDS between 1 and 5 (Group B), representing slight difficulty, with a mean NL of 8.1 cm (SD ± 1.24).

The remaining 37 patients who scored IDS 0 (Group A) have a mean NL of 8.77 cm (SD ± 1.24). Considering all IDS groups related to NL (divided to three groups: ≤7 cm, 7-10 cm and >10 cm) we found that the five patients with IDS >5 fell in the first two groups. All of these patients had a MMP score of 3 and BMI less than 40. Of these patients, three were female patients and only one had NC of >44 cm.

Other airway variables were weakly correlated with IDS score, except for TMD and age, with p value 0.015 and 0.035 respectively (Tables 2,3). There was a significant negative correlation observed between NL and IDS score (correlation coefficient r=-0.339 (P=0.001). However, no significant correlation was observed between BMI and neck length (r= 0.010; P=0.924) and IDS score (r= -0.040; P=0.701) (Table 4).

In considering patients’ height and neck length, we found a very low correlation between the two (Pearson r=0.171; P=0.094). In other words, the correlation between height and NL is not statistically significant.

4. Discussion

According to its medical definition, the neck is the “part of the body where the head is connected to the trunk; it extends from the base of the cranium to the top of the shoulders.” Or, it is “the usually narrowed part of an animal that connects the head with the body; specifically: the cervical region of a vertebrate” [17, 18]. Gray’s anatomy describes the neck as the area that “extends from the base of the cranium and the inferior border of the mandible to the thoracic inlet” [19].

What constitutes Short Neck, however, has not been systematically measured or defined. Instead, SN is often a subjective assessment. This led us to raise questions
surrounding the measurement of SN and its effect on airway management.

In one example, Short Neck has been defined by the National Human Genome Research Institute as the “decreased distance from the point where neck and shoulders meet to the inferior margin of the occipital bone” [20]. Although SN is widely mentioned in anesthesia textbooks, guidelines and articles concerned about airway management, the authors do not quantify SN nor specify the reason for doing so [21, 22, 23, 24, 25].

In our efforts to quantify it, we considered SN (apparent neck) as the distance between the points where the shoulders and neck meet, as defined above. We took the tip of the mastoid as the upper point as it lines up with first cervical vertebrae, according to Gray’s surface anatomy landmark.

Apart from congenital anomalies that affect NL, such as Klippel-Feil and Noonan Syndromes, one of the common causes of SN is obesity, especially in males. In these cases, there is a predilection for adipose tissue to accumulate around the neck, which causes an increase in NC and the NL appears shorter. Larger NC and shorter NL create difficulty in the patient achieving the “sniffing position” as extension occurs at the atlanto-occipital joint. This can make visualization of the cords difficult during direct laryngoscopy, which is why obese people are deemed to be of the difficult airway category.

The “apparent” reduction in NL would limit neck movement during laryngoscopy as the operator cannot extend the neck. For this reason, different approaches are utilized, such as optimizing the patient’s position (ramped) or using videolaryngoscopy as an adjunct. In addition, deposition of fat at the back of the neck, or “hump neck,” would magnify the difficulty. Although many published
articles focus on limited neck movement, they do not refer to SN as a possible cause [26, 27, 28, 29, 30].

This pilot study has not agreed with our hypothesis in some aspects. Morbid obesity (BMI > 40) was not associated with SN or IDS; however, obese patients with average BMI 34.8 have a good correlation with high IDS and SN. All of the airway measurements in singles lack sensitivity in predicting difficult intubation; sensitivity improves when all criteria are combined, adding one more measurement will improve further on their predication leverage.

With the advent of videolaryngoscopy and its vast use in difficult intubation, measuring SN, especially when associated with other criteria, can justify its early use when available, rather than the classical approach using direct laryngoscope. Finally, using fingers’ width to measure SN may be a simple and fast method, similar to measurements such as thyromental distance and mouth opening. Although fingers’ width is not an accurate method, it can be used subjectively in a quick assessment, especially in emergency situations.

The limitations of our study are the following: it is a pilot study; it included a small number of patients; and only obese patients were chosen. However, our study represents a first step towards quantifying SN. As a result, we hope to make a contribution to clarifying the effect of SN on airway management.

5. Conclusion

The term Short Neck (SN) has long been used by anesthesiologists and acute care physicians in order to subjectively define a patient with possible difficult airway, particularly in tracheal intubation. However, we believe we have established a quantitative value for SN. To further our understanding, we hope that future studies
will recruit a larger number of patients in conjunction with a comparative study that includes lean patients. Building on our pilot study, these developments will introduce new perspectives and further clarity to the subject of SN.

Abbreviations

Short neck: SN
Neck circumference: NC
Thyromental distance: TMD
Mouth opening: MO
Mallampati: MMP
Intubation difficulty score: IDS
Neck length: NL
Body mass index: BMI

Declarations

Ethics approval and consent to participate
The study was approved by the Medical Research Centre (MRC) and the IRB of Hamad Medical Corporation, reference number 16323/16 dated 19 November 2017.
Animal study: Not applicable.
All patients recruited had consented in writing to the study, including anthropometric measurements.

Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests
The authors declare that they have no competing interests.

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Authors' contributions
YEA, CBR, TMY, NK, SK, and AMRT have helped in obtaining informed consent, assessing inclusion and exclusion criteria, airway assessment and measurements and in providing feedback to the Principal investigator, JHF. SKM has helped in tables in addition to the above mentioned duties. ALA has helped in preparing the preoperative airway assessment sheet (Excel sheet) and in writing the manuscript including formatting it. JHF, principal investigator, led the overall supervision of the study, ensuring strict compliance, collecting and recruiting patients, writing the manuscript, answering queries raised by co-authors and steering pre-study and follow-up meetings with all co-authors. All authors read and approved the final manuscript.

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Tables
Table 1. Airway assessment and other demographic criteria of the five patients who scored more than 5 in the IDS

BMI: Body Mass Index; TM: Thyromental Distance; MO: Mouth opening; MMP: Mallampati; NC: Neck Circumference; IDS: Intubation Difficulty Score.

| Variable     | IDS =0 Mean ± SD | IDS 1 to 5 Mean ± SD | IDS >5 Mean ± SD | P value |
|--------------|------------------|----------------------|------------------|---------|
| Age (yrs.)   | 38.9 (11.3)      | 43.3 (10.3)          | 50.2 (7.95)      | 0.03    |
| Weight (kg)  | 106.4 (22.8)     | 107.3 (20.7)         | 91.1 (8.2)       | 0.26    |
| Height (m)   | 1.65 (0.09)      | 1.64 (0.09)          | 1.62 (0.08)      | 0.67    |
| BMI          | 38.8 (8.2)       | 39.4 (6.4)           | 34.8 (1.6)       | 0.38    |
| TM (cm)      | 7.8 (1.0)        | 7.4 (1.2)            | 6.3 (0.4)        | 0.01    |
| MO (cm)      | 5.2 (1.1)        | 4.9 (0.9)            | 4.6 (1.1)        | 0.20    |
| MMP          | 2.3 (0.7)        | 2.5 (0.8)            | 3.0 (0.0)        | 0.10    |
| NC (cm)      | 40.9 (4.4)       | 42.4 (5.2)           | 39.6 (4.2)       | 0.24    |
| NECK LENGTH (cm) | 8.8 (1.3) | 8.1 (1.2) | 7.6 (0.9) | 0.02 |

Table 2. Comparison of anthropometric and various other parameters across different IDS score values.

IDS: Intubation Difficulty Score; BMI: Body Mass Index; TM: Thyromental Distance;
MO: Mouth opening; MMP: Mallampati; NC: Neck Circumference.

| Variables               | IDS Group | P value |
|-------------------------|-----------|---------|
|                         | =0 (%)    | 1-5 (%) | >5 (%) |
| Neck length groups (cm) | <=7       | 3(8.1%) | 15(27.3) | 3(60) | 0.0 |
|                         | >7 to 10  | 29(78.4) | 38(69.1) | 2(40) |
|                         | >10       | 5(13.5) | 2(3.6) | 0(0) |
| Dentition               | F         | 36(97.3) | 54(98.2) | 5(100) | 0.5 |
|                         | E         | 1(2.7) | 1(1.8) | 0(0) |
| Prognathism             | U         | 31(83.8) | 47(85.5) | 4(80) | 0.9 |
|                         | O         | 16(16.2) | 8(14.5) | 1(20) |

Table 3. Association categorized IDS score and neck length and other variables. The percentage is within the IDS groups.
F: full dentition; E: edentulous; U: underbite; O: overbite.

| IDS      | BMI ≤40 n (%) | BMI >40 n (%) | P value |
|----------|---------------|---------------|---------|
| IDS=0    | 25 (40.3)     |               | 0.148   |
| IDS 1 to 5 | 32 (51.6) | 23 (65.7) |     |
| IDS>5    | 5 (8.1)       | 0 (0)         |         |

Table 4. Association between BMI and IDS score
BMI: Body Mass Index; IDS: Intubation Difficulty Score.