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ULTRASOUND ASSESSMENT IN PREDICTING DIFFICULT AIRWAY MANAGEMENT IN PATIENTS WITH POST-BURN CONTRACTURES OF THE FACE AND NECK

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Introduction

In patients with burn contractures of the face, neck, and chest, preoperative prediction of difficult airways is a primary task. Difficult laryngoscopy and tracheal intubation in most cases result from inadequate preoperative assessment of upper airway patency [2, 6]. Algorithms for managing difficult airways vary across countries [4, 12]. A unified system for assessing the risk of "difficult airway" during surgical treatment of severe burn injuries to the face, neck, and chest has not yet been developed in global anesthesiology practice [1].

Standard methods of assessing airway patency included in international guidelines cannot be applied to patients with post-burn contractures of the face, neck, and chest [1, 7]. All standard scales incorporate the same parameters, such as mouth opening, neck extension and flexion, successful or unsuccessful intubation in the past, and mandibular advancement, which are often impossible for patients with severe contractures of the face, neck, and chest. According to Bowness J. and Teoh W.H. [8], these patients represent a specific population in which the risk of difficult tracheal intubation is higher than average and reaches 11.2%, which is three times greater than in the general population.

Considering the anatomical and functional changes in the upper airways (UA), approaches to predicting difficult airway management, choosing the optimal method of tracheal intubation, anesthesia during intubation, and maintaining airway patency during reconstructive and plastic surgery in this category of patients require further study [3, 8]. All standard scales combine the same parameters, such as mouth opening, neck flexion and extension, history of successful or failed intubation, and mandibular protrusion, which are often unachievable in patients with severe contractures of the face, neck, and chest. This indicates a lack of reliability in these traditional tests and the need for more dependable testing parameters in this category of patients, which require further investigation. For this purpose, we hypothesized that the assessment of the above-

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mentioned parameters could be supplemented by ultrasound examination of the neck tissues.

Research Objective:
To determine the prognostic value of measuring the thickness of the soft tissues of the neck using ultrasonography for diagnosing possible difficult tracheal intubation.

Materials and Methods:
The study included ultrasound data of the soft tissues of the anterior surface of the neck from 78 patients who underwent surgery at the MMC clinic of the Andijan region. The patients were divided into two groups. The 1st (main) group consisted of 56 patients with severe contractures of the face, neck, and chest, aged 16 to 50 years (13 men – 23.2%, 43 women – 76.8%). The 2nd (control) group included 22 patients without neck deformities, prior to various abdominal surgical interventions. The age of patients in this group ranged from 18 to 50 years (8 men – 37.7%, 14 women – 63.3%).

The demographic characteristics of the examined patients are presented in Table 1 below and demonstrate the homogeneity and comparability of patients in both groups in terms of age, sex, and anthropometric indicators.

Table 1. Demographic data of patients in both groups (n = 78)

Indicators	Group 1 – patients with neck contractures (n = 56)	Group 2 – patients without neck deformity (n = 22)	P-value
Age	31.5 ± 8.7	32.2 ± 10.6	0.959
Sex (M/F)	13 (23.2%) / 43 (76.8%)	8 (37.7%) / 14 (63.3%)	—
ASA (I/II)	36 (64.3%) / 20 (35.7%)	5 (22.6%) / 17 (77.4%)	—
Height (cm)	157.97 ± 5.25	157.48 ± 5.63	0.949
Weight (kg)	63.87 ± 8.61	56.89 ± 9.01	0.577
BMI	25.59 ± 4.10	22.89 ± 3.21	0.6056

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From the presented data, it can be seen that the mean age of patients in both groups was **31.5 ± 8.7** and **32.2 ± 10.6**, with women outnumbering men — **76.8**% and **63.3**%. The causes of cicatricial deformities and defects of the soft tissues of the face, neck, and chest were burns caused by flame, hot liquids, acid, and electricity. All patients had their height, body weight, and body mass index (BMI) recorded. To assess airway patency, the modified Mallampati scale was used, supplemented with other standard screening tests.

The **thyromental distance (TMD = TMP)** was measured from the mentum to the thyroid cartilage with the patient's neck fully extended. The **sternomental distance (SMD = ГМР)** was measured from the suprasternal notch to the mentum with the neck fully extended. The **neck circumference (NC = ОШ)** was measured at the level of the thyroid cartilage. The **interincisor gap (IIG = МРП)** was measured from the upper central incisors to the lower central incisors with the patient's mouth fully open. The **upper lip bite test (ULBT = ТПВГ)** was performed by asking the patient to bite the upper lip.

Ultrasound measurements were performed using a **Fujifilm Sonosite Edge (Inc., USA)** device with a linear probe of **8–13 MHz**, according to the following method: the patient was placed in the supine position with the head and neck in a neutral position. The distance from the skin to the anterior surface of the trachea was determined by placing the linear probe transversely at three different levels of the neck: above the hyoid bone, at the thyrohyoid membrane, and at the anterior commissure [5, 11]. At the level of the thyrohyoid membrane, the distance from the skin to the epiglottis was measured midway between the hyoid bone and the thyroid cartilage. At the level of the anterior commissure, the minimum distance from the skin to the anterior commissure was obtained. The figure presents our own data.

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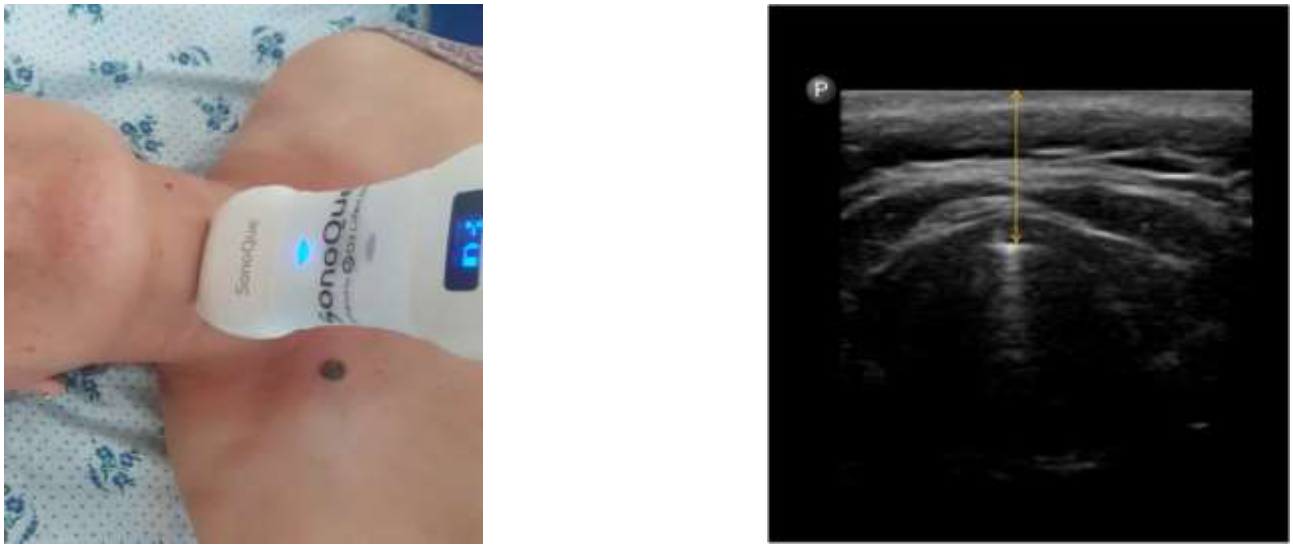

Figure. At the level of the hyoid bone, the minimum distance from the hyoid bone to the skin surface was measured.

To obtain reference normative values of the indicated parameters, the neck region was examined in **22 patients with abdominal pathology without skin deformities**.

Statistical Methods

Statistical data processing was performed using **Microsoft Office Excel 2010** (Microsoft Corp., USA) and **Statistica 6.0** (Stat Soft Inc., USA). Data are presented as the mean value (M) and the standard deviation of the mean (m). Categorical data are described as frequency, n (%). The significance of differences between stages, depending on the type of data, was assessed using the **Student's t-test**, the **Mann–Whitney U-test**, or **Fisher's exact test**, with a critical significance level (p) of less than 0.05.

To determine the threshold value, a **receiver operating characteristic (ROC) analysis** was performed, and the **area under the curve (AUC)** with a 95% confidence interval was calculated. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated for both scoring systems. The predictive accuracy of the scoring systems was compared using the ROC curve by measuring the AUC. All comparisons were two-sided, and $p < 0.05$ was considered significant.

Results and Discussion

During ultrasound examination of the upper airway tissues, a significant difference was observed between patients in Groups 1 and 2 for all studied parameters. Thus,

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the **thyromental distance** in patients of the main group was reduced by **1.3 cm** compared to the control group, while the **sternomental distance** was reduced by **1.2 cm** compared to controls. These changes were due to the inability to achieve full head extension because of scar contractures, which is consistent with the opinion of several researchers [9, 13].

In contrast, the **neck circumference** and the **distance between the skin and the hyoid bone** increased by **2 cm** and **0.8 cm**, respectively. An increase was also noted in the **distance between the skin and the epiglottis**, as well as the **distance between the skin and the anterior commissure**. All the above-mentioned parameters are presented in **Table 2** below.

Table 2. Airway assessment parameters for predicting difficult laryngoscopy

Indicators	**Group 1 (n = 56)**	**Group 2 (n = 22)**	**p-value**
Modified Mallampati score (MMS)			
MMS 1	2 (3%)	10 (45.4%)	–
MMS 2	5 (9.0%)	8 (36.4%)	–
MMS 3	35 (63.0%)	4 (18.2%)	–
MMS 4	14 (25%)	0 (0.0%)	–
Upper lip bite test (ULBT)			
ULBT 1	46 (82.0%)	22 (100%)	–
ULBT 2	10 (18.0%)	0 (0%)	–
Thyromental distance (TMD), cm	6.61 ± 1.02	7.92 ± 1.26	0.42
Interincisor gap (IIG), cm	6.29 ± 0.85	6.34 ± 0.57	0.96
Sternomental distance (SMD), cm	16.34 ± 2.41	17.60 ± 1.57	0.66
Neck circumference (NC), cm	35.18 ± 3.14	33.13 ± 2.64	0.61
Skin-to-hyoid distance (SHD), cm	1.03 ± 0.20	0.82 ± 0.13	0.38

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Indicators	Group 1 (n = 56)	Group 2 (n = 22)	p-value
Skin-to-epiglottis distance (SED), cm	1.49 ± 0.11	1.14 ± 0.14	0.053
Skin-to-anterior commissure distance (SACD), cm	1.92 ± 0.15	1.43 ± 0.10	0.008

Note: Data are presented as mean ± standard deviation or as the number of patients (percentage).
MMS – Modified Mallampati Score; ULBT – Upper Lip Bite Test; TMD – Thyromental Distance; IIG – Interincisor Gap; SMD – Sternomental Distance; NC – Neck Circumference; SHD – Skin-to-Hyoid Distance; SED – Skin-to-Epiglottis Distance; SACD – Skin-to-Anterior Commissure Distance.

The results of our study show that the thickness of the soft tissues of the anterior neck at the level of the hyoid bone, the thyrohyoid membrane, and the anterior commissure is greater in the main group. The values of three parameters (main group versus control group) — hyoid level (1.30 cm ± 0.20 vs. 0.82 cm ± 0.13), thyrohyoid membrane (1.49 cm ± 0.11 vs. 1.14 cm ± 0.14), and anterior commissure (1.92 cm ± 0.15 vs. 1.43 cm ± 0.10) — may be of important significance in diagnosing difficult tracheal intubation. We fully agree with the opinion of some authors who point out that these three parameters are independent predictors of difficult laryngoscopy [9].

Multivariate analysis revealed a strong positive correlation (r = 0.88) between the **skin-to-epiglottis distance (SED)** and the **skin-to-anterior commissure distance (SACD)**.

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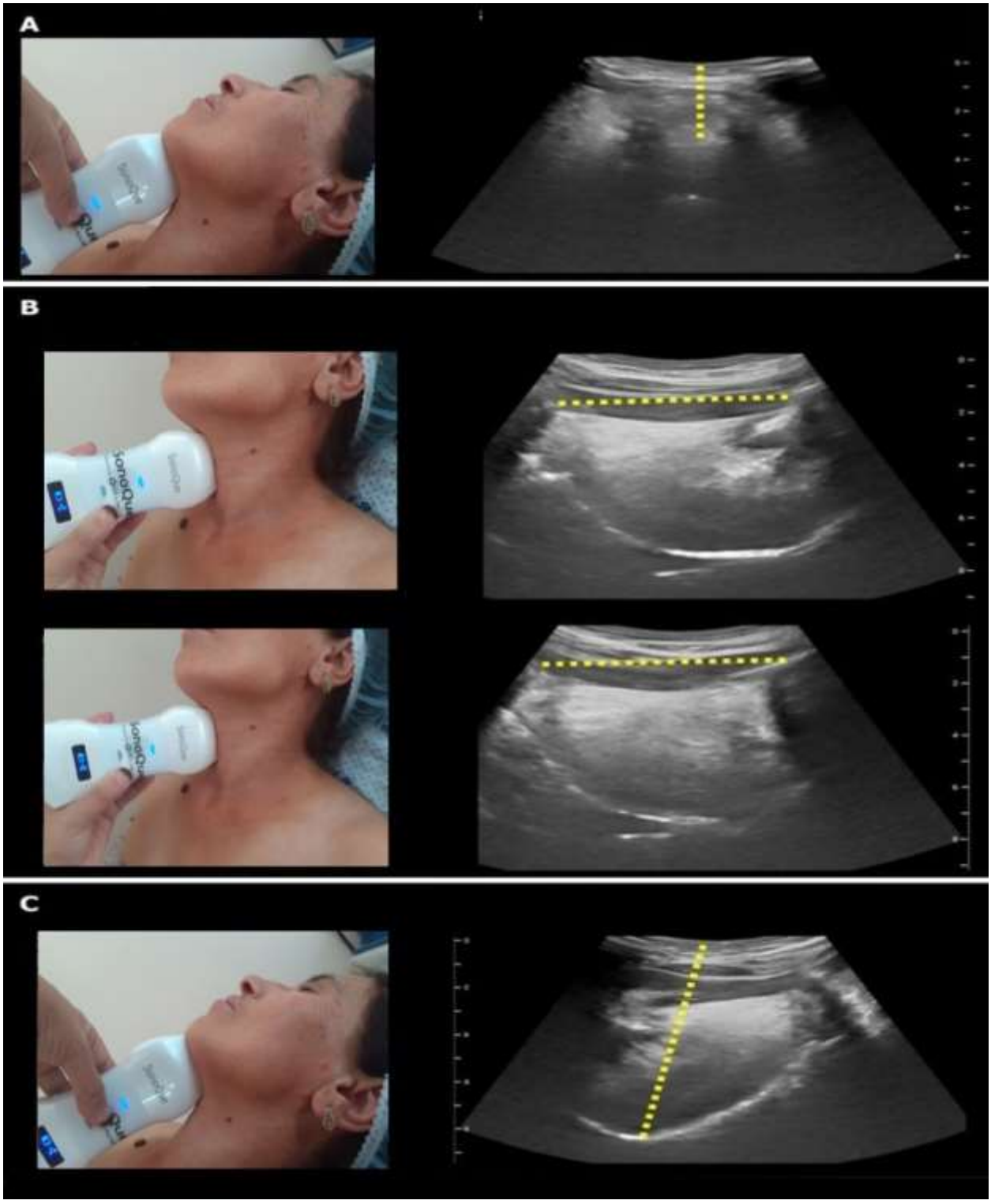

We present the ultrasonographic picture.

A moderate positive correlation was observed between the following studied parameters: **SED – skin-to-epiglottis distance** and **SHD – skin-to-hyoid distance;** SED – skin-to-epiglottis distance and **MMS – Modified Mallampati Score;** SHD – skin-to-hyoid distance and **MMS – Modified Mallampati Score; SACD – skin-to-**

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anterior commissure distance and MMS – Modified Mallampati Score; SACD – skin-to-anterior commissure distance and **NC – neck circumference; TMD – thyromental distance** and **IIG – interincisor gap;** TMD – thyromental distance and **SMD – sternomental distance.**

To analyze diagnostic accuracy, an **ROC curve** was constructed for each measured ultrasonographic parameter. The data are presented in **Table 3**.

Table 3. Area under the ROC curves (AUC)

Variable	AUC ± m (SE)	P-value	95% CI
SHD – Skin-to-Hyoid Distance	0.799 ± 0.052	<0.001	0.698–0.901
SED – Skin-to-Epiglottis Distance	0.975 ± 0.012	<0.001	0.951–1.0
SACD – Skin-to-Anterior Commissure Distance	0.999 ± 0.001	<0.001	0.997–1.0
TMD – Thyromental Distance	0.725 ± 0.054	<0.001	0.619–0.830
MMS – Modified Mallampati Score	0.800 ± 0.051	<0.001	0.700–0.899
SMD – Sternomental Distance	0.642 ± 0.012	<0.001	0.630–0.654
NC – Neck Circumference	0.589 ± 0.055	<0.001	0.534–0.634
ULBT – Upper Lip Bite Test	0.654 ± 0.012	<0.001	0.642–0.666
IIG – Interincisor Gap	0.598 ± 0.055	<0.001	0.543–0.613

Note: AUC – area under the ROC curve; ± SE – standard error; 95% CI – confidence interval; SHD – skin-to-hyoid distance; SED – skin-to-epiglottis distance; SACD – skin-to-anterior commissure distance; TMD – thyromental distance; MMS – Modified Mallampati Score; SMD – sternomental distance; NC – neck circumference; ULBT – upper lip bite test; IIG – interincisor gap.

Table 4. Optimal threshold values considering sensitivity and specificity for predicting difficult laryngoscopy

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Variable	Threshold Value	Sensitivity	Specificity
SHD – Skin-to-Hyoid Distance	.34	3%	2%
SED – Skin-to-Epiglottis Distance	.98	2%	9%
SACD – Skin-to-Anterior Commissure Distance	1 .68	00%	5%
TMD – Thyromental Distance	.59	7%	4%
MMS – Modified Mallampati Score		0%	2%

Sensitivity and specificity are indicated as percentages. Threshold values are given in centimeters, except for MMS (grade).

In our study, **TMD** showed an AUC > 0.7 with $p < 0.001$. Our result is consistent with studies by other authors predicting difficult intubation in patients without neck deformities [4]. The AUC value for **sternomental distance (SMD)** in our study was less than 0.7, making it a poor predictor of difficult laryngoscopy in this patient population. The AUC value for **interincisor gap (IIG)** was also <0.7. In some studies, this parameter is considered unreliable for predicting difficult laryngoscopy [6]. **Neck circumference (NC)** in our study was likewise a poor predictor of difficult laryngoscopy in this patient population.

We used the **upper lip bite test (ULBT)** as a screening test, but it proved useless as a screening test for difficult laryngoscopy in patients with post-burn contractures (AUC < 0.7). However, some studies [11] have shown that the ULBT is a more specific test for predicting difficult laryngoscopy and intubation [3].

The results of our study show that the thickness of the soft tissues of the anterior neck at the level of the hyoid bone, the thyrohyoid membrane, and the anterior commissure is greater in patients with scar contractures of the face, neck, and chest. The values of these three parameters (main group vs. control group) — hyoid: 1.30 cm ± 0.20 vs. 0.82 cm ± 0.13 cm; thyrohyoid membrane: 1.49 cm ± 0.11 vs. 1.14 cm ± 0.14; anterior commissure: 1.92 cm ± 0.15 vs. 1.43 cm ± 0.10 cm — may be of significant importance in diagnosing difficult tracheal intubation.

The optimal threshold values (sensitivity, specificity) for **Modified Mallampati Score**, **thyromental distance**, **skin-to-hyoid distance**, **skin-to-epiglottis distance**, and **skin-to-anterior commissure distance** for predicting

difficult laryngoscopy were **>2 grade (90%, 72%)**, **6.59 cm (87%, 54%)**, **1.68 cm (100%, 95%)**, **0.98 cm (92%, 69%)**, and **1.34 cm (93%, 82%)**, respectively.

From our results, only the **TMD (thyromental distance) index** showed an AUC > 0.7 with $p < 0.001$. This makes it the most suitable parameter for predicting difficult laryngoscopy in patients with scar contractures of the face, neck, and chest.

Conclusions:

Thus, the **Modified Mallampati test** is a good predictive test for diagnosing difficult airway management. However, in patients with severe anterior keloid scars of the face, neck, and chest, due to limited mouth opening and marked head flexion associated with contractures, this method lacks reliability. Therefore, it can be concluded that **ultrasonographic measurement of the soft tissue thickness at the hyoid bone, the thyrohyoid membrane, and the anterior commissure of the vocal cords** are good independent predictors of difficult laryngoscopy. Individual parameters showed limited reliability, but in combination with traditional screening tests, they improve the ability to predict difficult laryngoscopy.

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