EVALUATION OF DIAPHRAGMATIC ULTRASONOGRAPHY AS ONE OF THE CRITERIA OF DISCONTINUATION OF MECHANICAL VENTILATION

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Received: 4/11/2021
Accepted 1/12/2021

Online ISSN: 2735-3540

ABSTRACT:

Background: *Weaning process is a key element of mechanical ventilation, occupying up to 50% of its total duration. The diaphragm is the principal respiratory muscle, and its dysfunction predisposes to respiratory complications and can prolong the duration of mechanical ventilation.*

Aim of the Work: *to evaluate ultrasound derived measurements of diaphragmatic thickness as one of the criteria for discontinuation of mechanical ventilation.*

Patients and Methods: *The study was carried out on 60 intubated ventilated patients with various causes of respiratory failure who were on invasive mechanical ventilation. When planning for the weaning and extubation the patient was randomly allocated into one of the two groups: Control Group (C) upon which traditional criteria for weaning was used and Study Group (S) the same traditional criteria was used also and (Δ tdi%) ≥ 30% was used as a reference for extubation.*

Results: *There was non significant difference as regarding demographic variables, mortality, causes of mechanical ventilation and hemodynamics after extubation. However a significant difference between two groups was detected regarding reintubation with p value 0.0326. Also, there was a significant difference regarding days of mechanical ventilation with p value 0.001.*

Conclusion: *Ultrasound derived measurements of diaphragmatic thickness can be used as one of the criteria for discontinuation of mechanical ventilation but needs further wide scale studies.*

Key words: *Diaphragmatic ultrasonography, mechanical ventilation discontinuation,*

INTRODUCTION:

The optimal time to discontinue patients from mechanical ventilation is critical, as premature discontinuation may be followed by reinstitution of ventilator support in up to 25% of patients. On the other side, delayed weaning may be associated with ventilator-induced diaphragm atrophy[1].

In addition, unnecessary delays in weaning from mechanical ventilation can lead to deleterious Complications such as ventilator-associated pneumonia and ventilator induced diaphragm atrophy even with short periods of mechanical ventilation [2].

The respiratory muscle load-capacity imbalance (the common pathophysiology of weaning failure) can also contribute to extubation failure[3].

As spontaneous breathing trial (SBT) monitoring is insensitive to detect early signs of load-capacity imbalance. Several indices have been developed to assess the patient's ability to breathe spontaneously. Variables such as{minute ventilation, maximum inspiratory pressure, respiratory rate, rapid shallow breathing index (respiratory frequency/tidal volume), airway occlusion pressure 0.1 s, and a combined index named CROP (compliance, rate, O2, pressure index) have been used in common clinical practice, however these indices have done little to improve the timing of successful extubation (4)**.**

The diaphragm is considered the main muscle of respiration as it contributes approximately to 70% to tidal volume during inspiration in normal people. Thus it is not uncommon to report diaphragmatic dysfunction in patients with difficult weaning. Recently, diaphragmatic ultrasonography has been considered as a simple, non-invasive method for evaluation of diaphragmatic contractile activity either by assessment of diaphragm excursion or diaphragmatic thickness (5)**.**

Since diaphragmatic motion plays a prominent role in spontaneous respiration, observation of the diaphragm kinetics seems essential. The use of tools previously available for this purpose is limited due to the associated risks of ionizing radiation (fluoroscopy, computed tomography) or due to their complex and/or highly specialized nature, requiring a skilled operator (transdiaphragmatic pressure measurment, diaphragmatic electromyography, phrenic nerve stimulation, magnetic resonance imaging) (6)**.**

Bedside ultrasonography is a valuable tool in the intensive care unit. This is especially true where an adequate imaging technique is frequently limited by a variety of factors, including difficulty of patient transportation to the radiology department due to illness severity. Ultrasonography is a noninvasive technique, which has proved to be an accurate, safe, easy to use bedside modality, overcoming many of the standard limitations of imaging techniques (2).

AIM OF THE STUDY:

The aim of the study was to evaluate the diaphragmatic thickness fraction as a new parameter to assess the patient readiness for extubation.

PATIENTS AND METHODS:

After obtaining an informed consent and ethical approval, 60 patients who are admitted to the ICUs of Ain Shams University hospitals for any etiology, being mechanically ventilated and fulfilling the criteria for weaning are enrolled in the study.

Inclusion criteria:

Patients on mechanical ventilatory support who met the following criteria and consented were included in the study: 18-70 years old, Weaning Criteria Guide:, Evidence for reversal of the underlying cause for respiratory failure, adequate oxygenation; PaO_2/FiO_2 ratio $\geq$ 150, $Fi0_2 \leq$ 0.40, $Sp0_2 \geq$ 90%, $PaO_2 \geq$ 60 mmHg and PEEP $\leq$ 8 cmH20, PH $\geq$ 7.30, maximum inspiratory pressure < -20 to -30 cmH2O, Respiratory rate $\leq$ 35 breath/min, Heart rate $\leq$ 140 bpm, SBP 90 – 180 mmHg, Hemodynamic stability; no or minimal vasopressors or inotropes, Glasgow coma scale score $\geq$13 without sedation infusion or neuromuscular blocking agents, Body temperature from 36.5 to37.5 °C for 24 hour, Adequate hemoglobin $\geq$8 g/dl and/or no evidence of haemorrhage.

Exclusion Criteria:

Patients with history of diaphragmatic or neuromuscular disease, BMI > 40 or not meeting the weaning criteria above were excluded from the study.

All selected patients were subjected to the following: , History taking, Personal data: age, gender, Past history of chronic diseases; diabetes mellitus (DM), cardiac, pulmonary, neurological, renal and hepatic disease, Drug history, Habits: smoking, addiction, Clinical examination:, Complete physical examination on admission has been done with emphasis on: General and Chest examination, Vital sign (heart rate, respiratory rate, mean arterial blood pressure, temperature), Laboratory evaluation:, Arterial blood gases (on admission, before SBT), Routine investigation: (Complete blood count (CBC), Sodium (Na), Potassium (K), Urea, Creatinine, Liver enzymes, Coagulation profile).

Radiologically: X-Ray chest was done on admission and before weaning, This study was scheduled as Follows: Evidence for reversal of the underlying cause for respiratory failure, The weaning process was explained to the patient, Spontaneous Breathing Trial **was** done in all patients as follows:, Patients were placed on pressure support 5 cmH_2O and CPAP 5 cmH_2O, weaning process was continued for 120 minutes, The spontaneous breathing trial was considered successful when the patient succeeded to pass 120 minutes without the appearance of any of the following termination criteria:, Respiratory rate > 35 breath/min, Blood pressure changing as:, A drop of 20 mm Hg systolic or, A rise of 30 mm Hg systolic or, Systolic value > 180 mm Hg or, A change of 10mm Hg diastolic, Heart rate increasing > 20% or exceeds 140 bpm, New arrhythmias, Patient agitation or anxiety, $SpO_2 < 90\%$ with increasing $FiO_2 \geq 0.5$, Deterioration of arterial blood gas values eg, $PaO_2 \leq 60$mmHg, $PaCO_2 \leq 35$ mmHg, $PaCO_2 \geq 45$ mmHg, pH≤7.30, Any patient failed to pass 120 minutes of spontaneous breathing trial was excluded from the study, Patients were allocated so that the odd numbers represented the control group (C) and the even number represented the study group (S)

Control group (C):

Weaning using traditional parameters and follow up with endpoint failure or success of extubation.

Study group (S):

Weaning using traditional parameters plus diaphragmatic ultrasonography measurements taken just before extubation using tdi% more than 30% as a parameter of extubation with endpoint failure or success of extubation.

For the study group (S) Diaphragmatic thickness was measured on both sides during the spontaneous breathing trial and diaphragmatic thickness fraction was calculated as follow:

$$\frac{\text{Thickness at end inspiration} - \text{Thickness at end expiration}}{\text{Thickness at end expiration}} \times 100$$

Any patient with diaphragmatic thickness fraction less than 30% was excluded from the study, Extubation was done with supplementary oxygen $FiO_2 = 0.4$, Respiratory care after extubation in the semisitting position with supplementary oxygen $FiO_2 = 0.4$ by mask or nasal cannula according to patient preference and monitoring the vital data : heart rate, blood pressure, oxygen saturation and arterial blood gases, Following the vital data of the extubated patients for the following 48 hours and monitoring the success or failure of extubation, Successful weaning means 48 hours without reintubation, The primary outcome was the rate of reintubation in both groups and the secondary outcome was the clinical parameters of the patient after 2 hours of extubation.

Technical Aspects of Measuring Diaphragmatic Thickness:

- Mindray digital ultrasonic diagnostic imaging system, model DP- 20 used and real time movement of the diaphragm was recorded by B-mode using a 10 MHz linear transducer.
- Subjects were in the semisitting position with head elevated between 20° and 40°.
- The probe was placed between the 7th or 9th intercostal space in the mid axillary or anterior axillary line.
- The ultrasound beam was directed perpendicular to the diaphragm; i.e. the probe was positioned perpendicular to the chest wall in a long axis configuration with the left end cephalad. The probe position was adjusted until the diaphragm could be clearly visualized by B-mode.
- With using M-mode the diaphragm is identified as the last set of parallel lines on the image, corresponding to the pleural and peritoneal membranes overlying the less echogenic muscle.
- Once identified, real time movement of the diaphragm was recorded. Repeated measurements obtained in each subject were compared to assess intra-observer reproducibility.
- Measurements were made from the middle of the pleural line to the middle of the peritoneal line.
- End expiratory diaphragm thickness was measured in three consecutive respiratory cycles during the end expiratory pause, when the diaphragm is relaxed. And End inspiratory diaphragm thickness was measured in three consecutive respiratory cycles during the end inpiratory pause.
- Diaphragmatic thickness fraction was calculated as follow:

$$\frac{\text{Thickness at end inspiration} - \text{Thickness at end expiration}}{\text{Thickness at end expiration}} \times 100$$

- All subjects in which image acquisition failed were excluded from the study.

1- The statistical analysis was performed using a standard SPSS software package version 17 (Chicago, IL). Normally distributed numerical data were presented as mean ± SD and were compared using Student's *t*-test, Non-normally distributed numerical data were presented as median (IQR) and were compared using Mann-Whitney U-test. Categorical variables were analyzed using the χ^2 test, with p values <0.05 considered statistically significant.

2- Sample size calculation was by the following formula:

$$\frac{Z\ (P)^2 \times 1 - P}{0.0025} = 60$$

RESULTS:

Table (1): The main clinical demographic characteristics of the population enrolled in the study.

	Group (C) (n=30)	Group (S) (n=30)	p-value
Age (yr)	50.07± 14.77	52.9± 14.94	0.82
Height (m)	1.64± 0.089	1.6 ± 0.09	0.745
Weight (kg)	79.03 ± 9.8	80.82± 10.31	0.769
Gender (M, F)	18/12	16/4	0.795
Cause of ventilation			0.919
- Postoperative	7	6	
- Polytrauma	2	3	
- Stroke	3	5	
- Heart failure	5	5	
- Sepsis	10	7	
- COPD	3	4	

P>0.05 was considered statistically non-significant.
P<0.05 was considered statistically significant (*).

Regarding rate of reintubation there was significant decrease in the study group compared to the control group as 11 patients were reintubated in goup (C) and only 3 patients were reintubated in group (S) with p value 0.0326* (table 2).

Table (2): The rate of reintubation.

	Group C (n=30)	Group S (n=30)	P-value
Rate of reintubation	11 (36.67 %)	3 (10%)	0.0326*

P<0.05 was considered statistically significant (*).

Regarding days of mechanical ventilation there was decrease in the study group comparing to the control group with p value 0.001* (P< 0.05) as days of mechanical ventilation in group (C) was 6.93 ± 1.68 and group (S) was 5.33± 1.59 (table 3).

Table (3): Days of mechanical ventilation.

	Group (C) (n=30)	Group (S) (n=30)	p-value
Days of mechanical ventilation	6.93 ± 1.68	5.33± 1.59	0. 001*

P<0.05 was considered statistically significant (*).

Regarding mortality rate there was no significant difference between both groups as 4 patients died in group (C) and 3 patients in group (S) with p value 0.85 (table 4).

Table (4): Mortality rate.

	Group (C) (n=30)	Group (S) (n=30)	p-value
Mortality	2	1	0.5

Regarding respiratory mechanics just before extubation, there was no significant difference between both groups as for group (C) [MV (6.2 ± 1.8) L/min, RR (16.1 ± 3.2) and V_t (8.1 ± 1.3) ml/kg] and for group (S) [MV (6.4 ± 1.9) L/min, RR (15.2 ± 2.9) and V_t (7.8 ± 1.2) ml/kg] (table 5).

Table (5): Respiratory mechanics just before extubation.

	Group C (n=30)	Group S (n=30)	P-value
MV (L/min)	6.2 ± 1.8	6.4 ± 1.9	0.68
RR	16.1 ± 3.2	15.2 ± 2.9	0.26
Vt (ml/kg)	8.1 ± 1.3	7.8 ± 1.2	0.36

MV=Minute ventilation, RR = Respiratory rate, Vt = Tidal volume

Regarding clinical data two hours after extubation there was no significant difference between both groups as for group (C)[HR (85.5 ± 14.22)b/min, MABP (73.63± 13.07) and SpO2 (94.43 ± 2.89)%] and group (S))[HR (86.27 ± 12.49)b/min, MABP (75.73 ± 14.8) and SpO2 (94.1± 2.64)%] (table 6).

Table (6): Clinical data two hours after extubation.

	Group (C) (n=30)	Group (S) (n=30)	p-value
HR	85.5 ± 14.22	86.27 ± 12.49	0. 683
MABP	73.63± 13.07	75.73 ± 14.8	0.546
SpO2	94.43 ± 2.89	94.1± 2.64	0.643

P<0.05 was considered statistically significant (*).

Regarding arterial blood gases between both groups two hours after extubation, there was no significant difference between them (table 7).

Table (7): Arterial blood gases after 2 hours of extubation.

	Group c (n=30)	Group S (no=30)	p-value
PH	7.40 ± 0.02	7.39 ± 0.03	0.13
PO_2	90.1 ± 5.3	88.3 ± 6.2	0.23
PCO_2	43.6 ± 5.4	41.3 ± 6.1	0.13
HCO_3	23.1 ± 5.1	22.2 ± 3.1	0.41

DISCUSSION:

Ultrasonograghy has become an extension of the physical examination in clinical practice. This technology is increasingly used by intensive care physicians to assist in central line placement and other procedures. Ultrasound has been used since 1960s to evaluate diaphragm structure and function[7].

Recently, as technology has progressed and image resolution has improved markedly, B-mode sonography has become more readily available. Ultrasound is a simple, rapid, reproducible, and non-invasive test that can be repeated several times without radiation hazards or any risk for patients. B-mode sonography has been recently proposed as a non-invasive method of quantification of diaphragmatic contractile activity through measurement of diaphragmatic thickness or measuring the percentage variation of diaphragm thickness (tdi) between end-inspiration and end-expiration. This technique would be helpful to assess the contribution of the diaphragm to respiratory workload and to predict the extubation failure[2].

Weaning procedures are usually started only after the underlying disease process that necessitated mechanical ventilation has improved or is resolved. The patient should also have an adequate gas exchange, appropriate neurological and muscular status, and stable cardiovascular function. Weaning indices are objective criteria that are used to predict the readiness of patients to maintain spontaneous ventilation [8].

Some parameters based on respiratory mechanics, gas exchange, and breathing pattern have been proposed as predictors of weaning outcome that could guide clinicians in determining the optimal time to discontinue mechanical ventilation [1].

This study evaluated a new weaning index consisting in the diaphragm thickening fraction (tdi%) assessed by B- mode ultrasound and M-mode.

The purpose of this study is to evaluate ultrasound derived measurements of diaphragmatic thickness new parameter to assess the patient readiness for extubation.

As regards demographic profile, causes of ventilation there was no significant difference.

As for hemodynamic data (heart rate, mean arterial blood pressure and oxygen saturation oximetry) there was no significant value between both study groups.

The main finding of this study was decreased days of mechanical ventilation, reintubation rate and mortality rates in study group compared to control group.

Lee and colleagues[9] studied 31 pediatric patients and ultrasound assessments were performed, immediately after intubation, the initial diaphragm thickness and (tdi%) were measured to be 1.94 ± 0.44 mm and 25.85% ± 3.29%, respectively, in the first 24 hours of mechanical ventilation.

They conclude that diaphragm thickness and the (tdi%) decreased substantially and decreased gradually thereafter.

After extubation, the (tdi%) was significantly higher in the successful compared to failed extubation groups, and a (tdi%) value of <17% was associated with extubation failure.

This is consistent with the current results as regards the importance of measurement of diaphragmatic thickness difference as a weaning predictor although there is difference between the tdi% in the current study which is >30%. This may be due to type and number of patients as Lee studied 31 pediatric patients.

Ferrari and colleagues [10] studied Forty-six patients, all of them were ventilated in pressure support through a tracheostomy tube. They underwent a spontaneous breathing trial (SBT) when they met all the following criteria: $FiO_2 < 0.5$, PEEP ≤5 cmH_2O, $PaO_2/FiO_2 > 200$, respiratory rate <30 breaths per minute, absence of fever, alert and cooperative, and hemodynamic stability without vasoactive therapy support.

During the trial, the right hemi-diaphragm was visualized in the zone of apposition using a 10-MHz linear ultrasound probe. The patient was then instructed to perform breathing to total lung capacity (TLC) and then exhaling to residual volume (RV).

Diaphragm thickness was recorded at TLC and RV, and the Diaphragm thickness fraction was calculated as percentage from the following formula:

Thickness at end inspiration − Thickness at end expiration / Thickness at end expiration. Also, the rapid shallow breathing index (RSBI) was calculated.

Weaning failure was defined as the inability to maintain spontaneous breathing for at least 48 hours, without any form of ventilatory support.

A significant difference between diaphragm thickness at TLC and RV was observed both in patients who succeeded SBT and patients who failed. Diaphragm Thickness fraction was significantly different between patients who failed and patients who succeeded SBT.

A cutoff value of a Diaphragm Thickness fraction >36% was associated with a successful spontaneous breathing trial.

This study concluded that using ultrasound Diaphragm Thickness fraction with cut off value 36% was predictive for discontinuation of mechanical ventilation in tracheostomised patients.

This may be due to the type and number of patients as they studied tracheostomised patients after difficult weaning from mechanical ventilation.

The results of the current study also agree with *DiNino and colleagues* [11] who studied Sixty-three mechanically ventilated patients in 2013 to test if ultrasound measurements of diaphragm muscle thickening during inspiration can predict extubation success or failure. Diaphragm thickness (tdi) was measured in the zone of apposition of the diaphragm to the rib cage using a 7–10 MHz ultrasound transducer.

The percent change in tdi between end-expiration and end-inspiration (Δtdi%) was calculated during either spontaneous breathing or pressure support weaning trials. A successful extubation was defined as spontaneous Breathing for more than 48 hours following endotracheal tube removal.

The study found that 27 patients were weaned with spontaneous breathing and 36 were weaned with pressure support ventilation. The combined sensitivity and specificity of Δtdi% ≥30% for extubation success was 88% and 71%, respectively.

The positive predictive value and negative predictive value were 91% and 63% respectively. The study concluded that ultrasound measures of diaphragm muscle thickening may predict extubation success or failure with Pressure support and spontaneous breathing.

The current results were also in accordance with the prospective study carried out by ***Farghaly and Hasan*** **[12]** on fifty four mechanically ventilated patients in respiratory ICU of Assiut University Hospital assessed by ultrasound during spontaneous breathing trial evaluating diaphragmatic excursion, diaphragmatic thickness (tdi) at end inspiration, at end expiration and diaphragmatic thickness fraction. Simultaneously traditional weaning parameters were recorded. Patients were followed up for 48 hours after extubation.

The study found that Diaphragmatic excursion, tdi at end inspiration, at end expiration and diaphragm thickness fraction were significantly higher in the successful group compared to those who failed extubation.

Cutoff values of diaphragmatic measures associated with successful extubation were ≥10.5 mm for diaphragmatic excursion, ≥21 mm for tdi at end inspiration, ≥10.5 mm for Tdi at end expiration, ≥34.2% for diaphragm thickness fraction giving 87.5%, 77.5%, 80% and 90% sensitivity respectively and 71.5%, 86.6%, 50% and 64.3% specificity respectively.

Combining diaphragmatic excursion ≥10.5 mm and tdi at end inspiration ≥21 mm decreased sensitivity to 64.9% but increased specificity to 100%. Rapid shallow breathing index (RSBI) <105 had 90% sensitivity but 18.7% specificity.

The study concluded that Ultrasound evaluation of diaphragmatic excursion and thickness at end inspiration could be a good predictor of extubation outcome in patients who passed spontaneous breathing trials.

Agmy and colleagues[13] in Assiut University Hospital studied 78 patients with COPD exacerbation. All patients were ventilated with pressure support through endotracheal tube. During spontaneous breathing trial (SBT), the right diaphragm was visualized in the zone of apposition using a 7.5 MHz linear ultrasound probe.

Diaphragm Thickness was calculated as percentage from the following formula:

Thickness at end inspiration − Thickness at end expiration / Thickness at end expiration.

It was recorded at total lung capacity (TLC) and residual volume (RV). The rapid shallow breathing index (RSBI) was calculated. Weaning failure was defined as the inability to maintain spontaneous breathing for at least 48 hours, without any form of ventilatory support.

A significant difference between diaphragm thickness at TLC and RV was observed both in patients who succeeded SBT and patients who failed. Diaphragm thickness was significantly different between patients who failed and patients who succeeded SBT.

A cutoff value of a Diaphragm Thickness fraction >40% was associated with a successful SBT with a sensitivity of 88%, a specificity of 92%, a positive predictive value (PPV) of 95%, and a negative predictive value (NPV) of 82%.

On the other hand, RSBI <105 had a sensitivity of 95%, a specificity of 90%, a PPV of 96%, and a NPV of 92% for determining SBT success.

This study agrees with the current study that using ultrasound is an excellent predictor of weaning outcome in COPD patients undergoing mechanical ventilation.

Osman and Hisham **[14]** also assessed whether the diaphragmatic and lung ultrasound can be used as additive new parameters for weaning process in intensive care units (ICU) patients in comparison to the traditional weaning parameters.

They studied 68 patients admitted in different ICU Units in Ain Shams University for different causes mainly post major surgeries. All patients met the traditional criteria for weaning, had diaphragmatic and lung ultrasound after extubation.

They measured the diaphragmatic excursion, diaphragmatic thickening fraction as well as the degree of lung aeration.

They compared the ultrasound results with the clinical data and concluded that 50 patients showed successful weaning process. Diaphragmatic excursion and diaphragm thickness fraction showed high sensitivity and specificity in correlation with the other parameters.

The cut off value was 10 mm for the excursion and 28% for the diaphragm thickness fraction and 12 for the lung ultrasound score. A score was put to predict the outcome of weaning process.

They concluded that lung aeration ultrasound and diaphragmatic ultrasonography can be used together in weaning process. This also confirm the result of the current study.

Conclusion

The study shows that diaphragmatic thickness fraction >30% measured by ultrasound can be used as a parameter for extubation with a good predictive value for less days of mechanical ventilation and rate of reintubation.

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تقييم استخدام الموجات فوق الصوتية على الحجاب الحاجز كإحدي معايير الفطام من جهاز التنفس الصناعي

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نبذة مختصرة

الخلفية: تعتبر عملية الفطام من جهاز التنفس الصناعي عنصرًا أساسيًا ، حيث تشغل ما يصل إلى ٥٠٪ من إجمالي مدة التنفس الصناعي. و تعتبر عضلة الحجاب الحاجز هي العضلة الرئيسية في عملية التنفس، و قد يؤدي ضعفها لاطالة مدة التنفس الصناعي و مزيد من المضاعفات.

الهدف من العمل: تقييم القياسات المشتق من جهاز الموجات فوق الصوتية لسمك الحجاب الحاجز كأحد معايير فصل جهاز التنفس الصناعي.

المرضى والطرق: أجريت الدراسة على ٦٠ مريضا علي جهاز التنفس الصناعي بسبب أسباب مختلفة من فشل الجهاز التنفسي عند التجهيز للفطام من جهاز التنفس الصناعي وفصل الأنبوبة الحنجرية ، تم توزيع المريضي بشكل عشوائي في احدي المجموعتين: المجموعة الضابطة (C) التي استخدمت عليها المعايير التقليدية للفطام مجموعة البحث (S)استخدمت نفس المعايير التقليدية أيضًا بجانب القياسات المشتقة من سمك الحاجاب الحاجز عند الانقباض و الانبساط و تم استخدام ٣٠ ٪ كمرجع لنزع الأنبوبة الحنجرية.

النتائج: لم يكن هناك فرق كبير فيما يتعلق بالمتغيرات الديموغرافية والوفيات وأسباب التنفس الصناعي و العلامات الحيوية بعد نزع الأنبوب. ومع ذلك تم اكتشاف فرق كبير بين مجموعتين فيما يتعلق اعادة تركيب الانبوبة الحنجرية مع قيمة .p 0.0326 أيضا ، كان هناك اختلاف كبير فيما يتعلق بأيام التهوية الميكانيكية بقيمة .p 0.001

الاستنتاج: يمكن استخدام القياسات المشتقة بالموجات فوق الصوتية للسمك الغشائي كأحد معايير إيقاف التهوية الميكانيكية ولكنها تحتاج إلى مزيد من الدراسات واسعة النطاق.

الكلمات الرئيسية: التصوير بالموجات فوق الصوتية علي الحجاب الحاجز ، فصل جهاز التنفس الصناعي