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INTEGRATED USE OF BEDSIDE LUNG ULTRASOUND AND ECHOCARDIOGRAPHY AS AIDING PREDICTORS IN SUCCESSFUL WEANING PROCESS

By

Ahmed Mohamed Abdalla Beshir, Ismael Abd El-Menem Attia, Mahmoud El-Saeed Ahmed, Ebrahim Faragallah Saeed*

Departments of Chest disease and Cardiology*, Faculty of Medicine, Al-Azhar University

Corresponding authors: Ahmed Mohamed Abdalla Beshir,

Mobile: +201288845932**, E-mail:** ahmedbeshir.6@azhar.edu.eg

ABSTRACT

Background: We hypothesized that bedside lung ultrasound (LUS) and echocardiography could be a predictor of postextubation distress by detecting a high lung aeration defect immediately before weaning by evidencing significant lung derecruitment during the spontaneous breathing trial (SBT).

Objective: To evaluate the effectiveness of Lung Ultrasound (LUS) and Transthoracic Echocardiography (TTE) in predicting successful weaning of mechanically ventilated patients.

Patients and Methods: This study was performed on 50 mechanically ventilated patients in general and respiratory ICU during the period from August 2019 to January 2021, at Bab-Al-Sha'reia University Hospital. Lung ultrasound and echocardiography were determined before and at the end of a 60-min spontaneous breathing trial (SBT) and 4 hrs. after extubation. To quantify lung aeration, a lung ultrasound score was calculated.

Results: Forty-five patients had SBT success (90%) and 5 patients experienced SBT failure (10%), From those patients with SBT success, there were 16 patients (35.56%) had post extubation distress, and 29 patients (64.44%) had post extubation success. In patients who successfully passed the SBT, a lung ultrasound score ≤10 at the end of the SBT was highly predictive of postextubation success with a statistically significant difference (p value < 0.001). On the other hand, lung ultrasound score ≥18 at the end of the SBT was highly predictive of postextubation distress with a statistically significant difference (p value < 0.001). We found significant differences in E/A ratio 1.08 ± 0.2 in patients with spontaneous breathing trial success, and 1.6 ± 0.1 in patients with SBT failure with a statistical significant (p-value < 0.001).

Conclusion: LUS and TTE during spontaneous breathing trial may accurately predict postextubation distress.

Key Words: Lung ultrasound, diastolic dysfunction, mechanical ventilation, postextubation distress, reintubation, weaning.

INTRODUCTION

Unnecessary extubation delays can increase the morbidity and mortality associated with prolonged ventilation. Nevertheless, trying to decide when to extubate patients from mechanical ventilation can be challenging for the clinician and has been reported by some to be more art than science *(Peouelas et al., 2011)*.

Most proposed predictors of postextubation distress either require special equip-ment are too complex for bedside use, or have a limited predictive value *(Nemer et al., 2011).*

There are no simple clinical indices known to be powerful predictors of postextubation distress. Many mechanisms whose relative weights vary from one patient to another may have an impact on the ability to wean from me¬chanical ventilation *(Heunks and van der Hoeven, 2010).*

Lung ultrasound (LUS) could be a predictor of postextubation distress by detecting a high lung aeration defect im¬mediately before weaning and/or by evidencing significant lung derecruitment during the SBT *(Boles et al., 2011).*

Cardiac dysfunction is another leading cause of weaning failure. The abrupt cessation of positive pressure ventilation increases venous return and left ventricular (LV) afterload, decreases LV compliance, and may even induce cardiac ischemia. All these factors tend to increase LV filling pressure, and may subsequently result in cardiogenic pulmonary edema *(Girard et al., 2017).*

The aim of this work was to evaluate the effectiveness of LUS and TTE in predicting successful weaning of mechanically ventilated patients.

PATIENTS AND METHODS

Study design: This was a prospective study for evaluation the use of (LUS) and (TTE) in predicting successful weaning of mechanically ventilated patients. It was performed on 50 mechanically ventilated patients in general and respiratory ICU during the period from August 2019 to January 2021, at Bab-Al-Sha'reia University Hospital.

Data collection:

1. Data were collected from these patients: Demographic data, clinical diagnosis, days of admission, cause of mechanical ventilation, days of mechanical ventilation, underlying cardiac and pulmonary diseases, and Simplified Acute Physiology Score (SAPS II).
2. LUS scoring to detect lung aeration defect before and at the end of a 60-min spontaneous breathing trial and 4 hrs. after extubation **(Table 1)**.

Table (1): Lung US score for detection of the degree of lung aeration

Points for each lung zone (12 zones)	Degree of lung aeration	Pattern
0 point	Normal aeration	Horizontal A-line (no more than two B-line)
1 point	Moderate loss of aeration	Multiple B-line either regularly spaced or irregularly spaced
2 points	Severe loss of aeration	Multiple coalescent B-lines
3 points	Complete loss of aeration	Lung consolidation
Total score	From 0 to 3	

3. TTE at the end of a 60-min spontaneous breathing trial for assessment of fractional area changes, peak velocity of early and late mitral flow, ratio between early and late mitral flow, and deceleration time of velocity of early mitral flow.

Inclusion criteria: Patients mechanically ventilated for more than 48 hrs. when the underlying respiratory disease that has required intubation was considered by the attending physician as reversed, rendering the patient eligible to1-hr SBT.

Exclusion criteria: Patients aged <18 yrs., patients with tracheostomy, Paraplegia with medullar level above T8, significant cardiac arrhythmias and severe ICU-acquired neuromyopathy.

Statistical analysis: Data were analyzed using Statistical package for the Social Sciences (SPSS) version 15.0. Quantitative data were expressed as mean ± standard deviation (SD) and were compared by independent t-test. Qualitative data were expressed as frequency and percentage and were compared by Chi square test.

RESULTS

As regard spontaneous breathing trial, there were success in 45 patients (90%) and failure in 5 patients (10%). As regard post extubation distress/success, there were distress in 16 patients (35.5%) and success in 29 patients (64.4%) **(Table 2)**.

Table (2): Description of spontaneous breathing trial and post extubation distress/success in all studied patients

		Studied patients (N = 50)	
Spontaneous breathing trial	**Success**	45	90%
	Failure	5	10%
Post extubation	**Distress**	16	35.56%
	Success	29	64.44%

No statistical significant difference of diagnosis, MV causes and associated diseases as regard spontaneous breathing trial. Statistically significant difference of simplified acute physiologic score II, duration of MV, ICU stay and ICU mortality were as regard spontaneous breathing trial **(Table 3)**.

Table (3): Comparison of clinical data as regard spontaneous breathing trial

Parameters \ Spontaneous breathing trial		Success (n = 45)		Failure (n = 5)		P-value
Diagnosis	**Medical**	32	71.1%	3	60%	0.607
	Surgical	13	28.9%	2	40%	
MV causes	**Respiratory failure**	14	31.1%	1	20%	0.946
	Multiple trauma	8	17.8%	1	20%	
	Non-traumatic coma	2	4.4%	0	0%	
	Severe hemodynamic instability	16	35.6%	2	40%	
	Post-operative complication of abdominal surgery	5	11.1%	1	20%	
Associated diseases	**None**	6	13.3%	0	0%	0.665
	Pulmonary disease	21	46.7%	3	60%	
	Cardiovascular disease	14	31.1%	1	20%	
	Cardiovascular disease and pulmonary disease	4	8.9%	1	20%	
Simplified Acute Physiologic Score II	**Mean ±SD**	49.9 ± 12.5		66.8 ± 14.7		**0.013***
Duration of MV (days)	**Mean ±SD**	5.2 ± 1.4		7.4 ± 0.9		**0.002***
ICU stay (days)	**Mean ±SD**	11.6 ± 5.5		19.8 ± 3.03		**0.004***
ICU mortality	**No**	41	91.1%	3	60%	**0.042**
	Yes	4	8.9%	2	40%	

*: Mann Whitney U test.

There was a statistical significant difference of LUS (before SBT, End of SBT & H4 post-extubation) as regard post-extubation success/distress **(Table 4)**.

Table (4): Comparison of LUS as regard post-extubation success/distress.

Parameters \ Post-extubation		Distress (n = 16)	Success (n = 29)	P-value
LUS before SBT	**Mean ±SD**	15.3 ± 1.4	9.8 ± 2.5	**< 0.001***
LUS end of SBT	**Mean ±SD**	18.3 ± 1.1	9.8 ± 2.5	**< 0.001***
LUS H4 post-extubation	**Mean ±SD**	20.3 ± 5.4	10.4 ± 2.8	**< 0.001***

*: Mann Whitney U test.

No statistical significant difference of fractional area change (%), peak velocity of late mitral flow, and deceleration time of velocity of early mitral flow as regard spontaneous breathing trial. Statistical significant difference of peak velocity was of early mitral flow and ratio between early and late mitral flow as regard spontaneous breathing trial **(Table 5)**.

Table (5): Comparison of ECHO as regard spontaneous breathing trial

Parameters \ Spontaneous breathing trial		Success (n = 45)	Failure (n = 5)	P-value
Fractional area change (%)	**Mean ±SD**	45.5 ± 4.3	48.6 ± 4.5	0.141
Peak velocity of early mitral flow (m/sec)	**Mean ±SD**	0.79 ± 0.08	1.06 ± 0.08	**< 0.001**
Peak velocity of late mitral flow (m/sec)	**Mean ±SD**	0.73 ± 0.11	0.68 ± 0.08	0.309
Ratio between early and late mitral flow	**Mean ±SD**	1.08 ± 0.2	1.6 ± 0.1	**< 0.001**
Deceleration time of velocity of early mitral flow (msec)	**Mean ±SD**	169.7 ± 21.3	181.2 ± 39	

DISCUSSION

Unnecessary extubation delays can increase the morbidity and mortality associated with prolonged ventilation. Nevertheless, trying to decide when to extubate patients from mechanical ventilation can be challenging for the clinician and has been reported by some to be more art than science *(Peouelas et al., 2011).*

As regard simplified acute physiologic score II (SAPSII) in our study the mean of SAPSII in patients with spontaneous breathing trial success and in patients with Spontaneous breathing trial failure showed a statistical significant difference. On the other hand the mean of SAPSII in patients with post extubation distress and in patients with post extubation success it showed a statistical significant difference. In contrary to our result, *Soummer et al. (2012)* and *Sliva et al. (2017)* found that SAPS II has no statistical significance in predicting weaning failure.

Despite elevated SAPS II at admission, ICU-mortality rate was low (12%) in agreement with *Soummer et al. (2012)* with mortality (8%) and *Sliva et al. (2017)* with mortality (10%). The fact that the

SAPS II score on admission was not associated with death may be explained by the significant proportion of patients that died before any weaning attempt was made. Thus, the power of the SAPS II score to predict death as associated with the weaning categories may have been weakened by the loss of the most severely ill patients.

The mean length of stay in ICU was significantly prolonged in patient with post extubation distress. This coincided with a recent retrospective study of *Chung et al. (2020)* who established a model for predicting extubation based on the predictive factors of successful extubation. This result could be attributed to the more severity and more associated comorbidities of those patients with prolonged ICU stay.

As regard the mean duration of MV, patients with post extubation distress and patients with post extubation success showed a statistically significant difference. This finding matches with those of *Abdel Rahman et al. (2020)* who showed that prolonged mechanical ventilation of critically ill patients is associated with higher rates of mortality and morbidity.

These results show that the means of SAPS II, length of ICU stay and duration of MV have great effect on weaning process and considered critical causes of post extubation distress.

Among patients who successfully pass SBT, the derecruitment was greater in patients who developed postextubation distress than in those who were definitively weaned. *Ferré et al. (2019)* concluded a similar observation in their study which included 42 patients and aimed at detecting weaning-induced pulmonary edema (WIPO) using lung ultrasound.

In patients who successfully passed the SBT, a lung ultrasound score ≤10 at the end of the SBT was highly predictive of postextubation success with a statistically significant difference. On the other hand, lung ultrasound score ≥18 at the end of the SBT was highly predictive of postextubation distress with a statistically significant difference. Similarly, *Soummer et al. (2012)* reported that LUS score less than 13 was associated with extubation success, while LUS score more than 17 was associated with extubation failure (EF) in ventilated adults.

On MV, before the SBT, we found significant differences in E/A ratio in patients with spontaneous breathing trial success and in patients with spontaneous breathing trial failure with a statistical significant. There was in agreement with *Ait-Oufella et al. (2012)* in the study of patients undergoing a spontaneous breathing trial on a T-tube to assess the cardiac consequences of successful respiratory weaning using the variations of circulating B-type and atrial natriuretic peptides (BNP, ANP) and Doppler mitral flow.

CONCLUSION

The use of transthoracic ultrasound aimed at assessing lung aeration changes during SBT, a new, easy-to-perform, and noninvasive measurement, may contribute to reducing the occurrence rate of postextubation distress, a clinical condition associated with increased morbidity and mortality. Assessment of Lung aeration and LV diastolic function before attempting a weaning process

could be useful in the detection of patients likely to fail weaning.

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الاستخدام التكاملى للموجات فوق الصوتية السريرية على الرئة و تخطيط صدى القلب كمتنبئات مساعدة لعملية الفطام الناجحة

أحمد محمد عبدالله محمد بشير، إسماعيل عبدالمنعم عطية، محمود السعيد أحمد، ابراهيم فرج الله سعيد

قسم الأمراض الصدرية و قسم القلب والأوعية الدموية، كلية الطب، جامعة الأزهر، القاهرة

E-mail: ahmedbeshir.6@azhar.edu.eg

خلفيـــة البحـــث: يمكـــن أن تكـــون الموجـــات فـــوق الصـــوتية للرئـــة الســـريرية وتخطـــيط صـــدى القلـــب مؤشـــرا علـــى ضـــائقة مـــا بعـــد ازالـــة الانبوبـــة الحنجريـــة عـــن طريـــق الكشـــف عـــن عيـــب شـــديد فـــي تهويـــة الرئـــة علـــى الفـــور قبـــل الفطـــام عـــن طريـــق إثبـــات عـــدم تجنيـــد الرئة بشكل كبير أثناء تجربة التنفس التلقائي.

الهـــدف مـــن البحـــث: تقيـــيم فعاليـــة الموجـــات فـــوق الصـــوتية للرئـــة وتخطـــيط صـــدى القلـــب عبر الصدر في التنبؤ بالفطام الناجح للمرضى الذين يخضعون للتهوية الميكانيكية.

المرضـــى و طـــرق البحـــث: أجريـــت هـــذه الدراســـة علـــى 50 مريضـــاً خضـــعوا للتهويـــة الميكانيكيـــة بوحـــدة الرعايـــة العامـــة و وحـــدة العنايـــة المركـــزة التنفســـية خـــلال الفتـــرة مـــن أغســـطس 2019 إلـــى ينـــاير 2021 فـــي مستشـــفى بـــاب الشـــعرية الجـــامعى. وقـــد تـــم عمـــل الموجـــات فـــوق الصـــوتية للرئـــة وتخطـــيط صـــدى القلـــب قبـــل وفـــي نهايـــة تجربـــة التـــنفس التلقـــائي لمـــدة 60 دقيقـــة و 4 ســـاعات بعـــد نـــزع الأنبوبـــة الحنجريـــة لقيـــاس تهويـــة الرئـــة، و تم حساب درجة الموجات فوق الصوتية للرئة.

نتـــائج البحـــث: حقـــق 45 مريضًـــا نجاحًـــا فـــي تجربـــة التـــنفس التلقـــائي (90٪) فيمـــا عـــانى 5 مرضـــى مـــن فشـــل تجربـــة التـــنفس التلقـــائي (10٪)، ومـــن هـــؤلاء المرضـــى الـــذين نجحـــوا فـــي تجربـــة التـــنفس التلقـــائي كـــان هنـــاك 16 مريضًـــا (35.56٪) يعـــانون مـــن ضـــائقة مـــا بعـــد نـــزع الأنبـــوب، بينمـــا حقـــق 29 مريضًـــا (64.44٪) نجاحًـــا بعـــد نـــزع الأنبـــوب. وفـــي المرضـــى الـــذين اجتـــازوا اختبـــار تجربـــة التـــنفس التلقـــائي بنجـــاح، كانـــت نتيجـــة الموجـــات فـــوق الصـــوتية للرئـــة ≤10 فـــي نهايـــة اختبـــار تجربـــة التـــنفس التلقـــائي

متنبئًا بدرجة عالية بنجاح العملية مع وجود فرق إحصائى (p <0.001). من ناحية أخرى، كانت درجة الموجات فوق الصوتية للرئة ≤18 في نهاية تجربة التنفس التلقائي تنبؤية للغاية لضائقة ما بعد الأنبوب مع وجود فرق إحصائيًا (p<0.001). وقد وجدنا فروقًا ذات دلالة إحصائية في نسبة E/A 1.08±0.2 في المرضى الذين نجحوا في تجربة التنفس التلقائي و 1.6 ±0.1 في المرضى الذين يعانون من فشل تجربة التنفس التلقائي مع قيمة ذات دلالة إحصائية (P<0.001).

الاستنتاج: قد تتنبئ الموجات فوق الصوتية للرئة وتخطيط صدى القلب عبر الصدر أثناء تجربة التنفس التلقائي لحدوث ضائقة ما بعد ازالة الأنبوبة الحنجرية.

الكلمات الدالة: الموجات فوق الصوتية للرئة، قصور القلب الإنبساطى، التهوية الميكانيكية، الفطام.