

Association of Diaphragmatic Thickness and Peripheral Muscle Thickness Using Ultrasonography in Extubation Outcome

Dr Smriti Khari¹, Dr Ved Prakash², Dr Pulkit Gupta³,
Dr Ravi Kant Pandey⁴, Dr Shubham Tiwari⁵

^{1,3,4,5}Senior Resident, Department of Pulmonary and Critical Care Medicine,
King George Medical University, Lucknow

²Professor, Department of Pulmonary and Critical Care Medicine,
King George Medical University, Lucknow

Abstract

Introduction

Patients in ICU who are critically sick require basic life support in the form of mechanical ventilator. Ventilator associated complications are common in them. Prediction of ICU acquired weakness can prevent extubation failure, decrease in hospital mortality and increase ICU free day. Thereby decreasing financial burden. Both central and peripheral muscle thickness play a role in predicting extubation success.

Aim/Objective: Aim is to measure muscle strength of diaphragm and quadriceps muscle using ultrasonography and to find if central and peripheral muscle strength can be used as a predictor for patients' extubation outcome.

Study design: Prospective cross sectional single centered observational study.

Place and duration of the study: The study was carried out in PCCM department of KGMU from January 2023 to October 2023.

Methodology: Diaphragm excursion, diaphragm thickness at inspiration and expiration was measured using ultrasonography on right side at 8th and 9th intercostal space between anterior and mid axillary lines. Quadriceps thickness was also measured at mid point between the anterior superior Iliac spine to patella and was compared with the outcome of the intubated patient.

Results: Out of 42 patients 52% were male (n=22) and 48% were female (n=20). The study showed that the diaphragmatic excursion (p value <0.001) and diaphragmatic thickness at inspiration (p value 0.007) was significant in predicting outcome of the patient from mechanical ventilator but quadriceps thickness had no significance (p value 0.012). The excursion of the patient <7, 7-11 and >11 has extubation success of 0%, 46.2% and 53.8% respectively. The diaphragmatic inspiration thickness of <1.65, 1.65 - 3.7 >3.7 has successful weaning of 0%, 100% and 0% respectively.

Conclusion: Diaphragm excursion plays a strong role in predicting the success of extubation and preventing ICU acquired weakness. The study reflects the role of diaphragmatic thickness in better outcomes. Quadriceps muscle couldn't be related much with weaning and extubation.

Keywords: Mechanical ventilator, diaphragm muscle thickness, quadriceps muscle thickness, ultrasound, icu acquired weakness, extubation, weaning.

INTRODUCTION

Patients in icu who are critically sick require basic life support in form of mechanical ventilator. Intubation both nasal and oral and tracheostomy are required to support life in patients with MODS, CVA, Transplantation, cardiopulmonary arrest and many more.

For time being patient life can be prolonged temporarily using them but as a result many complications like VAP, VTE, DVT, sepsis, tracheal stenosis and muscle weakness (most common) etc can occur. Muscle weakness both central and peripheral tend to occur formerly known as Icu Acquired weakness. If the patient's condition improves, he / she should be tried for weaning in order to prevent extubation failure and decrease mortality. Critical care Physicians or icu intensivists should focus on the optimal time on tapering patient from mechanical ventilator via spontaneous breathing trial.

Even if the patients could smoothly wean from the ventilator and be transferred out of the ICU, 1/3rd of them would still face severe dysfunction, and 1/4th of them would have reduced mobility^{1,2}. Few data are available on whether muscle weakness, a complication of patients in the ICU, is correlated with the prognosis of subsequent functional activities.

ICU-acquired weakness can lead to extubation failure or prolonged / delayed weaning as proposed by many studies. Evaluating the association of diaphragmatic muscle and quadriceps muscle thickness role in extubation outcome remained limited.

Therefore, in this study preliminarily explored whether diaphragmatic thickness excursion and quadriceps thickness affect extubation outcomes and prognosis.

Our study aimed to measure the diaphragmatic and quadriceps muscles.

It will be a rapid and non-invasive measurement approach for the evaluation of timely extubation.

Aims and objectives

Diaphragmatic muscle excursion, thickness and peripheral muscle thickness in extubation outcome from mechanical ventilator.

Material & Methods

This study will be an observational prospective study to be carried in pccm icu Stabdi building of KGMU in 2023.

The sample size will be taken according to formula

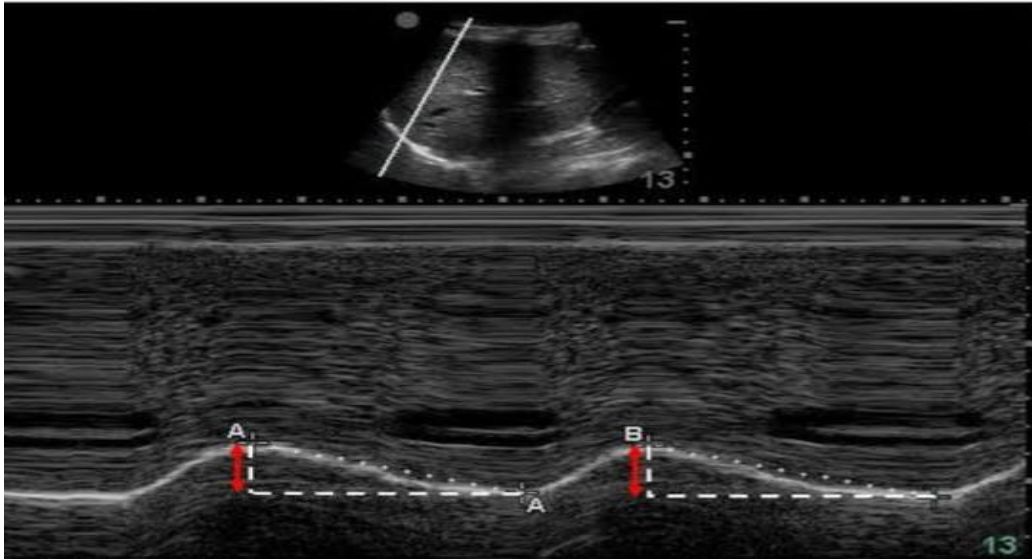
$$n = Z^2 P(1-P) / d^2 = 42$$

Following test will be performed

Measuring diaphragmatic thickness and diameter using ultrasonography

The excursions of the two hemidiaphragms can be measured using two-dimensional or M-mode ultrasonography. Visualization of the diaphragm is achieved by placing the transducer perpendicularly to the chest wall (at the 8th/9th intercostal space, between the anterior and mid axillary lines) to observe the zone of apposition of the muscle 0.5–2 cm below the cost phrenic sinus using M mode using curvilinear probe 2.5–5.0 Hz.

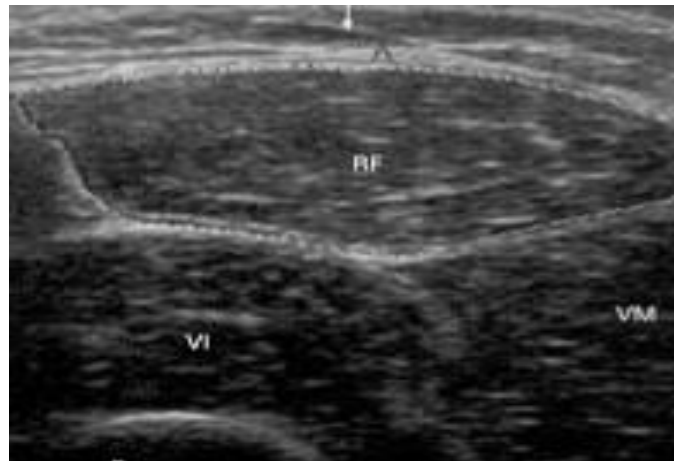
Diaphragm muscle thickness using linear probe 7.5–10.0 Hz



Measuring quadricep thickness using usg

Circumferential mark was applied at the midway between the tip of the greater trochanter and the lateral joint line of the knee. The linear array USG probe was placed on the anterior aspect of this circumferential line, perpendicular to the skin, and the probe was moved along the line drawn till a suitable image was obtained. Keeping the focus on the suitable image, a point corresponding to the centre of the probe was marked with a vertical line.

The usg guided measurement of the patient was done and outcome of the patient was observed



Extubation failure:

Extubation failure was defined as the need to re-intubate a patient or death within 48 hours of extubation¹⁰

Patient on invasive mechanical ventilation in intensive care unit

Ages 12 years

Exclusion criteria

1. Existing Neuropathy
2. Myopathy
3. Road traffic accidents

- 4. Altered sensorium
- 5. Ventilator associated dependent

Results

		outcome						p-value
		Death(8)		Re- intubated 16		successes wean(26)		
		N	%	N	%	N	%	
Excursion	<7	8	100.0%	4	50.0%	0	.0%	<0.001
	7 to 11	0	.0%	4	50.0%	12	46.2%	
	>11	0	.0%	0	.0%	14	53.8%	
	Total	8	100.0%	8	100.0%	26	100.0%	
D.insp.thick	<1.65	4	50.0%	0	.0%	0	.0%	<0.001
	1.65 to3.7	4	50.0%	8	100.0%	26	100.0%	
	>3.7	0	.0%	0	.0%	0	.0%	
	Total	8	100.0%	8	100.0%	26	100.0%	
D.expthick	<1.2	0	.0%	2	25.0%	2	7.7%	0.205
	1.2 to 2.79	8	100.0%	6	75.0%	24	92.3%	
	Total	8	100.0%	8	100.0%	26	100.0%	
Q.thick	<2.1	2	25.0%	0	.0%	0	.0%	0.012
	2.1 to 4.143	6	75.0%	8	100.0%	26	100.0%	
	Total	8	100.0%	8	100.0%	26	100.0%	

The total number of patients (42)were analysed . In the study 52.4 % were males (n =22) and 47 .6% were female (n =20) . The mean age was 46.24 with minimum 19 and maximum 78 . Most of the patient were in age interval of 51 to 65 years with 38.1 % . . In the study the mean excursion was 9.57 mm with SD of 3.53 . The thickness of diameter at inspiration had mean of 2.09 mm SD 0.45 ranging from minimum 1.45 and maximum of 3.10 . The quadricep thickness was minimum of 2.01mm and maximum 3.66mm showing mean of 2.90 mm. In our study death occurred in 19 % of the patient . 19 % patients were reintubated whereas 61.9 % were successfully weaned . 38.1 % OF patients had diaphragmatic excursion falling in range of 7 to 11 . All patient who expired had diaphragmatic excursion of <7 mm ,0% death in diaphragmatic excursion in range of 7 -11and >11 mm . 50% of 7 -11 mm group while 0% in >11 mm group were reintubated . successful weaning was 0% in 7mm group46.2 % in 7-11 and 53.8% in >11 mm. The inspiratory diaphragmatic thickness <1.65 had death 50% , patient who got reintubated wherein range 1.65 to 3.7 . Quadricep thickness death was 75% in 2.1 to 4.1 mm , reintubation was 100 % in range of 2.1 - 4.13 mm ..The study showed that the diaphragmatic excursion was significant value <0.001 with weaning outcome of the patient . Diaphragmatic thickness at inspiration had p value 0.007 but quadriceps thickness had no significant pvalue(0.012) using Kruskal Wallis test for significance . But the quadricep thickness of <2.1 had significant value of p 0.012 using Chai square (C2) test .

	outcome						p-value
	Death		Re-intubated		successes wean		
	Mean	SD	Mean	SD	Mean	SD	
Excursion	5.25	.46	7.25	1.75	11.62	2.73	<0.001
D.insp.thick	1.69	.29	2.28	.53	2.15	.40	0.007
D.expthick	1.42	.26	1.63	.41	1.49	.27	0.414
Q.thick	3.11	.68	2.80	.35	2.86	.48	0.366

Discussion

Patients in ICU who are critically sick require basic life support in form of mechanical ventilator. Intubation both nasal and oral and tracheostomy are required to support life in patients with MODS, CVA, Transplantation, cardiopulmonary arrest and many more. Even if the patients could smoothly wean from the ventilator and be transferred out of the ICU, 1/3rd of them would still face severe dysfunction, and 1/4th of them would have reduced mobility^{1,2}. Few data are available on whether muscle weakness, a complication of patients in the ICU, is correlated with the prognosis of subsequent functional activities. Ultrasound can be used to predict the probability of successful extubation, decreasing ICU mortality and increasing ICU free stay. It can have a great impact on decreasing financial burden in device-equipped ICU with expert physician, well-trained staff and multidisciplinary involvement. Critically ill patients with sepsis are at increased risk of loss of muscle^{5,6,7}.

Tsu g et al⁸ showed a total of 52 patients were enrolled in this study, and the rate of extubation failure was 15%. The muscle strength of the quadriceps was significantly correlated with the prognosis after extubation, 48% of the patients were able to ambulate after being transferred to the general ward. The overall mortality rate was 11%, and there was a significant correlation between the biceps muscle strength and in-hospital mortality.

However, none of the previously published studies on muscle thickness on USG reported the data related to muscle thickness and outcomes^{5,6,7}.

Sarah et al⁹ A total of 81 patients were enrolled. Muscle mass was associated with successful extubation (OR 1.02, 95% C.I. 1.00-1.03, p = 0.017), shorter ICU stay (OR 0.97, 95% C.I. 0.95-0.99, p = 0.03) and decreased hospital mortality (HR 0.98, 95% C.I. 0.96-0.99, p = 0.02). Muscle density was associated with successful extubation (OR 1.07, 95% C.I. 1.01-1.14; p = 0.02) and had an inverse association with the number of complications in ICU (B -0.07, 95% C.I. -0.13 - -0.002, p = 0.03), length of hospitalization (B -1.36, 95% C.I. -2.21 - -0.51, p = 0.002) and in-hospital mortality (HR 0.88, 95% C.I. 0.78-0.99, p = 0.046).

In our study carried out at PCCM department with help of dedicated ICU ultrasound we can measure the diaphragmatic excursion and diameter and analyse its role in predicting the probability of outcome. Our study had a significant effect of diameter of diaphragm at inspiration and excursion on outcome of the patient. The present study also showed that thin diameter of quadriceps muscle showed poor outcome. In conclusion, excursion of > 11 had successful weaning and diaphragm thickness at inspiration 1.65 - 3.71 mm were associated with successful weaning.

References

1. Fletcher, S. N. et al. Persistent neuromuscular and neurophysiologic abnormalities in long-term survivors of prolonged critical illness. *Crit. Care Med.* 31, 1012–1016 (2003).
2. van der Schaaf, M., Beelen, A. & de Vos, R. Functional outcome in patients with critical illness polyneuropathy. *Disabil. Rehabil.* 26, 1189–1197 (2004).
3. Baldwin CE, Bersten AD. Alterations in respiratory and limb muscle strength and size in patients with sepsis who are mechanically ventilated. *Phys Ther.* 2014;94(1):68–82
4. Callahan LA, Supinski GS. Sepsis-induced myopathy. *Crit Care Med.* 2009;37(10 Suppl):S354–67.
5. Parry SM, El-Ansary D, Cartwright MS, Sarwal A, Berney S, Koopman R, et al. Ultrasonography in the intensive care setting can be used to detect changes in the quality and quantity of muscle and is related to muscle strength and function. *J Crit Care.* 2015 ;30(5):1151.e9–14.
6. Gruther W, Benesch T, Zorn C, Paternostro-Sluga T, Quittan M, Fialka-Moser V, et al. Muscle wasting in intensive care patients: ultrasound observation of the M. quadriceps femoris muscle layer. *J Rehabil Med.* 2008;40(3):185–9
7. Reid CL, Campbell IT, Little RA. Muscle wasting and energy balance in critical illness. *Clin Nutr.* 2004;23(2):273–80
8. Impact of peripheral muscle strength on prognosis after extubation and functional outcomes in critically ill patients: a feasibility study; Tsung-Hsien Wang, Chin-Pyng Wu & Li-Ying Wang
9. Influence of reduced muscle mass and quality on ventilator weaning and complications during intensive care unit stay in COVID-19 patients Sarah Damanti 1, Giulia Cristel 2, Giuseppe Alvise Ramirez 3, Enrica Paola Bozzolo 4, Valentina Da Prat 4, Agnese Gobbi 5, Clarissa Centurioni 5, Ettore Di Gaeta 6, Andrea Del Prete 6, Maria Grazia Calabrò 7, Maria Rosa Calvi 7, Giovanni Borghi 7, Alberto Zangrillo 8, Francesco De Cobelli 2, Giovanni Landoni 8, Moreno Tresoldi q American journal of Respiratory and Critical care Medicine, Arnaud W. Thille 1, Jean-Christophe M. Richard 2,3, and Laurent Brochard 2,3,4