ORIGINAL ARTICLE

Diagnosis of Diaphragmatic Paralysis in adults by the use of M Mode Ultrasound

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ABSTRACT
Design of study: Retrospective.
Objectives: To evaluate Diagnosis of Diaphragmatic paralysis in adults by the use of M mode Ultrasound.
Setting: Department of Diagnostic Radiology, Ch. Pervaiz Elahi Institute of Cardiology, Multan.
Results: The movement of diaphragm was noted on quiet respiration and on sniff test showing the result of normal diaphragmatic movement in three patients, unilateral diaphragmatic paralysis in six patients. On Chest X-ray four of these patients with diaphragmatic paralysis had a elevated hemi-diaphragm, because two patients were on ventilator they did not have elevated diaphragm on chest radiography. The scanning of patients on Ultrasound was recorded in M- mode and bilaterally on quiet respiration and on sniffing. No evidence of movement is recorded on paralyzed side on M-mode.
Conclusion: M mode ultrasonography can be used with ease and accuracy for the evaluation of diaphragm in the adults suspicious of diaphragmatic paralysis and having advantage of performing more than one time and at bedside.
Equipment: GE LogiqF8 using a 2–5 MHz curved transducer.
Keywords: M-mode, Ultrasound, Diaphragm, Adults, Paralysis.

INTRODUCTION
M mode of ultrasound is used for the evaluation of moving structures. It is being used widely for the evaluation of suspected diaphragmatic paralysis. The main conflict exist in the method for the evaluation of diaphragm with suspected paralysis. Other investigations used for the evaluation of diaphragmatic paralysis include fluoroscopy(with much success), transthoracic pressure studies and chest xray.

METHODS AND MATERIALS
Included Patients: The patients with probability of diaphragmatic paralysis due to high spinal cord injury, having raised hemidiaphragm on chest xray or due to suspected phrenic nerve injury during CABG who were refereed during the period extending from September 2017 to June 2020. Total of 10 patients (8 Male and 2 female) were included having range of age between 19-55 years.

Used Technique: Using 2-5 MHz transducer with probe angled angled towards head so that a 90 degree angle is obtained with diaphragm and laying the patient in supine position, the movement of diaphragm was noted on sniffing and on quiet respiration. The line of M mode was placed at the anterior axillary line and was angled such that maximum excursion of diaphragm may be obtained. For viewing the diaphragm on right side liver was used as window, and window of spleen was used on left side for better visualization.

RESULTS
Movement of diaphragm on M-mode against time was studied. As the normal person inhales air, the diaphragm moves caudally and the M-mode trace is recorded in upward direction due to the movement of diaphragm towards probe. While on expiration, diaphragm moves inward and this movement on M mode trace is recorded in upward direction as the diaphragm moves away from the direction of sound beam. When the patient is asked to sniff, it will show an upstroke movement on m-mode. When this method is utilized in paralyzed diaphragm, it will show no movement or it will show paradoxical movement.In this study for our purpose we only noted direction of excursion as the range of diaphragmatic excursion was not purpose of our study excluding the cases who required reassessment.

Table A:Findings of Chest x-ray and on M- Mode of all patients

Subject	Gender	Age(y)	Reason	On Chest X-ray	On M-mode US
1	M	25	C-6 level spinal injury	Raised L hemi-diaphragm on CHEST X-RAY	Left sided diaphragmatic paralysis
2	M	60	Severe exertional dyspnea	Elevated R diaphragm on CHEST X-RAY	Right sided diaphragmatic paralysis
3	M	19	Spinal injury involving C5(Incomplete)	No abnormality on CHEST X-RAY	No abnormality seen

4	M	31	C4 incomplete tetraplegia	No CHEST X-RAY abnormalities	No abnormality seen
5	F	23	Disseminated encephalomyelitis	No CHEST X-RAY abnormalities	R diaphragmatic paralysis
6	F	51	SLE resulting in loss of lung volume, paradoxical respiratory movements	Bilaterally raised diaphragms CHEST X-RAY	Bilaterally normal diaphragmatic movement
7	M	28	Post CABG, Right phrenic nerve injury incomplete C3 tetraplegia	Raised R hemi-diaphragm on CHEST X-RAY	R diaphragmatic palsy
8	M	18	Complete C2 tetraplegia,	No CHEST X-RAY abnormalities	L diaphragmatic palsy.
9	M	28	Spinal C2 trauma tetraplegia, ventilator dependent	No CHEST X-RAY abnormalities	Bilateral palsy with paradoxical movement
10	M	17	Right sided injury of brachial plexus	Elevated R diaphragm on CHEST X-RAY	paradoxical movement of right diaphragm

DISCUSSION

The major muscle involved in respiration is diaphragm; along with other accessory muscles it acts in a synchronized way to facilitate the inhalation and exhalation. As we breathe in, diaphragm moves caudally which creates negative intra thoracic pressure , resulting in inward passage of air. As the diaphragm relaxes, it decreases the transthoracic diameter of chest, which in turn creates positive intrathoracic pressure which facilitates the outward passage of air, thus accomplishing the respiratory cycle.

In cases of unilateral or bilateral diaphragmatic paralysis, during inspiration, net negative intrathoracic pressure is created, which facilitates the cranial movement of diaphragm contrary to its caudal movement in normal circumstances.

In another study published by Houston et al[5]concluded that with help of ultrasound one can measure the movement of diaphragm quantitatively more efficiently contrary to the fluoroscopy. Also fluoroscopy has certain limitation with application, which demand a lot cooperation from the patient to resulting it fruitful. Like patient must be ble to stand properly without support and can sustain apnea of small duration to rule out diaphragmatic palsy, without these prerequisites fluoroscopy result could be of no use.

In another one study of its kind Gottesman and McCool[7] elaborated the use of other means and parametes which could result in easily diagnosing diaphragmatic palsy. In this study it was resulted that by measuring the thickness of diaphragm one can easly rule out the diaphragmatic paralysis in sucah a way that paralytic diaphragm will have less thickness as compared to diaphragm with normal movement, but this method had a disadvantage that it could not be used in cases of diaphragmatic palsy of short onest of duration, as the acutely paralyzed diaphragm requires some time in days before declaring as atrophied with loss of muscle thickness.

Previously in a study conducted by Epelmanet al.[2]Riccabonaet al[3]in padiatric age population for the diagnosis of diaphragmatic palsy, made comparative study involving ultrasonogram conventionally and M-mode ultrasonogram. Study which completed with follow up examination of patients showed M-mode ultrasonogram can be used adequately for the palsy of diaphragm.

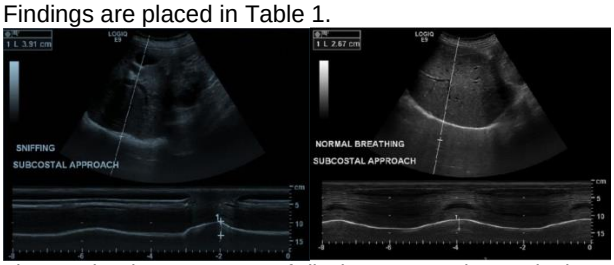
As already been described in above mentioned section of technique for this study, measuring range of diaphragmatic excursion was not our purpose, as this study is not related to look for the status of patients on reassessment in the days to follow.

Previously M-mde ultrasound was being used in pediatric population but through this study it is seen, this modality can be used with good results in adult population. Although with recent advances, M-mode has encouraged the scientists of this field to pay attention to it. Inspite of being not used frequently in most of the world, it has shown good result and needs to be studied further.

This technique of M-mode ultrasound with help of experienced operator can be used easily as it does not require that the patient should hold breathing or the necessity of standing position, neither it is time consuming. An experienced operator can perform it within five minutes and also along bedside as in the cases of post-CABG evaluation of diaphragm in ICU settings.

CONCLUSION

Findings are placed in Table 1.



Figures showing movement of diaphragm on quiet respiration and on sniffing in normal circumstances.

Patients with normal examination:(Shown in above figures)Patients who demonstrated caudal movement of diaphragm bilaterally on M mode tracing and on sniff test a sharp upstroke were concluded having normal diaphragm. Number of such subjects turned out to be three.

Patients with diaphragmatic paralysis: Patients who presented with injuries causing unilateral phrenic nerve palsy resulting in paralysis of diaphragm due to the reason of suffering from autoimmune disease, spinal injury from C6 to C2, post CABG and traumatic injury to brachial plexus had a unilateral diaphragmatic paralysis. Count of such patients was six. On chest x-ray four of these six patients had shown elevated diaphragm of one side. Other two patients who were found to have diaphragm at normal level on chest x-ray, one was on ventilator and other had not shown any abnormality on chest x-ray. While tracing the movement of diaphragm on ultrasound with the help of M- mode, the movement which was recorded depicted

caudal movement of diaphragm while inhaling air on normal side and acute upstroke movement was depicted on sniff maneuver. Scanning was done of the paralyzed side on M mode which demonstrated on inspiration that diaphragm had no caudal movement illustrating it to be paralyzed and on sniff maneuver showed paradoxical movement on inspiration.

On statistical analysis which we executed after different calculations sensitivity was proven to be 64.6% for unilateral paralysis while on chest x-ray for the purpose of diagnosing paralysis in general it came out 54%.

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