Original Research Article

Evaluation of Diaphragmatic Ultrasonography in Infants with Acute Bronchiolitis

Abstract

Background: Bronchiolitis is an acute viral respiratory illness that affects children younger than 24 months of age, with severe disease more common among infants from 1–3 months. The aim of the research was to investigate the correlation between diaphragmatic ultrasound parameters, with clinical scoring of acute bronchiolitis to evaluate their role in assessment of disease severity and to evaluate diaphragmatic ultrasound findings in patients with acute bronchiolitis.

Methods: This research was carried out on sixty infants aged from (one month to 2 years) at 1st attack of wheezy chest. According to clinical scoring cases were divided in to three groups: group (1): mild bronchiolitis with clinical scoring from (1-3) including 30 patients, group (2): Moderate bronchiolitis with clinical scoring (4-7) including 20 patient, and group (3): severe bronchiolitis with clinical scoring from (8-14) including 10 patients. All infants were subjected to chest X-ray, laboratory methods (Complete blood count and C-reactive protein), and clinical Scoring.

Results: There was a significant positive correlation between diaphragmatic excursion and length of hospital admission (r 0.395, $p<0.00$), a positive significant correlation between inspiratory slope and length of hospital admission. (r 0.439, $p<0.001$).

Conclusions: Lung ultrasonography may play a role in the evaluation and workup of babies with bronchiolitis in the emergency room, helping doctors identify infants who may require more intensive treatment. Ultrasound of the diaphragm appears to be an objective and valuable technique for assisting the clinician in evaluating and treating bronchiolitis.

Keywords: Diaphragmatic Ultrasonography, Disease Severity, Infants, Acute Bronchiolitis

Introduction:

Bronchiolitis is an acute respiratory viral disease that primarily affects newborns between 1 and 3 months of age. Fever, cough, tachypnoea, chest retraction, are early signs of infection [1].

Bronchiolitis is one of the most common reasons for hospitalisation of children around the world, and Variability in the illness state might complicate the evaluation of babies with bronchiolitis and necessitate repeated assessments throughout time. In addition, this evaluation is dependent on subjective clinical observations, which might differ from physician to physician; hence, quantifiable measures have been devised to quantify respiratory distress and predict prognosis.

It is crucial to monitor the diaphragm's kinetics [3] since the diaphragm is the most important muscle for respiration and its functionality might be diminished by pulmonary diseases. It has been demonstrated that diaphragmatic ultrasonography is a non-invasive, readily conducted, quickly taught, and reliable method for measuring diaphragmatic function. It is a straightforward application of echography that is speedy, portable, reproducible, and non-ionizing, which is particularly essential in newborns who have a higher risk of cancer from exposure to radiation than persons of other ages [4].

Studies have demonstrated that ultrasound measurement of the diaphragm can quantify respiratory discomfort in bronchiolitis; consequently, we will connect the ultrasound diaphragmatic parameters with illness outcome.The aim of the research was to investigate the correlation between diaphragmatic ultrasound parameters with clinical scoring of acute bronchiolitis to evaluate their role in assessment of disease severity

Meterials and Methods:

This research was carried out on sixty infants aged from (one month to 2 years) at 1st attack of wheezy chest from the Emergency department, inpatient of Chest and Allergy unit and Pediatric intensive care unit (PICU) Pediatric department, Tanta University Hospital with clinical diagnosis of acute bronchiolitis according to American Academy of Paediatrics (AAP).

Every studied infant was subjected to detailed history taken, clinical examination, chest X-ray, laboratory methods (Complete blood count and C-reactive protein), and clinical Scoring.

According to clinical scoring cases were divided in to three groups: group (1): mild bronchiolitis with clinical scoring from (1-3) including 30 patients, group (2): Moderate bronchiolitis with clinical scoring (4-7) including 20 patient, and group (3): severe bronchiolitis with clinical scoring from (8-14) including 10 patients.

Exclusion criteria were infants with life threatening disease requiring immediate intervention, preterm infant, patients with history of any underlying chronic disease, recent history of surgery, major trauma or burn, wheezing in age of < 1month or > 2yrs, recurrent wheezing, clinical course not compatible with acute bronchiolitis, positive family history of asthma, finding concomitant with other lung pathology in chest x-ray and chronic lung diseases or evident of gastroesophageal reflux disease.

Lung ultrasonography: Transthoracic Lung ultrasound examination was performed for patients and control groups with ultrasound machines (Mindray DP20) with frequencies ranging from 6 to 12 MHz. In some cases, lung ultrasound was performed at emergency room (ER) before admission and in others it was performed after admission.

An echo graphic scoring was determined using the Bronchiolitis Ultrasound Scoring (BUS) previously described by Basile et al on the basis of pleural irregularity, B-lines, and the presence of sub-pleural consolidation on sonographic images.

Scoring of 1–3 points denote mild bronchiolitis; 4–6 moderate bronchiolitis; and 7–8 severe bronchiolitis [9].

Scorings of (0ne to three) were regarded as mild bronchiolitis, (four to six) as moderate bronchiolitis, and (seven to eight) as severe bronchiolitis, while a score of (zero) suggested a normal lung pattern.

US of diaphragm: The probe was positioned between the mid-clavicular and anterior axillary lines in the subcostal region and pointed medially, cranially, and dorsally to provide the best view of the right hemi-diaphragm utilising the liver as an acoustic window [10].

Right Hemi diaphragm sonographic perspective: During inspiration and expiration, the diaphragm appears as a free-moving echogenic line during M-mode imaging. Inspiration is seen on the ultrasonography as an positive deflexion (during inspiration, there is down motion of the diaphragm: i.e., toward the probe, resulting in positive deflexion of the waves). Expiration is defined by negative deflexion (during expiration, there is positive diaphragmatic motion: i.e., away from the probe, resulting in down-ward deflexion of the waves toward the baseline which is the expiratory pause that after expiration).

This vertical distance corresponds to right diaphragmatic movement. [11].

At the conclusion of expiration and inspiration, the vertical distance between the pleural and peritoneal layers was measured to assess the thickness of the diaphragm. The thickening fraction (TF) was computed as (TEI - TEE)/TEE, where TEI is the thickness of the diaphragm at the end of inspiration and TEE is the thickness of the diaphragm at the end of expiration, and it was recorded as a percentage.

Inspiratory slope (IS) or diaphragmatic contraction velocity was estimated by dividing the diaphragmatic excursion by the duration of inspiration. All measures were done while breathing normally and quietly. Numerous respiratory cycles were examined and recorded, and on average, three cycles were counted. The average time of a sonographic examination of the diaphragm was five minutes.

Statistical analysis

Data were analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Using the Shapiro-Wilks test and histograms, the normality of the data distribution was determined. Parametric quantitative data were given as mean and standard deviation (SD) and examined using an unpaired student t-test. Non-parametric quantitative data were provided as the median and interquartile range (IQR) and examined using the Mann-Whitney test. The frequency and percentage (%) of qualitative characteristics were displayed. Linear Correlation coefficient (r) was used for detection of correlation between two quantitative variables in one group. A two-tailed P value < 0.05 was considered statistically significant.

Results:

Table 1 shows distribution of the studied population according to history (present, past and family history) and clinical presentation, clinical examination of cases with history and clinical presentation matching with acute bronchiolitis, laboratory investigations of cases clinically and radio-logically concomitant with acute bronchiolitis. Table 1

Table 1: Distribution of the studied population according to history (present, past and family history) and clinical presentation, clinical examination of cases with history and clinical presentation matching with acute bronchiolitis, laboratory investigations of cases clinically and radio-logically concomitant with acute bronchiolitis

History and clinical presentation	No.	%
Matching with other disease	55	36.67
Matching with acute bronchiolitis	95	63.33
Clinical examination		
Clinical examination concomitant with acute bronchiolitis	77	81.1
Clinical examination concomitant with	13	13.7

Bronchopneumonia		
Clinical examination concomitant with CHD	5	5.2
CXR		
Finding concomitant with acute Bronchiolitis.	69	89.6
Finding concomitant with other lung pathology	8	10.4
laboratory investigations		
CBC **Normal** **Leukocytosis**	 60 9	 86.9 13.04
CRP	9	13.04

Regarding demographic data of the studied groups there was no statistically significant difference between patient and control. Table 2

Table 2: Demographic data of patients and control, classification of cases with clinical, radiological and laboratory findings concomitant with acute bronchiolitis according to wood downes clinical scoring

		Patient (60)		**Control (30)**		**P-value**
Age (Months)		6.583±2.919		6.833±3.724		0.728
		N	**%**	**N**	**%**	
Sex	**Male**	25	41.67	15	50.00	0.453
	Female	35	58.33	15	50.00	

Clinical scoring	**No.**	**%**
Group I (Mild)	30	50.0
Group II (Moderate)	20	33.33
Group III (Severe)	10	16.67
Mean ± SD.	4.54 ± 2.36	

Chest ultrasonography signs in control group (30)	**Sign**	**N**	**%**
A-Lines	present	30	100
	Absent	0	0
B-lines (focal)	present	5	16.7
	Absent	25	83.3

*: Statistically significant at $p \leq 0.05$

Mean TF was significantly lower in patient than in control with a statistically significance difference between studied groups with (p-value<0.05). Mean diaphragmatic thickness in expiration was significantly higher in control than in patient with a statistically significance difference between studied groups as (p- value<0.05) and mean thickness in inspiration was

higher in patient than control with statistically significance between them, mean excursion was higher in control than in patient with statistically significance between patient and control (p-value<0.05) and mean inspiratory slope (IS) was significantly lower in patient (1.15± 0.74) than in control (1.63± 0.57) with (p-value<0.05). Table 3

Table 3: Distribution of pathological chest ultrasonography signs in mild, moderate and severe groups (n=60), Comparison between cases and control as regard to M-mode diaphragmatic ultrasound parameters

Chest ultrasonography signs	Clinical scoring						p
	Mild (n = 30		Moderate (n = 20)		Severe (n = 10)		
	No.	%	No.	%	No.	%	
Pleural irregularities	16	53.3	19	95.0	10	100.0	0.001*
Consolidation	7	23.3	20	100.0	10	100.0	<0.001*
B lines							
Focal	30	100	15	75.0	0	0.0	<0.001*
Confluent	0	0.0	5	25.0	10	100.0	

M-mode diaphragmatic ultrasound parameters	Cases (n = 60)	Control (n = 30)	p
TEI(cm)	0.58 ± 0.22	0.48 ± 0.17	0.035*
TEE(cm)	0.47 ± 0.14	0.70 ± 2.14	<0.001*
TF%	26.06 ± 11.41	37.51 ± 14.66	<0.001*
IS(cm/sec)	1.15 ± 0.74	1.63 ± 0.57	<0.001*
DE(cm)	1.09 ± 0.36	1.28 ± 0.34	<0.001*

*: Statistically significant at $p \leq 0.05$, TEI: Diaphragm thickness at the end of inspiration, TEE: diaphragm thickness at the end of expiration, TF: thickening fraction, DE: diaphragm excursion and IS: inspiratory slope.

Mean value for diaphragmatic thickness in inspiration (TEI) was significantly higher in mild group (0.67 ± 0.19) than moderate (0.57 ± 0.22) and severe group (036 ± 0.12) with p value<0.001, Mean value for diaphragmatic thickness in expiration (TEE) was higher in mild group (0.51 ± 0.13) than moderate (0.43 ± 0.14) and severe group (0.42 ± 0.14) with p value 0.075 and it was statistically not significant , Infants with severe bronchiolitis had lower TF (Thickening Fraction) than those with moderate and mild clinical scoring with statistically significance between three groups ,Inspiratory slope increase with increase in clinical scoring with mean IS significantly higher in severe group and As regard to DE (diaphragmatic excursion) it was higher in severe group than mild and moderate group with statistically significance difference between groups. Table 4

Table 4: Relation between clinical scoring with different diaphragmatic ultrasound parameters in patient groups:

M-mode diaphragmatic ultrasound parameters	Clinical scoring			P
	Mild (n = 30)	Moderate (n = 20)	Severe (n = 10)	
TEI(cm)	0.67 ± 0.19	0.57 ± 0.22	0.36 ± 0.12	<0.001*
TEE(cm)	0.51 ± 0.13	0.43 ± 0.14	0.42 ± 0.14	0.075
TF%	28.12 ± 11.31	25.08 ± 10.04	21.87 ± 13.87	0.138
IS(cm/sec)	0.93 ± 0.63	1.13 ± 0.71	1.88 ± 0.66	0.001*
DE(cm)	0.66 ± 0.10	1.02 ± 0.34	1.27 ± 0.30	<0.001*

Variables are expressed as TEI: Diaphragm thickness at the end of inspiration, TEE: diaphragm thickness at the end of expiration, TF: thickening fraction, DE: diaphragm excursion and IS: inspiratory slope., *: Statistically significant at $p \leq 0.05$.

There was a positive significant correlation between clinical and bronchiolitis ultrasound scoring (P<0.001).

Discussion

Acute Bronchiolitis is a prevalent illness. Despite the fact that the majority of cases exhibit mild to moderate respiratory distress, some instances evolve to a more serious condition and may necessitate breathing assistance [12].

In our research we found that bronchiolitis ultrasound scoring (BUS) had a significant positive correlation with the clinical scoring to predict the disease severity and the need for hospital admission. ($p < 0.001$, r: 0.880*)

These results were concordant with results of La Regina et al., [13] who conducted prospective research on 63 infants with acute bronchiolitis. In this research, all children with bronchiolitis had a clinical examination with clinical severity score and lung ultrasonography with LUS scoring. By clinical scoring, nine babies had mild bronchiolitis, 37 had moderate bronchiolitis, and 17 had severe bronchiolitis. By LUS scoring, eleven infants had light bronchiolitis, 38 had moderate bronchiolitis, and 14 had severe bronchiolitis. In this research, Lung ultrasonography grading correlated positively with clinical scoring ($r=0.62$, $p < 0.001$) and hospitalization duration ($r= 0.42$; $p< 0.001$).

The results from our research are concordant with results from Caiulo et al., [15] who performed their research on In order to characterize the LUS findings in children with bronchiolitis, the researchers evaluated the severity of the condition using Downes' Scoring on 52 infants less than 16 months. The mildest form of the disease was characterized by the presence of few isolated B-lines, the moderate form by the presence of a single subpleural consolidation , and the severe form by the presence of total pulmonary consolidation, abnormalities of the pleura and pleural effusion. In every instance, the stated symptoms vanished entirely under patient monitoring.

In our research, we evaluated diaphragmatic function in previously healthy children with bronchiolitis and identified different respiratory parameters (DE, IS, TEI, TEE, and TF) that correlated with clinical scoring and length of hospital stay, thereby providing a new evaluation tool for children with bronchiolitis.

Few prior studies have evaluated these findings in acute bronchiolitis, the most common reason for hospitalization during the winter months, and no reference data are available.

In our research as regard to diaphragmatic thickness in inspiration and expiration, mean thickness was significantly higher in control than in patient with a statistically significance difference between them as (p- value<0.05). And we found that mean measure of diaphragmatic thickness during inspiration and Expiration (TEI, TEE) were higher in cases with mild bronchiolitis than patients with moderate and severe bronchiolitis.

This is concordant with the results from Buonsenso et al., [16] performed ultrasonography examinations of the diaphragm and (diaphragm excursion [DE], inspiratory excursion [IS], inspiratory/expiratory relationship [16], and TEI, TEF, TF were assessed. They found that diaphragmatic thickness during inspiration and expiration (TEI, TEE) were higher in mild and moderate cases than severe cases with bronchiolitis.

On the contrary in the research from Şık et al., [17] used modified Respiratory Distress Assessment Instrument (mRDAI) scoring to quantify the clinical severity of the disease. Diaphragmatic thickening at the end of inspiration and expiration, thickening ratio, EXC, IS, ES, and overall duration time of the respiratory cycle were then determined using ultrasonography of the diaphragm. In their research they found that diaphragmatic thickness was higher in cases with moderate to severe bronchiolitis than mild cases.

As regard to TF (Thickening Fraction), mean TF was significantly lower in patient (26.06 ± 11.41) than in control (37.51 ± 14.66) with a statistically significance difference between studied groups with (p-value<0.05). And as regard to thickening fraction in patients we found that infant with severe bronchiolitis had lower TF than moderate and mild bronchiolitis.

According to the findings of Buonsenso et al. [16], although not statistically significant, babies with severe bronchiolitis had a lower TF than those with a moderate or mild clinical grading. All kids with lower TF measure needs high nasal cannula, and one of them children additionally required positive airway pressure to be maintained continuously. Lower thickening fraction (TF) in individuals with bronchiolitis is indicative of diaphragm dysfunction in these cases.

On the contrary in the research from Şık et al., [17] thickening fraction was higher in moderate to severe cases than mild ones.

As regard to inspiratory slope (IS), we found that inspiratory slope differed significantly between studied groups with higher measure in severe bronchiolitis. A positive correlation between inspiratory slope and both clinical and Eco graphic scoring was found, and also positive correlation was found between (IS) and length of hospitalization.

This finding was concordant with result of Şık et al., [17] who concluded that inspiratory slope In patients suffering severe bronchiolitis who required respiratory assistance, the inspiratory

slope (IS) measure were considerably greater. Both clinical and echo graphic IS measure were greater in the moderate to severe cases compared to the mild cases. IS increased as the clinical scoring increased (p 0.001, r = 0.775) and they were positively connected, and Bronchiolitis ultrasonography scoring measure correlated with IS. (p <0.001, r = 0.562).

As regard to diaphragmatic excursion (DE) our research showed that diaphragmatic excursion was higher in patients suffered severe bronchiolitis than moderate and severe groups.

In the research by Buonsenso et al., [16] excursion increase with increase in clinical scoring with no statistical significance between three groups and in the research from Şık et al., [17] found that diaphragmatic excursion (DE) In the moderate to severe cases, measure were greater than in the mild cases, and there was a link between clinical rating and diaphragmatic excursion; as clinical score increased, EXC increased (p < 0.001, r = 0.200).

Conclusions:

Ultrasound of the diaphragm appears to be an objective and valuable technique for guiding the physician's diagnosis and therapy of bronchiolitis.

Limitations: Small sample size. Clinical scoring and Bronchiolitis ultrasonography scoring indicated that there were few individuals in the severe bronchiolitis category. Imaging with a micro-convex transducer as opposed to a high-frequency micro-linear transducer. The latter is more adept at seeing thin muscles and superficial structures, such as the hemi diaphragm.

Ethical Approval and Consent:

The research was be carried out after approval by Ethics committee of faculty of medicine Tanta University. An informed consent was obtained from all parents of the patients in the research.

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