

Assessment of Cardiac Functions in Neonates with Prolonged Mechanical Ventilation

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Abstract: Background: Mechanical ventilation (MV) is one of the most important emergency for admission in the neonatal period, especially premature infants. Prolonged mechanical ventilation (PMV) was defined as the need for mechanical ventilator support for more than 7 days. PMV is associated with the development of chronic lung disease. Other complications of MV include air-leak syndromes pneumothorax, pneumomediastinum, pneumopericardium, pulmonary interstitial emphysema. complications associated with endotracheal intubations, malpositioning, trauma to the vocal cords, larynx, and esophagus, development of subglottic stenosis and palatal groove and ventilator-associated pneumonias. MV always has some effect on the cardiovascular system. Positive-pressure ventilation can decrease preload, stroke volume, and cardiac output. Echocardiographic changes in particular Tricuspid Annular Plane Systolic Excursion (TAPSE), pulmonary hypertension and Tei index are a Doppler-derived index for the assessment of overall ventricular function that combines systolic and diastolic time intervals. **Aim:** Evaluate the Cardiac changes in neonates receiving of PMV clinically and by 2D transthoracic echocardiography. **Methods:** The present work was conducted on fifty neonates receiving of PMV, Detailed history-thorough clinical examination-Plain X-ray-Two dimensional, M-mode and Doppler echocardiographic examination with the measurement of myocardial performance index (MPI) of the left ventricle. **Results:** Our current study demonstrated statistically significant relation between the degree of duration of MV and pulmonary artery pressure, with increasing the duration of MV, the PAP is increased. TAPSE were gradually & significantly decreased with increasing the duration of MV, while Tei index is increased. Our study demonstrated positive moderate significant correlation between Tei index and PAP with the degree duration of MV. It also showed negative significant correlation between TAPSE with the degree of duration of MV which indicates that these patients may have subclinical ventricular dysfunction which should be followed up carefully. It also showed moderate significant correlation between TAPSE, Tei index and PAP with oxygenation index (OI). It also showed positive moderate significant correlation between Tei index and PAP with the degree of OI, while showed negative significant correlation between TAPSE with the degree of duration of OI. Among the studied infants 40 cases (80%) survived while 10 cases (20%) had expired. The causes of death were mainly related to complications of MV than the complications of the disease. Our study show relation between CRP and various echocardiographic measures which was statistically significant difference between cases had CRP<12 and cases had CRP=>12 regarding EF (%) and no statistically significant difference between cases had CRP<12 and cases had CRP=>12 regarding Tei index, LA/Ao ratio, TAPSE (cm) and PAP (mmHg). **Conclusion:** When PMV was coupled with some clinical findings as poor peripheral perfusion, cardiomegaly and audible murmur and echocardiographic findings of pulmonary hypertension and impaired contractility, the disease was severe and the outcome was poor. These clinical and echocardiographic findings seemed to be a better index of the outcome of PMV than other clinical, laboratory or radiological parameters.

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Keywords: Prolonged mechanical ventilation (PMV), echocardiogram, Tricuspid Annular Plane Systolic Excursion (TAPSE), pulmonary hypertension (PHN) and Tei index.

1. Introduction

The National Association for Medical Direction of Respiratory Care (NAMDR) in its consensus statement has defined PMV as the need for >21 consecutive days of MV for >6 h/day (1).

Prolonged mechanical ventilation is associated with the development of chronic lung disease. Other

complications of mechanical ventilation include air-leak syndromes pneumothorax, pneumomediastinum, pneumopericardium, pulmonary interstitial emphysema), complications associated with endotracheal intubations, malpositioning, trauma to the vocal cords, larynx, and esophagus, development

of subglottic stenosis and palatal groove) and ventilator-associated pneumonias.

Prolonged mechanical ventilation is associated with impaired health – related quality of life compared with that of a matched general population. Despite these handicaps, 99% of long - term survivors evaluated were independent and living at home three years after ICU discharge. While acute physiology is the primary risk factor for death in the initial ICU period within the first 14 days, age, a pre -admission immunocompromised status, and duration of mechanical ventilation for >35 days are the primary risk factors for death after ICU discharge (2).

Objective

To evaluate the cardiac functions in neonates with prolonged mechanical ventilation clinically and by Two dimensional (2D) transthoracic echocardiography and to correlate the duration and pathology underlying the prolonged ventilation and the degree of cardiac dysfunction and to detect any echocardiographic predictors of poor outcome.

2. Patients and Methods

Study Types:

Cross sectional study.

Study Population:

50 neonates admitted in the neonatal intensive care unit of Bab El Sheria hospital of Al-Azhar university with prolonged mechanical ventilation, their gestational age ranged from 28 to 40 wks.

Population Age:

Post-natal age ranged from 1 to 29 days.

Study Time:

Period from 2016 to 2017.

Inclusion criteria

- Neonate with prolonged mechanical ventilation ≥ 7 day.
- Age: any gestational age

Exclusion criteria

- Congenital heart diseases
- Neonates with mechanical ventilation < 7 days.

Ethical considerations:

Informed consents were obtained from parents of patients included in this study which were approved by the local ethical committee. The study was approved by Ethical Committee of Al-azhar University.

Methods

All Neonates in the study was subjected to the following:

- Detailed perinatal history: maternal diseases and drug intake, high risk pregnancy, mode of delivery, risk factors of prematurity, labor (prolonged, obstructed, abnormal presentation), presence of

meconium, antenatal ultrasound and risk factors of infection.

- Full clinical examination including: gestation age in weeks, post natal age in days, Apgar score at 1 min and 5 min, down score, anthropometric measures performed on percentile charts, general examination, cardiac examination, chest examination, abdominal examination and neurological examination, and mean arterial blood pressure.

Laboratory Investigations include:

- Complete Blood Count (CBC).
- C – Reactive protein, Arterial Blood Gases (ABG).

Radiological investigation include: Chest X – Ray.

- Detailed 2D transthoracic echocardiography: assessment of systolic function, estimation of pulmonary artery pressure, myocardial performance index, TAPSE, assessment of right ventricular function.

3. Results

Our current study demonstrated statistically significant relation between the degree of duration of MV and pulmonary artery pressure, with increasing the duration of MV, the PAP is increased. TAPSE were gradually & significantly decreased with increasing the duration of MV, while Tei index is increased. Our study demonstrated positive moderate significant correlation between Tei index and PAP with the degree duration of MV. It also showed negative significant correlation between TAPSE with the degree of duration of MV which indicates that these patients may have subclinical ventricular dysfunction which should be followed up carefully.

It also showed moderate significant correlation between TAPSE, Tei index and PAP with oxygenation index (OI). It also showed positive moderate significant correlation between Tei index and PAP with the degree of OI, while showed negative significant correlation between TAPSE with the degree of duration of OI. Among the studied infants 40 cases (80%) survived while 10 cases (20%) had expired. The causes of death were mainly related to complications of MV than the complications of the disease. Our study show relation between CRP and various echocardiographic measures which was statistically significant difference between cases had CRP<12 and cases had CRP= \geq 12 regarding EF (%) and no statistically significant difference between cases had CRP<12 and cases had CRP= \geq 12 regarding Tei index, LA/Ao ratio, TAPSE (cm) and PAP (mmHg).

Table (1) Relation between the oxygenation index and various echocardiographic measures

Variable	oxygenation index <10 (n=36)		Oxygenation index 10-25 (n=8)		oxygenation index >25 (n=6)		P. value
	Mean	SD	Mean	SD	Mean	SD	
Tei index	0.36	±0.24	0.45	±0.05	0.54	±0.20	<0.001
LA/Ao ratio	1.02	±0.15	1.02	±0.08	0.90	±0.08	0.146
TAPSE (cm)	1.20	±0.20	0.95	±0.24	0.75	±0.20	<0.001
PAP (mmHg)	29.55	±10.51	40.75	±5.82	55.66	±11.32	0.014

This table showed that, Relation between the oxygenation index (OI) and various echocardiographic measures, which show statistically significant difference between oxygenation index regarding Tei index (show gradual increase with increasing the

severity of OI), TAPSE (cm) (show gradual decrease with increasing the severity of OI), and PAP (mmHg) (show gradual increase with increasing the severity of OI), and no statistically significant difference between oxygenation index regarding LA/Ao ratio.

Table (2) Relation between the duration of MV and various echocardiographic measures

Variable	duration of MV (d)<10 (n=28)		duration of MV (d)=>10 (n=22)		P.value
	Mean	SD	Mean	SD	
Tei index	0.46	±0.12	0.68	±0.26	<0.001
TAPSE (cm)	1.02	±0.28	0.90	±0.23	<0.001
PAP (mmHg)	31.07	±11.33	50.72	±9.42	0.019

This table showed that, Relation between the various duration of MV and various echocardiographic measures, there was statistically significant difference between cases on MV < 10 days and cases on MV =>10 days regarding Tei index (show gradual increase

with increasing duration of MV), TAPSE (cm) (show gradual decrease with increasing duration of MV) and PAP (mmHg) (show gradual increase with increasing duration of MV).

Table (3) Relation between CRP and various echocardiographic measures

Variable	CRP<12 (n=22)		CRP=>12 (n=28)		P. value
	Mean	SD	Mean	SD	
EF (%)	66.41	±10.14	75.98	±8.54	0.001
FS (%)	39.80	±13.71	42.65	±8.29	0.368
Tei index	0.50	±0.19	0.66	±0.24	0.375
LA/Ao ratio	1.08	±0.17	1.01	±0.12	0.956
TAPSE (cm)	0.78	±0.24	0.53	±0.18	0.379
PAP (mmHg)	28.45	±7.08	32.85	±12.23	0.140

This table showed that, there was statistically significant difference between cases had CRP<12 and cases had CRP=>12 regarding EF (%). there was no statistically significant difference between cases had CRP<12 and cases had CRP=>12 regarding Tei index, LA/Ao ratio, TAPSE (cm) and PAP (mmHg).

4. Discussion

In our study the Relation between the oxygenation index (OI) and various echocardiographic measures, which show statistically significant difference between oxygenation index regarding Tei index (show gradual increase with increasing the severity of OI), TAPSE (cm) (show gradual decrease with increasing the severity of OI), and PAP (mmHg) (show gradual increase with increasing the severity of

OI), and no statistically significant difference between oxygenation index regarding LA/Ao ratio.

In our study There was positive correlation between oxygenation index regarding Tei index p-value (0.011), and PAP (mmHg) p-value (0.039) and negative correlation with TAPSE p-value (0.043). which agree with (3). which reveals that the OI had a positive correlation with MV duration on the third and fifth days, reflecting the severity of the initial ventilatory disturb and disagree with (4). which did not find any significant differences when comparing OI, but their data were collected only on the first and second MV days.

Oxygenation (OI) are currently used to evaluate MV duration and/or the severity of ventilation disorders in pediatric patients (5). as well as to evaluate therapeutic interventions (6).

OI ≥ 10 in <1500 g at <72 hours of age and after surfactant has a positive predictive value for death or CLD of 74% which suggested that infants with an OI of ≥ 10 were at high risk of adverse outcome. (7).

In our study the Relation between the various duration of MV and various echocardiographic measures was statistically significant difference between cases on MV < 10 days and cases on MV ≥ 10 days regarding Tei index (show gradual increase with increasing duration of MV), TAPSE (cm) (show gradual decrease with increasing duration of MV) and PAP (mmHg) (show gradual increase with increasing duration of MV). The evaluation of factors associated with time receiving MV may generate important data to optimize the care provided to these patients (8).

In our study There was statistically significant positive correlation between various duration of MV and Tei index p-value (0.011), which agree with El-Ashmawy et al, 2015, Right ventricular Tei index was higher in patients with failed weaning in comparison to successfully weaned patients ($P < 0.001$), also left ventricular Tei index was higher in patients who failed to be weaned ($P = 0.007$) (9).

The higher mean value of the Tei index in the RV might be reflecting the “persistent” fetal status of this ventricle in the first day of life. Although constant value of the Tei index in the LV reflect the degree of neonatal myocardial immaturity (10).

The myocardial performance (Tei) index is a reliable parameter suggesting global left and right ventricular function. Tei index has particularly been used for the evaluation of left ventricular function (11). It has also been used to evaluate the right ventricular function in various pulmonary diseases such as pulmonary hypertension, COPD and cardiac amyloidosis. However, the evaluation of RV function by echocardiography has some limitations because of its geometry and complex contraction mechanism. Tissue Doppler imaging (TDI) echocardiography has been used to evaluate of the right ventricular function as a more quantitative method (12).

In our study There is statistically significant negative correlation between various duration of MV and TAPSE p-value (0.039) which agree with Papaioannou et al, 2010, which had ($p < 0.001$) and concluded that in mechanically ventilated patients, low TAPSE are associated with delayed liberation from mechanical ventilation, probably due to more severe LV heart failure. (13).

In our study There was statistically significant positive correlation between various duration of MV and PAP p-value (0.045).

Despite recent advances in the specific treatment of pulmonary hypertension (PH), RV failure following or in the context of severe rise of pulmonary vascular resistance (PVR) is a challenging complication of PH

and is associated with substantial morbidity and mortality (14).

PPHN was significantly increased with increased the duration of MV. PPHN is characterized by severe hypoxemia shortly after birth, with marked pulmonary hypertension with PDA and/or PFO (15).

It remains one of the most challenging and very serious conditions in the NICU and is usually associated with high morbidity & mortality (16).

The Relation between CRP and various echocardiographic measures, show statistically significant difference between cases had CRP < 12 and cases had CRP ≥ 12 regarding EF (%). and, no statistically significant difference between cases had CRP < 12 and cases had CRP ≥ 12 regarding Tei index, LA/Ao ratio, TAPSE (cm) and PAP (mmHg). this disagree with Abdel-Hady et al, 2012 in which Tei indexes were significantly higher in septic neonates compared to nonseptic neonates (mean \pm SD: 0.51 ± 0.09 vs. 0.28 ± 0.05 , $p < .001$, and 0.56 ± 0.07 vs. 0.39 ± 0.04 , $p < .001$, respectively). (17).

The Correlation between CRP and relevant echocardiographic measures, show statistically significant positive correlation between CRP and EF (%) p-value (0.003), and no statistically significant correlation between between CRP and Tei index, LA/Ao ratio, TAPSE (cm) and PAP (mmHg).

Echocardiography can play a key role in the critical septic patient management, by excluding cardiac causes for sepsis, and mostly by guiding hemodynamic management of those patients in whom sepsis reaches such a severity to jeopardize cardiovascular function. In recent years, there have been both increasing evidence and diffusion of the use of echocardiography as monitoring tool in the patients with hemodynamic compromise. Also thanks to echocardiography, the features of the well-known sepsis-related myocardial dysfunction have been better characterized (18).

Many are the reasons that make ECHO suitable for guiding hemodynamic management of septic critical patients at different stages of their critical illness: non-invasiveness, rapidity in adequately trained hands ECHO has the potential to non-invasively provide at the bedside instantaneous relevant diagnostic information on patients' cardiovascular status (19).

The Relation between surfactant and various echocardiographic measures, show no statistically significant difference between cases used surfactant and not used regarding various echocardiographic measures. Which agree with Vitali et al, 2014, in which left ventricular velocities did not change significantly after surfactant. (20).

Cardiac data comparison of lived and Died demonstrates statistically significant difference between

lived and died cases regarding audible murmur, cardiomegaly and inotropes. This is in agreement with Kozák *et al*, in which mid wall fractional shortening at 2 to 5 days ($P < .05$), and fractional shortening area ($P < .05$), as well as mid wall fractional shortening ($P < .01$) at 1 month of age. (21).

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