One Year Experience in Using High Frequency Oscillatory Mechanical Ventilation in Kasr El-Aini NICU in the Treatment of Neonatal Respiratory Failure

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Article History: Received: 15.05.2023 **Revised:** 25.06.2023 **Accepted:** 01.07.2023

Abstract:

Background: Respiratory distress is recognized as any signs of breathing difficulties in neonates. In the early neonatal period respiratory distress is common, occurring in up to 7% of newborn infants, resulting in significant numbers of term-born infants being admitted to neonatal units. Multiple conditions can present with features of respiratory distress. High frequency ventilation (HFV) has proved its unique efficacy in the treatment of acute respiratory distress, when conventional mechanical ventilation (CMV) has demonstrated a limited response. HFV was introduced in clinical practice in the early 1970s.

Aim and Objectives: The present work aims to study the outcome, complications and advantages and disadvantages of using high frequency ventilation in the management of respiratory distress in neonates.

Patient and Methods: We prospectively observed 40 neonates who were admitted in Kasr El-Aini NICU with respiratory distress. This population includes all full term and preterm neonates who developed respiratory distress over the first 24 hours after birth and needed to be mechanically ventilated with high frequency oscillatory ventilator.

Results: Died cases had significant lower GA with p value = 0.008 and weight p value = 0.002 as well as higher male frequency p value < 0.001. No significant difference between died and discharged cases regarding clinical findings at birth. Died cases had significant higher incidence of PDA, significant lower initial FiO2 than the final one and significant lower final PO2. In died cases both final pH and final PCO2 were significantly decreased. Death was associated with GA, weight, sex, PDA, HF start, initial FiO2 and final PO2.

Conclusion: Only Gestational age, weight and final pH and final PO2 had significant diagnostic performance in predicting death, moderate significance in initial PO2 and of low significance in the others.

Keywords: High frequency ventilation, diagnostic performance in predicting death.

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DOI: 10.48047/ecb/2023.12.9.159

Introduction:

Multiple conditions can present with features of respiratory distress. Common causes in term newborn infants include transient tachypnea of the newborn, respiratory distress syndrome, pneumonia, meconium aspiration syndrome, persistent pulmonary hypertension of the neonate and pneumothorax. Early recognition of respiratory distress and initiation of appropriate treatment is important to ensure optimal outcomes.(1)

Respiratory failure is the most common cause of neonatal hospitalization in NICU and is expressed as the existence of two or more than two of the following clinical and laboratory criteria: Clinical criteria: Retraction (suprasternal, supraclavicular, intercostals), Grunting, respiratory rate more than 60/min, central cyanosis, refractory apnea, reduced infant activities and Laboratory criteria: paCO2 > 60 mmHg, paO2 < 50 mmHg or sat O2 < 80% despite receiving 100% O2, pH < 7.25.(2)

Respiratory failure in infants has different intra and extra pulmonary causes, and rarely recovers without a ventilation support. Several solutions have been proposed for mechanical ventilation in neonates which include conventional mechanical ventilation and more recently high frequency ventilation (HFV), each has advantages and disadvantages .(3)

Our goal was to study the implementation, management strategies, benefits and complications of using high frequency oscillatory mechanical ventilation in neonates with respiratory failure admitted in NICU- Kasr El Aini hospital over 1 year either from the start of admission or after failure of other modes of ventilation such as Nasal CPAP or conventional mechanical ventilation.

Patients and Methods:

This study is a prospective observational study that was conducted on 40 neonates who were our population of study admitted in Kasr El-Aini NICU and put on high frequency ventilator either from

the start of their admission or after failure of other modes of ventilation like NCPAP or conventional mechanical ventilation over one year between March 2017 to April 2018. The study was approved by The Ethical Committee of Pediatrics Department, Faculty of Medicine, Cairo University.

Inclusion criteria

Our study population includes all full term and preterm neonates who developed respiratory distress over the first 24 hours after birth and needed to be mechanically ventilated with high frequency oscillatory ventilator, they were admitted in Kasr El-Aini NICU with respiratory distress syndrome (hyaline membrane disease), persistent pulmonary hypertension (PPHT), transient tachypnea of newborn, meconium aspiration syndrome (MAS), congenital pneumonia, air leak syndromes and congenital diaphragmatic hernia.

Exclusion criteria

The following neonates were excluded from this study: Patients with unstable vital signs as persistent hypotension with prolonged capillary refill time (> 3 sec) and with bradycardia, Complex congenital heart disease, Genetic syn¬dromes, Moderate to severe hypoxic-ischemic encephalopathy (HIE) (1-min Apgar score < 3), Infants with lethal malformations and Infants with recurrent apnea.

Methodology in details

In our study 40 neonates were subjected to the following: Demographic data collection and Careful history taking.

Detailed perinatal history was obtained, clinical examination (General examination, System examination and Chest examination) and Investigations (Capillary blood gases every 6 hours, Blood culture, Sputum culture, Chest x-ray, Cranial ultrasound and Echocardiography was done).

In the present study, all neonates were shifted to the NICU after initial stabilization in the delivery room. Neonates were monitored for development of respiratory distress over 24 hours of life. High frequency oscillatory ventilation was applied on 40 neonates who were admitted with respiratory distress to Kasr El- Aini NICU

Primary outcomes of using high frequency ventilation which are the most important outcomes to be assessed: Improvement and successful direct extubation from high frequency to NCPAP, Weaning from high frequency to conventional ventilation the extubation, Weaning from high frequency to conventional ventilation then to NCPAP then extubation, Further deterioration and death.

Statistical methods

The collected data were coded, tabulated, and statistically analyzed using IBM SPSS statistics (Statistical Package for Social Sciences) software version 18.0, IBM Corp., Chicago, USA, 2009.

Descriptive statistics were done for quantitative data as minimum & maximum of the range as well as mean ± SD (standard deviation) for quantitative normally distributed data, while it was done for qualitative data as number and percentage.

Inferential analyses were done for quantitative variables using Shapiro-Wilk test for normality testing, independent t-test in cases of two independent groups with normally distributed data and paired t-test in cases of two dependent groups with normally distributed data.

In qualitative data, inferential analyses for independent variables were done using Chi square test for differences between proportions and Fisher's exact test for variables with small expected numbers.

ROC curve was used to evaluate the performance of different tests differentiate between certain groups. The level of significance was taken at P value < 0.050 is significant, otherwise is non-significant.

RESULTS

Table (1). Comparison between Died and Discharged Cases Regarding Demographic Characteristics.

		Died (N=21)	**Discharged (N=19)**	***Statistics**
GA (weeks)		32.9 ± 4.3	36.6 ± 4.1	**#0.008***
Weight (kg)		1.8 ± 0.8	2.7 ± 0.7	**#0.002***
Sex	**Male**	17 (81.0%)	2 (10.5%)	**&<0.001***
	Female	4 (19.0%)	17 (89.5%)	
Survanta		8 (38.1%)	6 (31.6%)	#0.666
Mode of delivery	**CS**	19 (90.5%)	14 (73.7%)	§0.226
	NVD	2 (9.5%)	5 (26.3%)	

Total number of cases =40.

#Independent t-test; &Chi square test; §Fisher's exact test; *P-value is considered significant if it is less than 0.05; GA = gestational age; CS = cesarean section; NVD = normal vaginal delivery.

This table showed that there was a statistically significant difference between the studied groups as regard GA (weeks), Weight (kg) and Sex.

there was no statistically significant difference between the studied groups as regard Survanta and Mode of delivery.

Table (2). Comparison between Died and Discharged Cases Regarding Clinical Findings at Birth.

		Died (N = 21)	Discharged (N = 19)	Statistics
Apgar score 1 min		3.1±1.0	3.1±0.6	#0.969
Apgar score 5 min		7.0±1.2	6.9±1.0	#0.879
Downes score		6.0±0.6	5.8±0.7	#0.454
Causes of failure of other modes of ventilation	**Pneumothorax**	6 (28.6%)	5 (26.3%)	&0.967
	RDS	7 (33.3%)	6 (31.6%)	
	PPHT	8 (38.1%)	8 (42.1%)	

Total number of cases =40.

#Independent t-test, &Chi square test; RDS = Respiratory Distress Syndrome; PPHT = persistent pulmonary hypertension.

This table showed that there was no statistically significant difference between the studied groups as regard Comparison between Died and Discharged Cases Regarding Clinical Findings at Birth.

Table (3). Comparison between Died and Discharged Cases Regarding Basic Investigation.

		Died (N=21)	Discharged (N=19)	P
Culture	**Blood**	**4 (19.0%)**	**3 (15.8%)**	**§1.000**
	Sputum	**2 (9.5%)**	**0 (0.0%)**	**§0.488**
Echo-Cardiography	**PDA**	**18 (85.7%)**	**9 (47.4%)**	**#0.010***
	PPHT	**8 (38.1%)**	**13 (68.4%)**	**#0.055**
	PFO	**3 (14.3%)**	**6 (31.6%)**	**§0.265**
	Free	**2 (9.5%)**	**0 (0.0%)**	**§0.488**
x-ray	**Pneumothorax**	**9 (42.9%)**	**7 (36.8%)**	**#0.698**
	RDS	**10 (47.6%)**	**6 (31.6%)**	**#0.301**
	Free	**4 (19.0%)**	**0 (0.0%)**	**§0.108**
Cranial U/S	**Positive**	**12 (57.1%)**	**7 (36.8%)**	**#0.199**

Total number of cases =40.

&Chi square test, §Fisher's exact test; *P-value is considered significant if it is less than 0.05; PDA = patent ductus arteriosus; PHT = pulmonary hypertension; PFO = patent foramen ovale; RDS = respiratory distress syndrome; PPHT = persistent pulmonary hypertension.

This table showed that there was no statistically significant difference between the studied groups as regard Culture, x-ray, Cranial U/S and Echo-Cardiography except in PDA.

Table (4). Comparison between Died and Discharged Cases Regarding Initial Ventilation.

		Died (N=21)	Discharged (N=19)	Statistics
Initial	**HF**	0 (0.0%)	7 (36.8%)	§0.003*
	MV	8 (38.1%)	13 (68.4%)	&0.055
	CPAP	15 (71.4%)	2 (10.5%)	**&<0.001***
Duration (days)	**MV**	3.5±0.9	3.0±2.2	#0.544
	CPAP	1.5±1.1	1.0±0.0	#0.572
	Total duration before HF	2.4±1.5	2.2±2.2	#0.706

Total number of cases =40.

#Independent t-test, &Chi square test, §Fisher's exact test,*P-value is considered significant if it is less than 0.05; HF = high frequency; MV = mechanical ventilation; CPAP = continuous positive airway pressure.

This table showed that there was no statistically significant difference between the studied groups as regard Comparison between Died and Discharged Cases Regarding Initial Ventilation except in HF and CPAP.

Table (5). Comparison between Died and Discharged Cases Regarding Ventilation Conversion.

		Died (N = 21)	Discharged (N = 19)	Statistics
Conversion from HF	**Conversion**	8 (38.1%)	19 (100.0%)	#<0.001*
	MV	4 (19.0%)	13 (68.4%)	#0.002*
	CPAP	4 (19.0%)	8 (42.1%)	#0.112

Duration of HF (days)	2.9 ± 1.5	3.4 ± 1.6	#0.302

Total number of cases =40.

#Independent t-test, &Chi square test, §Fisher's exact test,*P-value is considered significant if it is less than 0.05; HF = high frequency; MV = mechanical ventilation; CPAP = continuous positive airway pressure.

This table showed that there was a statistically significant difference between the studied groups as regard Conversion from HF except in CPAP. there was no statistically significant difference between the studied groups as regard Duration of HF (days).

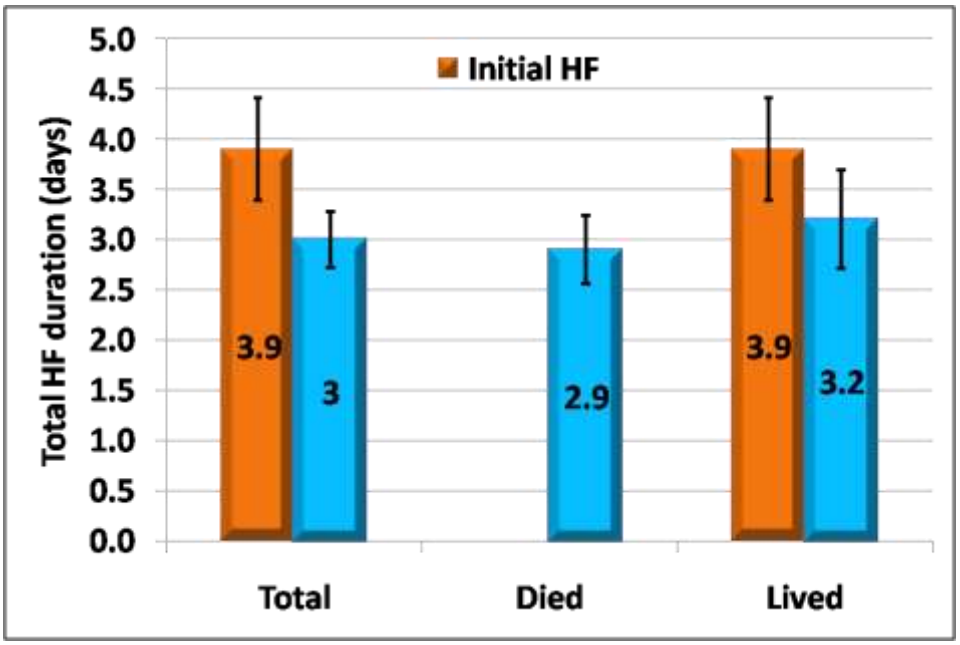

Figure (1). Comparison according to initial ventilation regarding total HFV duration in (days).

Table (6). Comparison between Died and Lived Cases Regarding Ventilation Parameters.

		Died (N=21)	Lived (N=19)	Statistics
FiO_2 %	**Initial**	81.3 ± 14.6	89.8 ± 10.8	**0.045***
	End	88.1 ± 18.2	81.9 ± 24.2	0.362
	^P	0.269	0.124	
MAP (CmH_2O)	**Initial**	18.5 ± 6.1	21.4 ± 4.9	0.108
	End	20.2 ± 8.0	20.9 ± 6.0	0.769
	^P	0.117	0.741	
pH	**Initial**	7.31 ± 0.21	6.54 ± 2.31	0.207
	End	7.19 ± 0.10	7.38 ± 0.15	0.091
	^P	**0.009***	0.110	
PO_2 (mmHg)	**Initial**	47.5 ± 27.6	65.0 ± 55.5	0.207
	End	40.1 ± 8.9	67.0 ± 46.1	**0.022***
	^P	0.153	0.910	
PCO_2 (mmHg)	**Initial**	52.1 ± 24.2	46.8 ± 24.0	0.495
	End	35.2 ± 6.6	35.1 ± 12.6	0.953
	^P	**0.004***	0.107	
HCO_3	**Initial**	17.9 ± 3.5	17.0 ± 6.6	0.591
	End	19.0 ± 4.0	21.1 ± 5.0	0.160
	^P	0.110	0.054	

#Independent t-test; &Chi square test; §Fisher's exact test; *P-value is considered significant if it is less than 0.05; FiO_2 = fraction of inspired oxygen; MAP = mean airway pressure; pH = the negative logarithm of hydrogen ion concentration; PO_2 = partial pressure of oxygen; PCO_2 = partial pressure of carbon dioxide; HCO_3 = bicarbonate.

This table showed that there was no statistically significant difference between the studied groups as regard Comparison between Died and Lived Cases Regarding Ventilation Parameters except in Initial FiO2 and End PO2.

Discussion:

High-frequency ventilation (HFV) uses small tidal volumes and extremely rapid ventilator rates. Despite the wealth of laboratory and clinical research on HFV, there are no established guidelines for prioritizing the use of HFV versus conventional mechanical ventilation (CMV) in neonatal respiratory failure. Examination of the currently available randomized controlled trials and meta-analysis of HFV versus CMV does not demonstrate any clear benefit of HFV either as a primary mode or as a "rescue" mode of ventilation in neonates who have respiratory insufficiency.(4)

Our results were agreeing with the study of Tana m. et al. which was done on 108 ELBW infants with RDS required elective HFOV within 24 hours of life and were directly extubated from HFOV, comparisons were made between newborns successfully extubated (Extubation Success Group) and newborns failing the extubation attempt (Extubation Failure Group). The only significant differences between the two groups were the higher percentage of males in the neonates who failed extubation and their lower GA.(5)

In our study we had 19 males (47.5%) and 21 females (52.5%). Amini et al. found in their study of 62 patients 37 patients (59.7%) were males and 25 patients (40.3%) were females (3). While the study of Chen et al. was carried on two groups, the first group included 103 neonates consisted of 59 males (57.3%) and 44 females (42.7 %) were put on nasal high frequency oscillatory ventilation (NHFOV), and the second group included 103 neonates consisted of 64 males (62.1%) and 39 (37.9 %) females were put on NCPAP.(6)

In our study, the Apgar score at 1 minute and that at 5 minute is of non-significant value among the died and discharged cases and this agrees with the study of Mukerji et al. which denoted that there was no significant value regarding the Apgar score at 1 minute and 5 minute respectively (7). These results agree also with those of a study carried out by Chen et al. who found that the Apgar score is of non-significant value (6). Also in Lee et al. the 1-minute Apgar score was 2.5 with range (1.0 – 5.0) and the 5-minute Apgar score was 5.4 with range (3.0 – 8.0) and both were of non-significant value .(8)

In our study we used HFV mode in 11 cases of pneumothorax, 6 cases of which were treated using high frequency and also HFV was used in 13 cases with respiratory distress syndrome 6 of which were passed; while Aurillia et al. reported in their study that five cases of preterm infants with birth weight ≤ 1250 g affected by respiratory distress syndrome and treated with NCPAP as first intention. These cases were intubated for worsening of respiratory distress due to occurrence of pneumothorax, and they were successfully treated using HFOV without chest tube insertion. So, they found that HFOV provided a conservative management, and reported their experience of using HFOV as a first-line of treatment of pneumothorax in preterm infants with respiratory distress syndrome.(9)

In Lee et al. study, no patients with congenital anomalies of cardiac, respiratory or central nervous system were found, while in our study 27 neonates had patent ductus arteriosus (PDA) and 9 neonates had Patent foramen ovale (PFO) (8). On the other hand, the exclusion criteria in Bottino et al. study were active medical treatment for patent ductus arteriosus (PDA), culture proven sepsis, major congenital malformations, genetic syndromes, and postoperative recovery period < 24 h in their study (10). Also, in A Mukerji et al. study the exclusion criteria were: (a) congenital/acquired abnormality of upper airways, (b) severe congenital anomalies and/or (c) severe nasal excoriation/injury.(7)

there are 17 cases with positive neurological findings like intraventricular haemorrhage (IVH) or periventricular leukomalacia 3 (PVL) or other neurological complications that represented 47.5% of the whole cases, and this was of non significant value to be occurred with HFV. These results are in agreement with the study of Salinas et al. who found that there was not an increased incidence of IVH or PVL in using HFV with high lung volume and so does not increase the risk of neurologic morbidity.(11)

In our study 17 cases were started with NCPAP for 1.4 ± 1days before shifting to HFV after CPAP failure. Fifteen cases of them were died when they were put on HFV after CPAP failure; that is of high significant value among the initial modes of ventilation, while those started with HFV have high significant value among the discharged cases or the discharged cases. Whereas; in Amini et al. study that compared CMV with HFPPV in the desired popula¬tion, 62 patients were entered to the study. Where 37 patients (59.7%) were males and 25 patients (40.3%) were females, both groups were matched in demographic characteristics and there was no significant difference for sex between them .(3)

CONCLUSION

Only Gestational age, weight and final pH and final PO2 had significant diagnostic performance in predicting death, moderate significance in initial PO2 and of low significance in the others.

Conflict of interest:

NIL.

Source of funding:

NIL.

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