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ORIGINAL ARTICLE

Outcome of Acute Respiratory Distress Syndrome Patients Mechanically Ventilated with Low Flow Rate, Decelerating Pattern and Positive End Expiratory Pressure

Mustafa Samy Negm [1*], Amany Fawzy Morsy [1], Adel Salah Ahmed [1]
1: Chest department,faculty of medicine,zagazig university,zagazig.Egypt

*** Corresponding author:**
Mustafa samy negm
Resident pulmonology at chest department ,faculty of medicine,zagazig university,zagazig.Egypt
mustafasamynegm558@gmail.com

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ABSTRACT

Background: Acute Respiratory Distress Syndrome(ARDS) was recognized as the most severe form of acute lung injury, a form of diffuse alveolar injury. The current ARDS protocol does not specify any particular ventilator mode.We aimed to assess the outcome of ARDS patients in relation to low tidal volume,low inspiratory flow rate with decelerating pattern and average Positive End Expiraory Pressure(PEEP). **Methods:** Twenty four newly admitted patients with ARDS were studied. Data parameters at onset of diagnosis were measured, upon them ARDS protocol of mechanical ventilation has been conducted.They were admitted in the period of November 2017 to December 2018 at Respiratory and General Intensive Care Units of Zagazig University Hospitals.The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. Low tidal volume with permissive hypercapnea, of 8 mL/kg of predicted body weight was applied then justified by 7 ml/kg then 6ml/kg to achieve best oxygenation.Plateau pressures not exceeding 30 cm H2O was maintained.Recruitment maneuvers with PEEP of 5cm H2O with titration by 2cm H2O aiming to achieve best PEEP which reach O2 saturation≥90% without cardiac output deterioration.Lowest flow rate with decelerating pattern was applied to increase inspiratory time with subsequent improvement oxygenation. Serial recording of ventilator and ABGs parameters at 1,4,8th day of mechanical ventilation. **Results:** In spite of using ARDS network ventilatory protocol ,the mortality is still high (58.3%) .Trauma was the most frequent risk factor in 60% of survived patients followed by pneumonia in 20% of survived patients ,aspiration in 10% and drug overdose in10%of survived patients.Trauma was the most frequent risk factor in 28.56% of died patients,followed by pneumonia ,aspiration and sepsis in 21.4% of died patients each then drug overdose in 7.24%of died ARDS patients. **Conclusion:** The optimal mean tidal volume used in survived ARDS patients was 6.16±0.32 (ml/kg), mean PEEP was 11.46±0.97(cm H2O) and mean inspiratory flow rate was 43.76±1.11(L/min)
Keywords: ARDS,tidal volume,PEEP,inspiratory flow rate.

INTRODUCTION

Acute respiratory distress syndrome (ARDS) is a life threatening respiratory condition characterized by hypoxemia, and stiff lungs [(1)]; without mechanical ventilation most patients would die. ARDS represents a stereotypic response to many different inciting insults and evolves through a number of

different phases: alveolar capillary damage to lung resolution to a fibro-proliferative phase [(2)]. The pulmonary epithelial and endothelial cellular damage is characterized by inflammation, apoptosis, necrosis and increased alveolar-capillary permeability.[(3)]

This study aimed to assess the outcome of ARDS patients on low tidal volume,low inspiratory flow rate with decelerating pattern and Positive End Expiraory Pressure.

METHODS

This study was carried out at Respiratory and General Intensive Care Units of Zagazig University Hospitals from November 2017 to December 2018. Written informed consents were obtained from all patients' relatives. After obtaining approval of Institutional Review Board-Zagazig University (IRB-ZU). Twenty four ARDS patients were studied . The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.They were (13) males , and (11) females with a mean age of 49.75±13.96 years.

Inclusion Criteria

All patients fulfilled the criteria of ARDS according to Berlin criteria 2012:Timing (within 1 wk of clinical insult or onset of respiratory symptoms). Radiographic changes (bilateral opacities not fully explained by effusions, consolidation, or atelectasis). Origin of edema (no evidence of LVF or fluid overload). Severity based on the PaO_2/FiO_2 ratio on 5 (cm H_2O) of PEEP[(4)] .

The 3 categories are mild (PaO2/FiO2 200-300), moderate (PaO2/FiO2 100-200), and severe (PaO2/FiO2 ≤100.

Exclusion criteria

no exclusion criteria and all patients of ARDS ,regaredless the cause, were evaluated.

Study design:

A cross sectional study.

Methods

The following was done for all patients :

All patients in the study were subjected to the following :

1-Meticulous medical history taking for diagnosis and identification of the aetiology of ARDS

2-General examination stressing on other system affection

3-Full local chest examination.

4-Portable chest x-ray (on admission and order by staff).

5-Laboratory investigations:

A) Complete blood count (CBC) :stressing on White blood cells total and differential count, Hemoglobin and platelet count to show severity and prognosis of ARDS patients.

B) LFT

C) KFT

D) Random blood sugar.

E) CRP in cases of ARDS secondary to pneumonia on admission and follow up daily.

F) ABGs on admission and follow up as more needed

6- ECG and Echo done to exclude heart failure that mimics bilateral infiltration of ARDS cases.

7- Continuous monitoring of Pulse oximetry, non-invasive blood pressure, central venous pressure, and urine output.

8-Serial daily recording of ventilator parameters as; TV (in mL/kg PBW), end-inspiratory plateau pressure (Pplat), positive end-expiratory pressure (PEEP), , inspired oxygen fraction (FiO_2), .

9-Reports of patients complictions

10-End point of the study is discontinuation of mechanical ventilation ,patient death or need for change to another strategy.

11-The ventilatory strategy is lung protective ventilation strategy according to **(Thompson and Bernard, 2011)**[(4)] :

ARDS Clinical Network Mechanical Ventilation Protocol was applied as the following (Thompson and Bernard, 2011):

- Predicted body weight was calculated as the following:

Males: =50 +2.3 (Height (inches) -60)

Females: = 45.5 +2.3 (Height (inches) -60)

- Tidal volume was firstly 8 ml/kg PBW and this was reduced by 1 ml/kg at intervals ≤ 2hours until TV became 6ml /kg PBW.
- TV & RR were adjusted to achieve a target pH & Pplat goals.
- Oxygenation goal : PaO_2 (55-80 mmHg) or SpO_2 (88-95%) by applying incremental FIO_2 /PEEP combination using a minimum PEEP of 5 CmH_2O
- Recruitment maneuvers with PEEP of 5Cm H_2O with titration by 2cm H_2O aiming to achieve best PEEP which reach O_2 saturation≥90% without cardiac output deterioration.
- Pplat goal: (≤ 30 CmH_2O).
  Check Pplat (0.5 sec inspiratory pause), at least every 4 hours and after each change of PEEP or TV.
  If Pplat > 30 Cm H_2O: TV was decreased by 1 ml/kg steps (minimum VT 4ml/kg).
  If Pplat < 25 Cm H_2O and TV is < 6ml /kg, TV was increased until Pplat > 25 Cm H_2O or TV = 6 ml /kg.
  If Pplat < 30 CmH_2O and breath stacking or dys-synchrony occurs: TV may be increased in 1ml/kg increment to 7 or 8 ml /kg provided Pplat ≤ 30 Cm H_2O
  - Set inspiratory flow rate about(40-45 L/min) to be the lowest to increase inspiratory time with subsequent improvement of oxygenation and continue monitoring Intrinsic PEEP(Total PEEP-Extrinsic PEEP).
  - All patients were subjected to decelerating pattern of flow to increase inspiratory time to improve oxygenation
- pH goal: 7.30-7.45
  Acidosis Management: (pH < 7.30)
  If pH 7.15-7.30: Increase RR until pH > 7.30 or PaCO2 < 25 (Maximum set RR = 35). If pH < 7.15: Increase RR to 35.
  If pH remains < 7.15, TV may be increased in 1 ml/kg steps until pH > 7.15 (P plat target of (30 Cm H2Omay be exceeded).
  May give NaHCO3
  Alkalosis Management: (pH > 7.45) Decrease ventilatory rate if possible.
- I: E ratio goal: Recommend that duration of inspiration be ≤ duration of expiration.
- Weaning
  A. Conduct a spontaneous breathing trial daily according to the protocol of weaning **(Osler,2014)**[5].

12- The following ventilatory and ABGs parameters were recorded and studied at 1,4,8th day of mechanical ventilation;TV,inspiratory flow rate,PEEP,plateau pressure ,pH,PaO_2 ,$PaSO_2$ and $PaCO_2$.

Statistical Analysis

Data collected throughout history, basic clinical examination, laboratory investigations and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 20.0)software for analysis. According to the type of data qualitative represent as number and percentage , quantitative continues group represent by mean ± SD , the following tests were used to test differences for significance;.difference and association of qualitative variable by Chi square test (X2) . Differences between quantitative independent groups by t test or Mann Whitney, multiple by ANOVA or Kruskal Wallis, correlation by Pearson's correlation or Spearman's . P value was set at <0.05 for significant results &<0.001 for high significant result.

RESULTS

Table(1): shows the characteristics of the studied patients . Mean age of the studied patients was 49.75±13.96 years . Regarding sex,the studied patients show that 54.2% were males and 45.8% were females . The percentage of smokers was 37.5% while 62.5% were non- smokers.

Table(2): shows mortality number which was (14)patients from total (24)patients while survived was (10) patients with a percent of 41.7% of studied ARDS patients.

Table(3):shows most frequent etiologies that leads to ARDS in survived and died patients.Trauma was most frequent in 60% of survived patients followed by pneumonia in 20% of survived patients ,aspiration in 10% and drug overdose in10%of survived patients while trauma was most frequent in 28.56% of died patients,followed by pneumonia ,aspiration and sepsis in 21.4% of died patients each then drug overdose in 7.24%of died ARDS patients.

Table(4):shows correlation between mean PEEP(positive end expiratory pressure) and mean inspiratory flow rate during MV of studied ARDS patients.PEEP was significantly positive correlated with PaO_2(partial pressure of oxygen) and FiO_2(fraction of inspired oxygen) but PaO2& FiO2 was significantly negative correlated with mean inspiratory flow rate.

Table(5):demonstrates difference of mean parameters of survived and died patients regarding mean parameters at the onset of ARDS and mean parameters of all days and concluded significant increase of mean FiO2,PEEP,PaO2 and SaO2(oxygen saturation).

in all patients at onset of ARDS and mean values of all days ,also shows statistically significant decrease of TV(tidal volume),Pplateau(plateau pressure) and inspiratory flow rate in all studied patients between onset of ARDS and mean values with no significant change in pH and PaCO2 (partial pressure of carbon dioxide) in all ARDS patients.

Table(6):shows comparison between survived and died cases regarding pH,PaO_2 and $PaCO_2$ and SaO2. pH was significantly lower in 4th day , 8th day and mean value.PaO_2 and $PaCO_2$ in the 8th day were significantly lower in died than survived ARDS patients while SaO2 was significantly lower in 8th day and in mean reading in died ARDS patients.

Table(7):shows comparison between survived and died cases regarding to FIO_2,TV,PEEP, Plateau pressure and inspiratory flow rate . FIO_2 was significantly higher in died patients in 8th day , regarding TV only in 1st day died was significantly lower.Regarding PEEP, died patients were significantly lower in 1st day but significantly higher in 8th day while inspiratory flow rate was significantly lower in 8th day and in mean reading.

Table 1. Age, Sex and smoking habit distribution among studied ARDS patients (N=24)

		Age(years)	
Mean± SD		**49.75±13.96**	
Median (Range)		**46.5 (19-75)**	
		N	**%**
Sex	**Male**	**13**	**54.2**
	Female	**11**	**45.8**
Smoking	**-VE**	**15**	**62.5**
	+VE	**9**	**37.5**
	Total	**24**	**100.0**

Table 2. Outcome of MVof studied ARDS patients

		N	%
Mortality	**Died**	**14**	**58.3**
	Improved	**10**	**41.7**
	Total	**24**	**100.0**

Table 3. Etiologies of ARDS in survived and died patients

		Survived		Died	
		N	**%**	**N**	**%**
Etiology	**Trauma**	**6**	**60%**	**4**	**28.56%**
	Pneumonia	**2**	**20%**	**3**	**21.4%**
	Aspiration	**1**	**10%**	**3**	**21.4%**
	Sepsis	**-**	**-**	**3**	**21.4%**
	Drug overdose	**1**	**10%**	**1**	**7.24%**
	Total	**10**	**100%**	**14**	**100%**

Table 4. Correlation between mean PEEP and mean inspiratory flow rate to mean PaO_2 and FiO_2 during MV of studied ARDS patients

		FiO_2(MEAN)	PaO_2(MEAN)
PEEP(MEAN)	**r**	**0.542****	**0.492***
	P	**0.006**	**0.012**
Flow rate(MEAN)	**r**	**-0.417***	**-0.409***
	P	**0.043**	**0.048**

Table 5. Comparison between ventilatory and ABG parameters at the onset of ARDS(zero day) and mean readings among died and survived ARDS patients

Mortality		Mean	Std. Deviation	Paired t	P
Died	FiO2(0)%	**46.7857**	**7.23430**	**4.929**	**0.00****
	FiO2(MEAN)%	**61.5476**	**10.40760**		
	TV(0)(ml/kg)	**7.3571**	**.74495**	**6.571**	**0.00****
	TV(Mean) (ml/kg)	**5.9524**	**.52472**		
	PH(0)	**7.3729**	**.03989**	**1.969**	**0.071**
	PH(MEAN)	**7.3496**	**.04904**		
	PEEP(0)($Cm.H_2O$)	**5.0000**	**.00000**	**19.882**	**0.00****
	PEEP(MEAN)($Cm.H_2O$)	**11.2857**	**1.18291**		
	Pplat(0) ($Cm.H_20$)	**30.2857**	**1.54066**	**5.156**	**0.00****
	Pplat(MEAN) ($Cm.H_20$)	**28.1429**	**1.60376**		
	PaO_2(0)%	**46.9286**	**6.52173**	**4.669**	**0.00****
	PaO_2(MEAN)%	**54.6667**	**7.95151**		
	$PaCO_2$(0)%	**40.9286**	**6.46249**	**2.038**	**0.062**
	PaCO2(MEAN)%	**37.9048**	**6.15425**		
	Flow(0) (l/min)	**55.9286**	**3.47440**	**11.496**	**0.00****
	Flow(MEAN) (l/min)	**44.3333**	**1.87197**		
	SaO_2(0)%	**76.2857**	**6.88844**	**7.237**	**0.00****
	SaO_2(MEAN)%	**83.7262**	**6.33691**		
survived	FiO_2(0)%	**43.5000**	**6.25833**	**6.552**	**0.00****
	FiO_2(MEAN)%	**63.3333**	**7.61739**		
	TV(0)	**7.6000**	**.51640**	**9.588**	**0.00****
	TV(Mean)	**6.1667**	**.32394**		
	PH(0)	**7.3890**	**.04280**	**1.227**	**0.251**
	PH(MEAN)	**7.4023**	**.01938**		
	PEEP(0)($Cm.H_2O$))	**5.0000**	**.00000**	**21.056**	**0.00****
	PEEP(MEAN)($Cm.H_2O$)	**11.4667**	**.97119**		

		Pplat(0) ($Cm.H_20$)	**31.7000**	**5.49848**	**2.786**	**0.021***
		Pplat(MEAN) ($Cm.H_20$)	**29.1000**	**4.00324**		
		PaO_2(0)%	**44.5000**	**5.56277**	**6.208**	**0.00****
		PaO_2(MEAN)%	**60.7333**	**7.40003**		
		$PaCO_2$(0)%	**38.7000**	**6.94502**	**0.449**	**0.664**
		$PaCO_2$(MEAN)%	**38.2000**	**4.72503**		
		Flow(0) (l/min)	**58.0000**	**5.83095**	**8.121**	**0.00****
		Flow(MEAN) (l/min)	**43.7667**	**1.11167**		
		SaO2(0)%	**74.9000**	**5.50656**	**8.510**	**0.00****
		SaO2(MEAN)%	**88.4000**	**3.67776**		

Table 6. Comparison of ABG parameters between survived and died ARDS patients

	Died (N=14)	Survived (N=10)	t	P
pH(0)	**7.37±0.039**	**7.38±0.042**	**0.948**	**0.353**
pH(1)	**7.36±0.053**	**7.4±0.04**	**1.924**	**0.067**
pH(4)	**7.34±0.057**	**7.39±0.02**	**2.870**	**0.009***
pH(8)	**7.34±0.03**	**7.4±0.03**	**4.707**	**0.00****
pH_MEAN	**7.34±0.04**	**7.4±0.01**	**3.207**	**0.004***
PaO_2(0)%	**46.92±6.52**	**44.5±5.56**	**0.954**	**0.350**
PaO_2(1)%	**50.85±9.13**	**52.0±7.37**	**-0.326**	**0.747**
PaO_2(4)%	**55.21±7.52**	**60.1±9.06**	**-1.441**	**0.164**
PaO_2(8)%	**58.2±3.91**	**70.1±7.24**	**-4.569**	**0.00****
PaO_2_MEAN%	**54.66±7.95**	**60.73±7.4**	**-1.895**	**0.071**
$PaCO_2$(0)%	**40.92±6.46**	**38.7±6.94**	**0.808**	**0.428**
$PaCO_2$(1)%	**41.64±7.42**	**38.4±9.2**	**0.955**	**0.350**
$PaCO_2$(4)%	**36.5±6.76**	**38.8±3.79**	**-0.968**	**0.344**
$PaCO_2$(8)%	**32.8±4.7**	**37.4±2.75**	**-2.666**	**0.016***
$PaCO_2$_MEAN%	**37.9±6.15**	**38.2±4.72**	**-0.127**	**0.900**
SaO_2(0)%	**76.28±6.88**	**74.9±5.5**	**0.526**	**0.604**
SaO_2(1)%	**80.35±7.48**	**82.2±6.62**	**-0.622**	**0.540**
SaO_2(4)%	**84.42±5.45**	**88.3±5.12**	**-1.756**	**0.093**
SaO_2(8)%	**88.1±3.34**	**94.7±1.05**	**-5.943**	**0.00****
SaO_2(MEAN)%	**83.72±6.33**	**88.4±3.67**	**-2.087**	**0.049***

Table 7. Comparison of ventilator parameters (between survived and died ARDS patients

	Died (N=14)	Survived (N=10)	t	P
FiO_2(0)%	**46.78±7.23**	**43.5±6.25**	**1.158**	**0.259**
FiO_2(1)%	**55.0±10.56**	**73.0±8.56**	**4.439**	**0.00****
FiO_2(4)%	**61.42±9.49**	**62.5±10.6**	**0.260**	**0.797**
FiO_2(8)%	**70.45±13.5**	**54.5±6.43**	**3.397**	**0.003***
FiO2(MEAN)%	**61.54±10.4**	**63.3±7.61**	**0.460**	**0.650**
TV(0) (ml/kg)	**7.35±0.74**	**7.6±0.51**	**0.887**	**0.385**
TV(1) (ml/kg)	**6.5±0.65**	**7.1±0.56**	**2.345**	**0.028***
TV(4) (ml/kg)	**5.85±0.66**	**5.9±0.31**	**0.189**	**0.852**
TV(8) (ml/kg)	**5.36±0.67**	**5.5±0.52**	**0.513**	**0.614**
TVMean(ml/kg)	**5.95±0.52**	**6.16±0.32**	**1.141**	**0.266**
PEEP(0) ($Cm.H_2O$)	**5**	**5**	**0.00**	**1**
PEEP(1) ($Cm.H_2O$)	**9.71±1.48**	**13.7±1.33**	**-6.734**	**0.00****

PEEP(4) (Cm.H_2O)	**11.57±1.45**	**11.2±1.03**	**0.691**	**0.496**
PEEP(8) (Cm.H_2O)	**13.0±1.49**	**9.5±0.97**	**6.220**	**0.00****
PEEP(MEAN) (Cm.H_2O)	**11.28±1.18**	**11.46±0.97**	**-0.397**	**0.695**
Pplat(0) (Cm.H_20)	**30.28±1.54**	**31.7±5.49**	**-0.920**	**0.367**
Pplat(1) (Cm.H_20)	**29.57±2.44**	**31.4±5.81**	**-1.060**	**0.301**
Pplat(4) (Cm.H_20)	**27.78±1.8**	**29.1±3.95**	**-1.100**	**0.283**
Pplat(8) (Cm.H_20)	**26.9±1.19**	**26.8±2.39**	**0.118**	**0.907**
Pplat(MEAN) (Cm. H_20)	**28.14±1.6**	**29.1±4.0**	**-0.813**	**0.425**
Flow rate(0) (L/min)	**55.92±3.47**	**58.0±5.83**	**-1.091**	**0.287**
Flow rate(1) (L/min)	**46.28±2.01**	**45.2±1.98**	**1.308**	**0.204**
Flow rate(4) (L/min)	**44.28±1.81**	**44.2±1.39**	**0.125**	**0.902**
Flow rate(8) (L/min)	**41.2±1.31**	**41.9±0.99**	**-1.342**	**0.196**
Flow rate (MEAN) (L/min)	**44.33±1.87**	**43.76±1.11**	**0.853**	**0.403**

DISCUSSION

ARDS involves a heterogeneous process that results in diffuse alveolar damage. The current characteristics include bilateral infiltrates on chest radiograph, PaO_2 to FiO_2 ratio less than **300**, no evidence of left ventricular failure evidenced by a pulmonary capillary wedge pressure less than 18 mm Hg , and usually need for invasive mechanical ventilator .[6]

In the study, we sought to determine the factors that improve outcomes in the treatment of ARDS in the new era of LPV strategy after application of the main important factors that improve survival: High PEEP,low tidal volume and low inspiratory flow rate.

General improvements in critical care contributed to some decline in the mortality of ARDS patients, but these benefits reached a plateau by the 1990s[7].

Our study showed that mean tidal volume in survived patients**, table(7)** was **(6.16±0.32 ml/kg)**with no significant difference between it and mean tidal volume of non survived patients**(5.95±0.52 ml/kg)** .This is near to an observational study of **Kallet et al.**[8] **and Amato et al.study**[9] where the ARDS Net protocol was more strictly adhered to,as evidenced by an average TV of **6.2 ml/kg** of the predicted body weight (PBW) that was maintained over the first week of ARDS, the hospital mortality rate was **32%** despite the presence of some of the same comorbid conditions as those found in the present study. **Yoshida et al.**[10] conducted one randomized study of low tidal volume **(TV = 6 mL/kg)** versus what was considered standard tidal volume **(TV = 12 mL/kg)** in all ventilated patients in a surgical intensive care unit (SICU).They found decreased morbidity in the low tidal volume group. Their analyses revealed that patients who were ventilated with tidal volume more than 6.5 ml/kg PBW had a higher ICU mortality, and each increase in initial tidal volume of 1 ml/kg PBW was associated with a 23% increase in ICU mortality[11].

Our study used average PEEP in LPV strategy and showed mean PEEP in survived patients in **table(7)** was **11.46±0.97 (cm.H_2O)** and **11.28±1.18(cm.H_2O)** in died patients. A study of **Briel et al.**[12] about this trade-off in PEEP has been conducted and the results showed that with higher PEEP strategy, they observed 5 % reduction in the mortality rate for the patients having the worst type of oxygenation defect**.** In contrast with **Pinatado et al.**[13] who stated protective mechanical ventilation with PEEP application according to the highest compliance was associated with less organ dysfunction and a strong nonsignificant trend toward lower mortality. The expected consequence of increased PEEP level would be

an increase in the physiological dead space, and the increase in dead space represents an impaired ability to excrete carbon dioxide,and the use of high PEEP might be the cause of decrease in flow rate in ARDS patients.

This study investigated inspiratory flow rate, **table(7)** that showed mean inspiratory flow rate in survived ARDS patients was **43.76±1.11** (L/min) and **44.33±1.87**(l/min) in died ARDS patients.Also **table(8)** showed highly significant statistical difference between zero reading at onset of ARDS and mean inspiratory flow rate in all studied ARDS patients which lead to increase and maintain mean airway pressure.This is in harmony with **Chen et al. study**[14] who stated the use of high PEEP was one of the causes of increased flow resistance and decreased inspiratory flow rate in ARDS patients.They concluded that monitoring of inspiratory flow rate and flow resistance during mechanical ventilation might be useful for the proper management of ARDS patients in the Surgical ICU.

As regard Mortality in relation to Risk factors, **table(3)** showed that the most frequent aetiology in the studied ARDS patients was trauma in **41.6%** of patients,followed by pneumonia in **20.8%** of patients then aspiration in **16.6%** of patients then sepsis in **12.6%** of patients finally drug overdose in **8.4**% of patient **.Table(6)** showed most frequent etiologies that leads to ARDS in survived and died patients.Trauma was the most frequent in **60%**of survived patients followed by pneumonia in **20%** of survived patients ,aspiration in **10%** and drug overdose in**10%** of survived patients while trauma was most frequent in **28.56%** of died patients,followed by pneumonia ,aspiration and sepsis in **21.4%** of died patients each , then drug overdose in **7.24%**of died ARDS patients.This meets the results of **Laura et al.**[15] who stated that trauma is the most common risk factor for ARDS. **Weiss et al.**[16]stated that several subphenotypes of ARDS have been described with sepsis associated ARDS being the most common. This can be explained by the relative small sample size of this study and most of cases were studied at Trauma Intensive Care Unit and SICU ,so the most common cause in my study was trauma. Regarding to risk factors in survived patients ,we found that most frequent causes that leads to ARDS in survived patients was t**rauma** in **60%** of survived patients .

We used decelerating flow pattern in all cases. As illustarated by **Pilbeam and Cairo** [17] as decelerating pattern offers the highest level of flow at the start of a breath, when patient flow demand is often greatest. This flow pattern, when used,may lead to improved patient/ventilator synchrony and provide benefits to those patients who demand high inspiratory flow rates. Additional advantages of this flow pattern include the ability to lower peak inspiratory pressure compared to a constant flow waveform pattern . **Guldager et al.**[18] revealed that a decelerating flow wave form pattern caused a 19% decrease in a patient's peak inspiratory pressures without impacting hemodynamics. Another study of decelerating waveform pattern has been shown to reduce dead space ventilation and alveolar-arterial gradient for oxygen[17].In other study, **Roth et al.** [19] showed that ventilation with decelerating inspiratory flow showed no benefit concerning alveolar recruitment, gas exchange or inspiratory pressures when compared with ventilation with constant inspiratory flow.

On the other hand ,after applying of LPV strategy we found significant difference of mean TV,PEEP ,FiO_2 ,PaO_2 ,$PaCO_2$,Pplat,pH**,** inspiratory flow rate and SaO_2**,table(5)** at the onset of ARDS and mean parameters of all days in the studied ARDS patients and showed significant improvement regarding all parameters except mean pH and mean $PaCO_2$ of died patients as patients passed in hypotension and shock which put them on vasopressor and some of them passed in refractory shock with metabolic acidosis and CO_2 decrease to compensate decreasing of HCO_3.Also 16.7% of the studied ARDS patients had renal failure leading to metabolic acidosis with low pH.

Table (4) showed that by applying high PEEP and decreased mean inspiratory flow rate with decelerating flow pattern which leads to more recruitment of alveoli and increased mean airway pressure.This strategy leads to improvement of PaO_2 so there is positive correlation between PEEP and PaO_2 and negative correlation between inspiratory flow rate and PaO_2.The increased FIO_2 with increased PEEP can be explained by ,the fact that our mortality rate is high 58.3% and there was worsenenig cases,we used high FiO_2 in our cases because we applied maximum allowable PEEP to guard against decreased COP or wosenenig shock so FiO_2 increased to fulfill more oxygenation to tissues with increased PEEP and decreased inspiratory flow rate.

Regarding mortality rate in **table(2)**, the mortality rate (**14 cases**) was approximately **58.3%**. Over the past two decades, there have been studies from the world's best medical centers claiming that mortality has decreased to **30%** , which may be due to improving in the specific management of patients with ARDS as well as in the general management of ICU patients[20] .Similarly, observational studies performed at the University of California San Francisco Hospital System over the past 15 years have also shown a decline in mortality. In the early 1990s, **Doyle et al.**[21] reported a hospital mortality rate of 58% for patients with ARDS, whereas by the late 1990s, **Nuckton et al.**[22] found that the mortality rate of patients with ARDS alone was 42%. The study of **Abdelbaset et al.**[23] showed that mortality rate reached 41%.Another study **Nafea et al.**[24] showed mortality rate 60% in ARDS patients.This finding suggests the possibility that relatively higher mortality rate in our patients, despite the intention to use lung protective ventilation due to presence of high co-morbidities and small sample size.

Regarding comparison between mean ABGs and ventilator parameters of survived and died ARDS patients (**Tables 6-7)** we have no signifiacant statistical difference between the 2 groups except in mean pH and mean SaO_2 as died patients passed in refractory shock and acute renal failure which changed pH towards metabolic acidosis. Mean SaO_2 in survived cases is improving and mean PaO2 is increasing in contrast to died cases which deteriorate and mean SaO_2 decreased.

CONCLUSION

In spite of the use of ARDS network ventilatory protocol , is still high (58.3%). We can applied lung protective ventilation of tidal volume 6.16±0.32 (ml/kg),PEEP11.46±0.97(cmH_2O) and flow rate 43.76±1.11(L/min) as they carried best outcome of ARDS patients. Decelerating flow pattern can be applied in ARDS patients.Lower PEEP after one week carry good prognosis in ARDS patients.Lower flow rate limits plateau pressure to target.

The management of ARDS patients requires well trained and expert intensivist and pulmonologist in the art of mechanical ventilation with the implantation of LPV. The application of low tidal volume,low inspiratory flow rate,decelerating pattern and average PEEP is advisable in ARDS patients.ARDS network protocol may not be the perfect solution for ARDS patients.

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