Predictors of weaning failure from mechanical ventilation in post cardiac surgery patients

Mohamed Abd Elkhalek Mohamed Ali[1], Noha Mohamed Kamar Mohamed ELsharnouby[1], Hanaa Mohamed Elgendy[1], Diaa Eldin Shalaby Mohamed[1], Hatem Mahmoud Sayed AbdelRasol[1*]

[1]Department of Anesthesiology, intensive Care medicine and pain management, Faculty of Medicine – Ain Shams University

***Corresponding author:** Hatem Mahmoud Sayed AbdelRasol
Mobile:
Email: dr.hatem123@gmail.com

ABSTRACT

Background: Cardiac surgery disrupts homeostasis, putting the patient in danger. Weaning from a ventilator requires clinical judgement and multiple signs. Patients recovering from anaesthesia can restart spontaneous ventilation. Cardiopulmonary bypass recovers during breathing. Weaning patients from mechanical ventilation after heart surgery involves vital capacity, tidal volume, respiratory rate, and minute ventilation. Others have related advanced age, comorbidities, protracted extracorporeal circulation, cardiac dysfunction, and low cardiac output to unsuccessful weaning of cardiac patients from mechanical ventilation and postoperative hemodynamics and neurological alterations to long-term ventilation.

Aim: To determine predictors of unsuccessful weaning from mechanical ventilation after cardiac surgery, and therefore avoid the potentially hazardous long stay in ICU.

Subjects and Methods: This study was conducted at Ain Shams University Hospital, post cardiac surgery ICU including 80 patients undergo cardiac surgery and receiving mechanical ventilation after operation.

Results: Most of our included patients were successfully extubated. Most of our included patients developed intraoperative complications; the commonest complications were pacemaker wire followed by VF. Most of our included patients have CABG followed by MVR. Most of our included patients have mild tracheal secretion followed by moderate secretion. Charlson Comorbidity Index, COPD and CVS were statistically significant higher in failed extubation than weaned group while MBP and PO2/FIO2 were statistically significant lower in failed than weaned patients.

Conclusion: From findings of this study we can conclude that SOFA (≥ 6), Comorbidity index (>3), sever tracheal Secretion, RR/TV (≥57), MV (≥ 13.5) are independent predictors of failed weaning from mechanical ventilation.

Key Words: weaning failure, mechanical ventilation, cardiac surgery.

INTRODUCTION

Cardiac surgery is a complex procedure that alters several mechanisms required for homeostasis, leading the patient to a critical condition. To ensure adequate recovery, intensive care management is required during post-operative period.[1] Ventilatory support is often removed right after admission to the intensive care unit (ICU), since the patient is lucid and has hemodynamic stability. However, sometimes patients need prolonged mechanical ventilation, which increases both the cost and the risk of complications.[2] Ventilator weaning decision must be based not only on clinical judgment, but also on several predictors that may be applied to support the decision-making process.[3]

Postoperative cardiac surgery patients are generally able to resume spontaneous ventilation as soon as they have recovered from the anaesthesia; therefore the mode of ventilation should have little impact on the decision to extubate these patients.[4] During ventilation cardiovascular

and other systems are thought to recover from the profound physiologic disturbances induced by cardiopulmonary bypass. However, recent efforts to improve the cost-effectiveness of surgical procedures, combined with revised anaesthetic techniques have resulted in a trend toward early weaning from ventilatory support after cardiac surgery.[5]

Unfortunately, ICU physicians' prediction for MV weaning is less clear and no clinical test or scoring system has been able to correctly identify patients for whom MV duration will be prolonged and therefore leading to their long stay in ICU and needless interventions such as tracheostomy.[6]

Parameters of respiratory mechanics and oxygenation including arterial blood gas analysis and the determination of ventilator indexes such as vital capacity, tidal volume, respiratory rate and minute ventilation are commonly used to wean patients from mechanical ventilation after cardiac operations.[7]

Others have identified advanced age, comorbidities, extended time of extracorporeal circulation, cardiac dysfunction, and low cardiac output as factors associated with the failed weaning of cardiac patients from mechanical ventilation, and postoperative hemodynamics and neurological alterations, as factors contributing to their long term ventilation.[8]

PATIENTS AND METHODS

This study was an Observational prospective study and it was conducted at Ain Shams University Hospital, post cardiac surgery ICU. The study duration was 24 months.

Patients underwent elective open heart cardiac surgery, admitted to the ICU and submitted to general anaesthesia and invasive mechanical ventilation, were enrolled in the study. . The patients were divided into two subgroups according to the duration of ventilator dependence (group 1 <48 hours, n=73, 91.3%; group 2 >48 hours, n=7, 8.8 %). Sample Size was 80 patients and sampling method was a convenient sample

Inclusion Criteria: Sex: both sexes and Age ≥18.

Exclusion Criteria: Mortality within 24hours post-operative and Pregnancy.

Ethical Considerations: will be followed by obtaining the hospitals Research/Ethics Committee approval and written informed consents from the patients.

Data collection

The patients were evaluated as follows: Preoperative Evaluation, Intraoperative Evaluation and Postoperative Evaluation.

Procedure

After ICU admission, the following hemodynamic parameters were obtained and recorded: heart rate, mean arterial pressure (MAP), central venous pressure (CVP). I also recorded the mechanical ventilation parameters, including the ventilation mode, plateau pressure and positive end-expiratory pressure (PEEP), respiratory rate in controlled and spontaneous mode, fraction of inspired oxygen (FiO2), oxygen saturation by pulse oximetry (SpO2), tidal volume and minute volume, rapid shallow breathing index or respiratory rate/tidal volume ratio and maximal inspiratory pressure. A blood gas analysis and measurement of hemoglobin levels were performed and recorded after ICU admission every 6 h during the first 24 h after cardiac surgery.

Statistical analysis

Data collected throughout history, basic clinical examination and outcome measures coded, entered and analyzed using Microsoft Excel software. Data were then imported into Statistical Package for the Social Sciences (SPSS version 21.0) (Statistical Package for the Social Sciences) 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. P value was set at <0.05 for significant results & <0.001 for high significant result.

RESULTS

Table (1): Descriptive clinical data of the studied population.

No.= 80		
Age (years)	**Mean ± SD**	**55.475 ± 8.732**
	Median [IQR]	**56 [13]**
	Range	**30- 73**
Sex	**Male**	**61 (76.3%)**
	Female	**19 (23.8%)**
BMI (Kg/m2)	**Mean ± SD**	**30.807 ± 6.618**
	Median [IQR]	**29.8 [8.93]**
	Range	**18.6 - 45.5**
Smoking	**No**	**56 (70%)**
	Yes	**24 (30%)**

In this current study the age of the patients ranged between 30- 73 years with mean value of 55.475 (± 8.732 years). Most of them were males 76.3% vs. 23.8% were females. 30% of them were smokers. Their Body mass index ranged between 18.6 - 45.5 with mean value of 30.807 (± 6.618) Kg/m2.

Table (2): descriptive outcome data of the studied population

No.= 80		
Outcome	**Successful Extubation in first 48h**	**73 (91.3%)**
	Failed extubation in first 48h	**7 (8.8%)**
Next ventilation need after 48h	**Noninvasive CPAP**	**4 (5%)**
	Still on invasive MV	**3 (3.7%)**
Mortality	**Survived**	**79 (98.75%)**
	Died	**1 (1.25%)**

This table showed that most of our included patients (91.3%) (n=73) were successfully extubated in the first 48h while 8.8% (n=7) failed extubation, 4 re-ventilated on non-invasive CPAP, 3 needed re-ventilation with invasive MV, one have done tracheostomy and one failed to survive and died.

Table (3): descriptive cardiac data of the studied population.

No.= 80		
Type of cardiac lesion	**MVR**	**13 (16.3%)**
	AVR	**5 (6.3%)**
	MVR & AVR	**6 (7.5%)**
	MVR & TR	**5 (6.3%)**
	CABG	**51 (63.8%)**
LV EF%	**Mean ± SD**	**56.950 ± 7.475**
	Median [IQR]	**57 [6.75]**

	Range	**35 -72**

This table showed that most of the included patients have CABG (63.8%) followed by MVR in 16.3%. echocardiography demonstrated that left ventricle EF% ranged between 35 -72%.

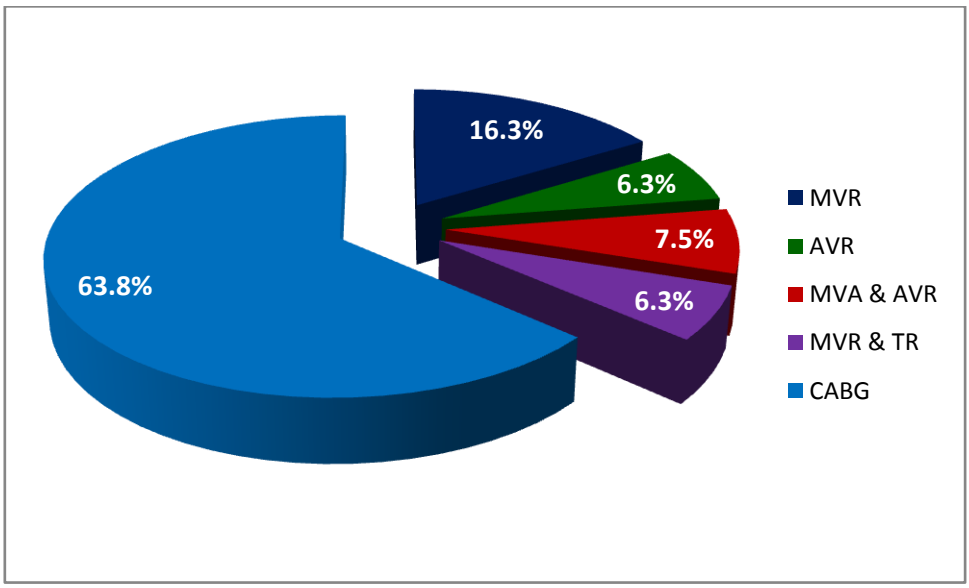

Figure 1: Type of cardiac lesion in the studied population.

Table (4): Comparison of ECC and ACC time of the studied groups.

		Weaned	**Failed**	**Independent student T test/ chi-square Test**	
		N=73	**N=7**	**t/X2**	**p-value**
ECC time	**Mean ± SD**	**119.986 ± 44.129**	**123.571 ± 44.320**	**-1.916**	**0.096**
	Range	**50 -300**	**75 - 200**		
ACC time	**Mean ± SD**	**77.055 ± 28.331**	**80.429 ± 25.993**	**-1.290**	**0.236**
	Range	**30 - 200**	**52 - 125**		

This table showed that there was no statistically significant difference between weaned and failed patients as regard the ECC and ACC time.

Table (5): Comparison of SOFA score of the studied groups.

		Weaned	**Failed**	**Mann Whitney U test/ chi-square Test**	
		N=73	**N=7**	**t/X2**	**p-value**
SOFA score	**Mean ± SD**	**4.657 ± 1.1453**	**7.285 ± 1.112**	**-3.870**	**<0.0001**
	Median [IQR]	**5 [2]**	**8 [1]**		
	Range	**3 - 8**	**5 -8**		

This table showed that there was statistically significant higher SOFA score in failed than weaned patients.

Table (6): Comparison of ventilator parameters of the studied groups.

	Weaned	Failed	Mann Whitney U test	
	N=73	N=7	t	p-value
RR/TV	43.493 ± 14.549	99.143 ± 31.667	-4.603	0.003
Pao2/FIo2	267.000 ± 48.875	183.429 ± 43.003	4.850	0.001
Minute Volume (L/min)	11.164 ± 2.273	15.429 ± 2.573	-4.230	0.004
Max inspiratory pressure (cmH20)	-27.699 ± 2.277	-20.143 ± 2.673	-7.232	<0.0001

This table showed that there was statistically significant higher RR/TV, minute volume and max inspiratory pressure and statistically significant lower Pao2/FIo2 in failed than weaned patients.

Table (7): Sensitivity, Specificity and cutoff value of laboratory investigations and ventilator parameter to predict the outcome

	Cutoff value	Area Under Curve	Sensitivity %	Specificity %	Asymptotic 95% Confidence Interval	
					Lower Bound	Upper Bound
RR/TV	≥ 57	0.932	85.7%	89%	0.846	1.000
Minute volume	≥ 13.5	0.883	85.7%	84.9%	0.716	1.000
Max inspiratory pressure	≥ -23	0.988	85.7%	98.6%	0.965	1.000
SOFA	≥ 6	0.933	85.7%	72.6%	0.823	1.000
PO2	≥121	0.865	97.3%	71.4%	0.658	1.000
PaO2/FIO2	≥218	0.893	89%	71.4%	0.770	1.000
MBP	≥72	0.871	98.6%	71.4%	0.701	1.000

This table showed that at cutoff value ≥ 57 RR/TV has 85.7% sensitivity and 89% specificity, at cutoff value ≥ 13.5 MV has 85.7% sensitivity and 84.9% specificity, at cutoff value ≥ -23 MIP has 85.7% sensitivity and 98.6% specificity, at cutoff value ≥ 6 SOFA has 85.7% sensitivity and 72.6% specificity to predict failed extubation.

At cutoff value ≥ 121 PO2 has 97.3% sensitivity and 71.4% specificity, at cutoff value ≥ 218 PaO2/FIO2 has 89% sensitivity and 71.4% specificity, at cutoff value ≥ 72 MBP has 98.6% sensitivity and 71.4% specificity to predict successful extubation.

DISCUSSION

This current study included 80 patients, their age ranged between 30- 73 years with mean value of 55.475 ± 8.732 years. Most of them were males 76.3% and 23.8% were females, 30% of them were smokers. Their BMI ranged between 18.6 - 45.5 with mean value of 30.807 ± 6.618. Most of our included patients (91.3%) were successfully extubated in the first 48h while 8.8%

were failed extubation, 4 re-ventilated on noninvasive CPAP, 3 needed re- ventilation with invasive MV, one have done tracheostomy and one failed to survive and died.

Mortality was statistically significant higher in failed extubation than weaned group. There was no statistically significant difference between weaned and failed patients as regard age, sex, BMI and smoking.

These results were supported by study of **Sanson et al.**[9] as they reported that their study population comprised 205 patients (men: 150, 73%; women: 55, 27%). The ages of the male (66.8 ± 10.0 years) and female (69.5 ± 11.3 years). There was no statistically significant difference between weaned and failed patients as regard age and sex.

These results were in line with study of **Lara et al.**[10] as they reported that mortality was statistically significant higher in failed extubation than weaned group.

The current study showed that most of the included patients 67.5% developed intraoperative complications; the commonest complications were pacemaker wire in 36.25% followed by VF in 27.5% and bradycardia in 5% of included patients. Most of the included patients have CABG (63.8%) followed by MVR in 16.3%. echocardiography demonstrated that left ventricle EF% ranged between 35 -72%. Mean blood pressure of the studied population ranged between 56 – 103 mmHg with mean value of 85.037 ± 9.914 mmHg.

In accordance with our results study of **Sanson et al.**[9] , reported that most of their included patients have CABG (51%) followed by valvar lesion in 26%. Tracheal secretions were statistically significant higher in failed than weaned patients.

Also, in the study of **Lara et al.**[10] they reported that LVEF was statistically insignificant between weaned and failed patients

In the study in our hands, ECC time of our studied population ranged between 50 – 300 with mean value of 122.925 ± 44.891 and ACC time ranged between 30 – 200 with mean value of 78.225 ± 28.236. There was no statistically significant difference between weaned and failed patients as regard the ECC and ACC time.

Our results were in agreement with study of **Sanson et al.**[9], as they reported that there was no statistically significant difference between weaned and failed patients as regard the ECC.

The present study showed that among the studied population, the SOFA score ranged from 3 to 8 with median of 5, and the FOUR score ranged from 2 to 13 with median 13. There was statistically significant higher SOFA score in failed than weaned patients. Among the studied population, 90% received one or more blood product transfusion; 80.1% received packed RBCs, 57.5% received FFP and 7.5% received platelet transfusion. There is no statistically significant difference between weaned and failed patients as regard the blood product transfusion.

In contrary to our results, study of **Sanson et al.**[9], reported that blood creatinine was statistically significant increase in failed extubation than success extubation and albumin was significantly lower in failed extubation than success extubation. The difference may be due to different associated comorbidities.

Also, in the study of **Lara et al.**[10] there was statistically insignificant difference in PO2 in weaned and failed patients, While in the study of **Yazdanian et al.**[11], the reintubated patients had lower preoperative PaO2 than did the control group.

These results showed that using ROC curve, at cutoff value ≥ 57 RR/TV has 85.7% sensitivity and 89% specificity, at cutoff value ≥ 13.5 MV has 85.7% sensitivity and 84.9% specificity, at cutoff value ≥ -23 MIP has 85.7% sensitivity and 98.6% specificity, at cutoff value ≥ 6.5 SOFA has 85.7% sensitivity and 72.6% specificity to predict failed extubation. At cutoff value ≥ 121 PO2 has 97.3% sensitivity and 71.4% specificity, at cutoff value ≥ 218 PaO2/FIO2 has 89% sensitivity and 71.4% specificity, at cutoff value ≥ 72 MBP has 98.6% sensitivity and 71.4% specificity to predict successful extubation.

Binary logistic regression analysis showed that SOFA (≥ 6), Comorbidity index (>3), sever tracheal Secretion, RR/TV (≥57), Minute volume (≥ 13.5) are independent predictors of failed weaning from mechanical ventilation.

While in the study of **El-Beheidy et al.**[12] revealed that rapid shallow breathing index (RSBI) differed significantly between patients who succeeded weaning from mechanical ventilation and those who failed (3.12±1 vs. 9.5±1.04 breath/min/ml/kg; P < 0.001). A cutoff value ≥3.5 breath/min/ml/kg on were associated with a prediction of failure of weaning from mechanical ventilation with a 100%sensitivity, 75% specificity,0.724 positive predictive value (PPV), 1 negative predictive value (NPV) and 84.91% accuracy.

Moreover, **Totonchi et al.**[13]**,** On univariate analysis, pre-operative variables; including gender, history of chronic obstructive pulmonary disease (COPD); chronic kidney disease and endocarditis, intra-operative variables; including type of surgery, operation time, pump time, transfusion in operating room and postoperative variables; including bleeding and inotrope-dependency were significantly different between patients with and without prolonged mechanical ventilation (PMV) (all P<0.001, except for COPD and transfusion in operating room; P=0.004 and P=0.017, respectively).

CONCLUSION

Studies have shown that, after cardiac surgery, extubation failure can be predicted by several pre, intraoperative and post-operative variables. In this study most of the included patients were successfully extubated. Charlson Comorbidity Index, COPD and CVS were statistically significantly higher in failed extubation than weaned group while MBP and PO2/FIO2 were statistically significantly lower in failed than weaned patients. So, from findings of this study we can conclude that SOFA (≥ 6), Comorbidity index (>3), sever tracheal secretion, RR/TV (≥57), MV (≥ 13.5) are independent predictors of failed weaning from mechanical ventilation.

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