SAS Journal of Surgery
Abbreviated Key Title: SAS J Surg
ISSN 2454-5104
Journal homepage: https://www.saspublishers.com

OPEN ACCESS

Prolonged Mechanical Ventilation Following Elective Adult Valve Replacement Incidence, Predictors Factors and Early Outcome

M.Moutaoukil[1], A.Elmoqaddem[2], H.Kechna[3], M.Bensghir[4]

[1,4]Department of Anaesthesiology, Military Hospital Med V Rabat, University of Med V Suissi Rabat, Morocco
[2,3]Department of Anaesthesiology, Military Hospital Moulay Ismail Mekness, University of Sidi Mohammed ben Abdellah Fes, Morocco

DOI: 10.36347/sasjs.2021.v07i08.001 | **Received:** 26.06.2021 | **Accepted:** 02.08.2021 | **Published:** 05.08.2021

***Corresponding author:** M. Moutaoukil

Abstract **Original Research Article**

Context: Prolonged mechanical ventilation (PMV) is associated with poor outcomes in the short and long term with major economic impact. ***Aims:*** This study aimed to determine the incidence, predictors and early outcome of PMV after adult elective valve replacement (EVR) under cardiopulmonary bypass (CPB). ***Settings and Design:*** This is single center retrospective study. ***Methods and Material:*** Adult patients undergoing EVR under CPB were included. Patients died within 24 hours of surgery were excluded. PMV was defined as a total of mechanical ventilation time ≥ 24 hours. In the case of re-intubation, the cumulative duration of intubation was taken into account. The anesthesia was performed according to standardized protocols and the surgery was performed by the same team. ***Results:*** During the Study Period, 328 patients were enrolled. 9.1% (30/328) of patients required PMV. Independent risk factors of PMV included preoperative renal dysfunction (OR: 11.073, (2.680–45.748); p: 0.001), use of Intra aortic counter-pulsation balloon (OR: 52.013, (2.169-1247.02); p: 0.015), and number of inotropic and vasoactive drugs (OR: 3.531, (1.335–9.337); p: 0.011). PMV was associated with a long stay in both intensive care unit (168 hours vs. 48 hours; p: <0.001) and hospital ward (23.50 days vs. 13 days; p: <0.001) and increased hospital mortality (94.1% vs. 5.9%; p: <0.001). ***Conclusions:*** The identification of risk factors of PMV after EVR is crucial as it is the first step for a preventive approach to avoid this complication and improve outcome after valve surgery.

Keywords: Prolonged mechanical ventilation; Elective valve replacement; Adult; Risk factors; Outcome.

INTRODUCTION

Mechanical ventilation is an important support in the postoperative management of patients undergoing valve surgery. Those one are likely to be extubated within 24 hours following valve surgery [1, 2]. However, many of them require mechanical ventilation for an extended period [1].

Prolonged mechanical ventilation (PMV) is associated with increased morbidity and mortality [3-6]. It has a major economic impact with a long stay in intensive care units (ICU) and hospital ward and an increase in the use of hospital resources [7]. It is also associated with poor long-term outcome with consequences for quality of life [6].

Few studies have been conducted to identify risk factors of PMV in valve surgery [1, 3, 8]. Our study aimed to determine the incidence, predictors and early outcome of PMV after adult elective valve replacement (EVR) under cardiopulmonary bypass (CPB).

SUBJECTS AND METHODS

We conducted a retrospective observational cohort study on consecutive adult patients who underwent EVR under CPB between January 2010 to June 2015.

PMV was defined as a total of mechanical ventilation time ≥ 24 hours. In the case of re-intubation, the cumulative duration of intubation was taken into account. Patients died within 24 hours of surgery were excluded.

For our data, 23 potential risk factors were collected [Table 1].

Table 1: Variables included in this study

Preoperative predictive factors	**Intraoperative predictive factors**
Age over 60 years	Type of valvular procedure
Gender	Cross clamp time (min)
BMI ≥ 30 (Kg/m²)	Cardiopulmonary bypass time (min)
Euroscore	Intraoperative blood transfusion
Prior heart operation	Number of red blood cells
Hypertension	Number of fresh frozen plasma
Diabetes mellitus requiring medication	Number of platelets
COPD	Intra aortic balloon pump insertion (IABP)
Smoking history	Use of intraoperative inotropic and vasoactive drugs
Ejection fraction (EF) < 30%.	Number of intraoperative inotropic and vasoactive drugs
PAPS greater than 60 mmHg	Duration of the operation
Preoperative renal dysfunction	

BMI: Body Mass Index; Euroscore: European System for Cardiac Operative Risk Evaluation; COPD: Chronic obstructive pulmonary disease; PAPS: Pulmonary artery systolic pressure; Preoperative renal dysfunction: Preoperative creatinine clearance (MDRD) < 60 ml/min; CEC: Extracorporeal circulation;

The anesthesia was performed according to a standardized protocol, and the surgical procedure was performed by the same team. A period of 6 hours fasting before the conduct of general anesthesia was respected in all patients along with an oral premedication with Hydroxizine (1mg/kg) the night before and on the morning of the surgery.

The induction of anesthesia was titrated, combining: Midazolam (0.05 mg/kg), Fentanyl (3–5 yg/kg), Etomidate (0.4 mg/kg) and Rocuronium (0.6 mg/kg).

The lungs were ventilated with 50% oxygen using volume controlled mode (tidal volume of 7–8 ml/kg, PEEP at 5 and a respiratory rate to obtain a $PaCO_2$ (35–40 mmHg).

Anesthesia was maintained with Isoflurane and boluses of Fentanyl and Cisatracurum. A standard CPB was performed for all patients under moderate hypothermia (34 °C) with a flow rate of 2.2 to 2.5 l/min/m2. The mean arterial blood pressure was maintained at 55 to 75 mmHg. It was conventionally installed between an aortic cannula and one or two venous cannulas after general heparinization.

Myocardial protection was provided by cold crystalloid cardioplegia and crushed ice in the heart. At the end of CPB, protamine sulfate was administered intravenously to achieve activated coagulation time (ACT) <160 s.

At the end of surgery, the patients were transferred to the ICU. Each patient received analgesia with Paracetamol (1g every 6 hours) and Morphine (1mg/ml) using a patient-controlled analgesia (PCA) system with a lockout interval of 7 min. The anticoagulant therapy was started as early as 6 hours in the absence of bleeding or clotting disorders. Omeprazole ensured the prevention of stress ulcers. Forced air warming was used to reach a temperature of 37 °C.

The decision to extubate was at the discretion of the consultant anesthetist and followed a predefined protocol. Once the patient is warmed, neurologically alert, oriented, obeying to commands. A stable hemodynamic status with no significant arrhythmia. Adequate hematosis with PaO_2 greater than 80 mmHg under FiO_2 less than 50% and a $PaCO_2$ of less than 50 mmHg. The blood loss less than 100 ml/hr.

Patients who did not meet these extubation criteria were sedated with Propofol and maintained under mechanical ventilation.

STATISTICAL ANALYSIS

Categorical variables were expressed in proportions and analyzed by Chi-square test. Continuous variables were described as means (SD) or medians (interquartile range) and compared using the Student t-test or the Mann-Whitney test. For all risk factors, univariate analysis was performed by logistic regression. Identified predictors with statistical significance (p value <0.05) were introduced into a logistic multivariate regression model by the input method. The odds ratio (OR) with 95% confidence interval (CI) was calculated. Data were analyzed using SPSS 20.0 software. Results were considered statistically significant if the p-value was <0.05.

RESULTS

During the study period, 328 patients were enrolled. 50% (164) of them underwent mitral valve replacement and 26.2% (86) aortic valve replacement. Combined valve surgery was found in 23.8% of cases. The mean age of our patients was 47.40±12.84 years. 58 patients (17.7%) were aged more than 60 years. The sex ratio (Male to Female) was 1.85. 11.3% of our patients had a high BMI. The mean Euroscore was

4.23±2.089. The median duration of mechanical ventilation was 7 hours [5-17]. 30 patients required a PMV giving a rate of 9.1%. The average length of stay in ICU was 48 hours [24-48]. The average length of stay in the hospital ward was 13 days [11-17]. The in-hospital mortality rate was 5.2% (17 patients). Demographic data and co-morbidities of our patients are shown in Table -2.

Table 2: Demographics data and comorbidities of patients

Variables	Population (n : 328)
Age (years)	47.40±12.84
Age over 60 years	58 (17.7)
Gender	
-Male	150(45.7)
-Woman	178 (54.3)
BMI≥30 Kg/m2	37(11.3)
Euroscore	4.23±2.089
History of cardiac surgery	7(2.1)
COPD	6(1.8)
Chronic smoking	90(27.4)
Carotid disease	1(0.3)
Diabetes	21(6.4)
Hypertension	30(9.1)
Type of valve replacement	
-Mitral valve replacement	164(50)
-Aortic valve replacement	86(26.2)
-Double valve replacement	78(23.8)
Incidence of prolonged ventilation	30(9.1)

Mean ± standard deviation; Number (percentage).
BMI: Body Mass Index; COPD: Chronic obstructive pulmonary disease

Twelve risk factors for prolonged ventilation were identified by univariate analysis [Table 3]. Among these, only three were found by multivariate analysis to be independent risk factors for PMV: preoperative renal dysfunction (OR: 11.073, (2.680-45.748); p: 0.001), use of IAPB (OR: 52.013, (2.169-1247.02); p: 0.015), and the number of inotropic and vasoactive drugs (OR: 3.531, (1.335-9.337); p: 0,011) (Table 4).

Table 3: Results of the univariate analysis Pre- and peri-operative factors predictive of prolonged ventilation (+24 hrs)

VARIABLE		Univariate analysis	
	Odds ratio	95% Confidence interval	P value
Preoperative factors			
Euroscore	1.593	(1.345-1.887)	<0,001
PAPS > 60 mmHg	3.815	(1.772-8.213)	0,001
Preoperative renal dysfunction	35.750	(13.114-97.461)	<0,001
Intraoperative factors			
Double aortic and mitral valve replacement	2.343	(1.074-5.112)	0.032
Duration of CEC	1,015	(1,006-1,024)	0,001
Blood transfusion	8.730	(3.792-20.102)	<0,001
Number of RBCs	2.351	(1.672-3.306)	<0,001
Number of FFPs	2.856	(1.317-6.196)	0,008
Use of IABP	127.286	(15,38-1052.88)	<0,001
Use of inotropic and vasoactive drugs	9.759	(2.859-33.310)	<0,001
Number of inotropic and vasoactive drugs	5.689	(3.261-9.927)	<0,001
Duration of the operation	1.014	(1.008-1.021)	<0,001

PAPS: Pulmonary arterial systolic pressure; CEC: Extracorporeal circulation; RBC: Red blood cells; FFP: Fresh frozen plasma; IAPB: Intra aortic balloon pump insertion.

Table 4: Independent risk factors for prolonged ventilation (+ 24 hrs)

VARIABLE		Multivariate analysis	
	Odds ratio	**95% Confidence interval**	**P value**
Preoperative factors			
-Preoperative renal dysfunction	**11.073**	**(2.680-45.748)**	**0,001**
Intraoperative factors			
-Use of IABP	**52.013**	**(2.169-1247.02)**	**0,015**
-Number of inotropic and vasoactive agents	**3.531**	**(1.335-9.337)**	**0,011**

IAPB: Intra aortic balloon pump insertion.

Prolonged ventilation was identified in our study as a risk factor for long stay both in ICU (168 hours vs. 48 hours; p: < 0.001) and hospital ward (23.50 days vs. 13 days; p: < 0.001). We also found an association with increased hospital mortality (94.1% vs. 5.9%; p: <0.001) (Table 5).

Table 5: Morbimortality related to prolonged ventilation (+24 hrs)

	Ventilation time (<24 Hours).	Ventilation time (≥24 Hours).	P value
Length of stay in ICU (Hours)	48 (24-48)	168 (114-282)	<0,001
Length of hospital stay (days)	13 (11-16)	23.50 (15-36.50)	<0,001
Hospital mortality	1 (5.9)	16 (94.1)	<0,001

Median [quartile]; Number (percentage)

DISCUSSION

In our study, prolonged ventilation was observed in 9.1% of cases. Risk factors for PMV following EVR included preoperative renal dysfunction, use of IAPB and a number of inotropic and vasoactive drugs. It has also been shown that PMV was a risk factor for prolonged stay in ICU and hospital ward and it was associated with increased hospital mortality.

Our rate of patients requiring PMV (9.1%) is close to the rates reported by previous studies, ranging between 6.6% and 12.2% [1, 3, 8]. This variation can be explained by the difference between the cut-off times chosen for the definition of PMV which vary between 24 and 72 hours [1, 3, 8]. Our choice of 24 hours as a cut-off time was based on different arguments. The majority of our patients are generally extubated within 24 hours of surgery with an average duration of mechanical ventilation of seven hours. We also believe that 24 hours is a sufficient time for hemodynamic stabilization and to offset the deleterious effects of surgery and CBP. In addition, the current Society of Thoracic Surgeons (STS) definition of PMV is a ventilation time exceeding 24 hours [1, 9].

In our study, preoperative renal dysfunction was identified as an independent predictor of PMV after EVR. This observation is reinforced by the results of three studies on the same topic [1, 3, 8]. In addition, renal dysfunction would predispose patients undergoing valve surgery to high morbidity with prolonged length of stay in ICU [1, 3, 8] and consequently to prolong hospitalization [8]. It was also associated with increased hospital mortality [3].

Patients with renal dysfunction have other associated comorbidities, including diabetes which is identified as a risk factor of PMV in valve surgery [3]. The atheromatous disease is also one of the complications of renal insufficiency, predisposing to the occurrence of postoperative stroke [3] which has been identified as a risk factor for PMV in valve surgery [3]. Preoperative renal failure is a predictive factor for intraoperative blood transfusion in cardiac surgery which was also found as a risk factor of PMV [10].

The use of IAPB and the number of inotropes and vasoactives drugs was associated with prolonged ventilation after EVR. These two factors are indicative of a low cardiac output that makes ventilatory weaning difficult [3, 7, 11]. Shiradz and colleagues have also found that the use of IAPB was a predictive factor of PMV [1].

In our study, prolonged ventilation was found as a risk factor for a long stay in both ICU (168 Hrs vs. 48 Hrs; p: <0.001) and hospital ward (23.50 Jrs. vs. 13Jrs; p: <0.001). It was also associated with increased hospital mortality (94.1% vs. 5.9%; p: <0.001).

Similar results were found in the literature [1, 3, 8]. Wang et al., in a retrospective study of 4003 valve surgery patients noted a statistically significant association between PMV and prolonged ICU stay [8]. Shirzad et al., and Filsoufi et al., reported a strong correlation between PMV and long hospital stay [1, 3]. The hospital over-mortality associated with PMV was observed by all three authors [1, 3, 8]. However, our in-hospital mortality rate was higher compared to that reported by the various authors [1, 3, 8].

Filsoufi et al., were the only ones interested in the long-term outcome associated with this complication. The authors noted a significant decrease in survival at one year and five years after valve surgery in patients with PMV [3].

The present study has several limitations. This is a retrospective, single-center study with low sample size. Inherent selection bias in reported results must be considered and the conclusions are necessarily limited. Further prospective multi-center studies involving a large number of valve surgery patients are needed.

The analysis of the outcome for PMV was limited to hospital mortality, length of stay in ICU and hospital wards. The influence of this complication on long-term prognosis and quality of life has not been studied.

CONCLUSION

In conclusion, PMV is associated with poor outcomes in the short and long term. The identification of risk factors of PMV after EVR is crucial as it is the first step for a preventive approach to avoid this complication and improve outcome after valve surgery.

REFERENCES

1. Shirzad, M., Karimi, A., Ahmadi, S. H., Marzban, M., Tazik, M., & Aramin, H. (2010). Predictors and early outcome of prolonged mechanical ventilation in contemporary heart valve surgery. Monaldi Archives for Chest Disease, 74(1).
2. Sivak, E. D. (1991, January). Management of ventilator dependency following heart surgery. In Seminars in thoracic and cardiovascular surgery (Vol. 3, No. 1, pp. 53-62). Elsevier.
3. Filsoufi, F., Rahmanian, P. B., Castillo, J. G., Chikwe, J., & Adams, D. H. (2008). Logistic risk model predicting postoperative respiratory failure in patients undergoing valve surgery. European journal of cardio-thoracic surgery, 34(5), 953-959.
4. Hein, O. V., Birnbaum, J., Wernecke, K. D., Konertz, W., Jain, U., & Spies, C. (2006). Three-year survival after four major post–cardiac operative complications. Critical care medicine, 34(11), 2729-2737.
5. Kollef, M. H., Wragge, T., & Pasque, C. (1995). Determinants of mortality and multiorgan dysfunction in cardiac surgery patients requiring prolonged mechanical ventilation. Chest, 107(5), 1395-1401.
6. Combes, A., Costa, M. A., Trouillet, J. L., Baudot, J., Mokhtari, M., Gibert, C., & Chastre, J. (2003). Morbidity, mortality, and quality-of-life outcomes of patients requiring≥ 14 days of mechanical ventilation. Critical care medicine, 31(5), 1373-1381.
7. Rajakaruna, C., Rogers, C. A., Angelini, G. D., & Ascione, R. (2005). Risk factors for and economic implications of prolonged ventilation after cardiac surgery. The Journal of thoracic and cardiovascular surgery, 130(5), 1270-1277.
8. Wang, C., Zhang, G. X., Lu, F. L., Li, B. L., Zou, L. J., Han, L., & Xu, Z. Y. (2013). A local risk prediction model for prolonged ventilation after adult heart valve surgery in a Chinese single center. Heart & Lung, 42(1), 13-18.
9. Ferguson Jr, T. B., Hammill, B. G., Peterson, E. D., DeLong, E. R., Grover, F. L., & STS National Database Committee. (2002). A decade of change—risk profiles and outcomes for isolated coronary artery bypass grafting procedures, 1990–1999: a report from the STS National Database Committee and the Duke Clinical Research Institute. The Annals of thoracic surgery, 73(2), 480-489.
10. Ravn, H. B., Lindskov, C., Folkersen, L., & Hvas, A. M. (2011). Transfusion requirements in 811 patients during and after cardiac surgery: a prospective observational study. Journal of cardiothoracic and vascular anesthesia, 25(1), 36-41.
11. Sharma, V., Rao, V., Manlhiot, C., Boruvka, A., Fremes, S., & Wąsowicz, M. (2017). A derived and validated score to predict prolonged mechanical ventilation in patients undergoing cardiac surgery. The Journal of thoracic and cardiovascular surgery, 153(1), 108-115.