Risk Factors of Prolonged Mechanical Ventilation in Post Coronary Artery Bypass Graft Patients: A Scoping Review

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Abstract: Prolonged mechanical ventilation (PMV) following CABG surgery is associated with increased patient morbidity and mortality. A consensus has yet to be reached regarding the time limit for PMV. Various studies have identified factors that influence PMV in patients following CABG surgery, but a review has yet to synthesize the results systematically. This review aimed to identify the definition and factors associated with PMV in patients following isolated CABG surgery. This scoping review used the framework developed by Arksey and O'Malley (2005). Primary sources of information were searched through 5 databases: PubMed, Scopus, Oxford Academy, Sage, and CINAHL and two search engines: Science Direct and Google Scholar, accessed on October 25, 2023. Eight articles with a total of 12,178 participants were included in this review. The PMV time limits used in the studies varied from >12 hours to >48 hours. The factors affecting PMV were grouped into preoperative, intraoperative and postoperative, with factors that have a high influence, including NYHA class, acute kidney injury and mediastinitis. Differences in the number of factors examined, criteria, characteristics, and time limits of the PMV used to make the study's results vary. Establishing guidelines regarding PMV time limits is essential according to current conditions.

Keywords: coronary artery bypass graft, factors, prolonged mechanical ventilation

Introduction

Prolonged Mechanical Ventilation (PMV) is one of the complications after cardiac surgery.[1] PMV can be caused by respiratory distress, severe underlying conditions, decreased cardiac function, or infection.[2,3] The incidence of prolonged mechanical ventilation in post-CABG patients globally varies depending on various factors and the definition of PMV, ranging from 2.18% to 48.11%.[4,5] Until now, there has not been a consensus regarding the time defined as PMV.

PMV can adversely affect patient outcomes following CABG surgery.[4] PMV increases mortality and prolongs Length of Stay (LOS) in the ICU and hospital.[4,6,7] There is an effective risk score to predict the prognosis of patients with coronary artery disease and help and guide the intensivists for the close follow-up of the patients using the Intermountain Risk Score (IMRS).[8,9] A study by Cinar et al (2023) found that IMRS was significantly higher in STEMI patients who did not survive than those who survived.[9] According to Cislaghi et al (2009), PMV increases the risk of LOS up to six times higher.[10] PMV also increases the risk of delirium and hemofiltration following cardiac surgery.[5] Furthermore, the high incidence of ventilator-associated pneumonia can affect patient prognosis.[11] Previous research conducted in Iran stated that the dominant predictor for PMV in postoperative cardiac surgery patients was the 24-hour postoperative creatinine value.[12] While research conducted in China stated that delirium after CABG surgery was the dominant factor for PMV.[13]

Various studies have been conducted to find factors affecting PMV in patients following CABG surgery, but studies have yet to be systematically reviewed to explore PMV and its influencing factors. A previous study reported that discontinuing mechanical ventilation, extubation, and prevention of PMV is clinically essential for patients.[14] Early

extubation following cardiac surgery has beneficial clinical effects, including improved patient comfort, increased patient mobility, decreased respiratory complications and decreased cost of care.[15] Therefore, it is essential to explore the factors influencing PMV to help healthcare workers systematically anticipate and effectively manage complications due to PMV.[16] Close monitoring and prompt intervention in patients with identified risk factors can contribute to improved postoperative outcomes and reduced healthcare costs.[17,18]

Based on our literature search, no studies have been systematically reviewed to explore synthesizing PMV and its influencing factors starting from the preoperative, intraoperative and postoperative stages. Based on these considerations, it is necessary to examine the factors that influence PMV in postoperative CABG patients through a scoping review so that it can provide input to anticipate and manage the occurrence of PMV in this population.

Materials and Methods
Design
This review used a scoping review design. Scoping reviews have a more comprehensive conceptual framework to explain relevant research findings. The scoping review framework consists of several stages, including articulating the research question, identifying relevant studies, selecting studies, mapping data, compiling literature search results, summarizing, and reporting.[19] This research protocol was not published or registered.

Eligibility Criteria
The articles in this review were selected by three reviewers based on the PRISMA Extension for Scoping Reviews (PRISMA-ScR) (see Figure 1).[20] This research article's questions and eligibility criteria used the PCC (Population, Concept, and Context) approach.[21] The research questions in this review are: What is the definition of Prolonged Mechanical Ventilation in postoperative CABG patients? What are the significant factors influencing Prolonged Mechanical Ventilation in postoperative CABG patients?

P (Population): Adults and patients post Coronary Artery Bypass Graft surgery.

C (Concept): Prolonged Mechanical Ventilation

C (Context): Risk Factors

The inclusion criteria in this review were full-text articles in English, published from 2013–2023, with case-control, cross-sectional, longitudinal, and cohort study designs that addressed factors affecting PMV in post-CABG patients. Furthermore, this review excluded non-English language studies, qualitative studies, inaccessible full-text publications, and secondary studies.

Data Collection and Analysis
Search Strategy
The literature search was conducted systematically using five databases (PubMed, Scopus, Oxford Academy, Sage, and CINAHL) and two search engines (Science Direct and Google Scholar). It was Accessed on October 25, 2023. The keywords used were

Coronary Artery Bypass Graft OR Coronary Artery Bypass Surgery OR Prolonged Mechanical Ventilation OR Prolonged Mechanical Ventilation OR Factors OR Risk Factor OR Predictor.

Study Selection and Quality Appraisal
Three authors independently selected relevant studies that met the eligibility criteria. The authors used Mendeley Reference Manager to check for duplicates during the initial article selection process. The authors then checked the titles and abstracts. They read the entire paper according to the relevance of the selected research topic and based on the inclusion and exclusion criteria set by the authors. In the final stage of study selection, the authors evaluated each paper that met the inclusion criteria using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case-Control and Cohort Studies.[22]

Identification of studies via databases and registers

Identification

Article identification by databases (n=859)

PubMed (n=55), Scopus (n=478), ScienceDirect (n=102), EBSCO-host CINAHL (n=12), Oxford Academic (n=104), Sage (n=98), Google Scholar (n=10)

→ Articles removed based on duplication (n=360)

Screening

Articles screening based on title and abstract (n=499)

→ Articles removed based on title and abstract (n= 458)

Articles screening based on comprehensiveness and inclusion criteria (intervention, and language) (n=41)

→ Articles removed based on these circumstances (n=25):
- Samples were not CABG patient (n=1)
- No data discussing prolonged mechanical ventilation (n = 22)
- Articles were not in English (n=2)

Eligibility

Articles with full text were assessed for eligibility using JBI Critical Appraisal Tools (n=16)

→ Articles removed based on:
- Eligibility using JBI Critical Appraisal Tools (n= 1),
- Because the population was not suitable (n= 7)

Included

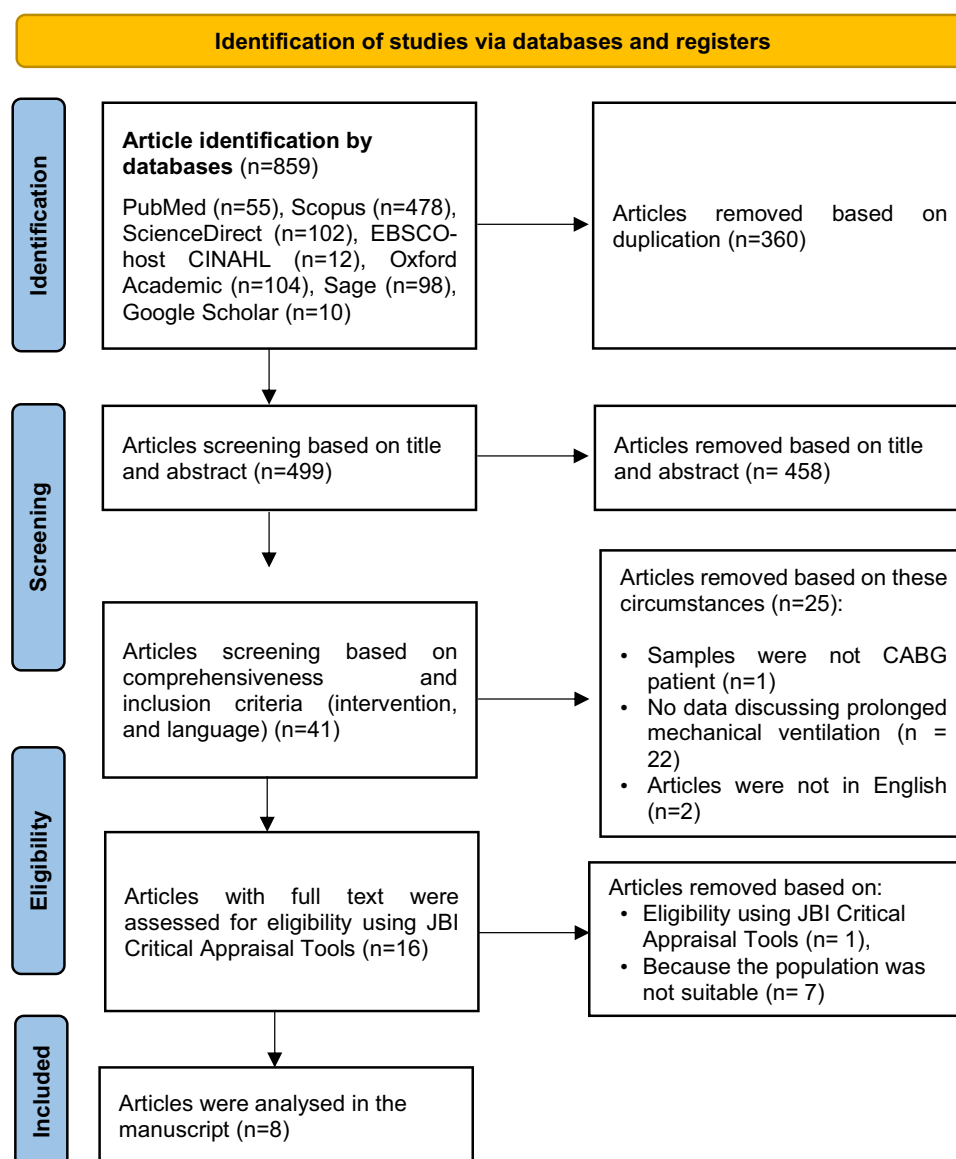Articles were analysed in the manuscript (n=8)

Figure 1 PRISMA Flow Diagram. Adapted from Page MJ, McKenzie JE, Bossuyt PM et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71. Creative Commons.[20]

Ratings consist of ``Yes'', ``No'', ``Unclear'', and ``Not Applicable'', with each ``Yes'' answer worth one and the other answers worth 0. The sum of these ratings determines how suitable the item is for inclusion in this review. This allows researchers to determine the reliability and relevance of their findings for inclusion in further discussion. After the JBI assessment, we excluded all studies with a JBI score below 70, with final approval from the first, second, and third authors, so that the final decision resulted in a unanimous opinion on the appropriateness of the studies to be analyzed in depth in this scoping review.

Data Extraction and Analysis

At the data extraction and analysis stage, this review used extraction tables to describe all research findings related to the research topic. The extraction table contains information related to study characteristics, including author, study design, country, type of surgery, PMV, sample (number of patients and number of PMV patients), study findings (category of factors and PMV factors), and JBI final results. All studies analyzed were primary studies with case-control, cross-sectional and cohort designs. Data analysis was conducted thematically and qualitatively with an exploratory, descriptive

approach. The data analysis process began with identifying and presenting the data obtained in tabular form based on the articles reviewed. After the data were obtained, the authors analyzed and discussed the results of each study with a focus on the factors that influence the PMV of patients after CABG surgery. The author categorized these factors into three categories based on the research findings, namely preoperative factors, intraoperative factors and postoperative factors.

Results
Study Selection
The study selection results in the initial stage of this review resulted in 859 articles. The authors then selected articles based on title, abstract, and predetermined inclusion criteria, leaving 41 studies, which were further analyzed based on full-text analysis of the articles. A total of 25 articles were excluded because they were not in English and did not discuss CABG and PMV. Sixteen studies were evaluated using the JBI tool, and one article was excluded due to ineligibility. Seven articles were excluded because the population did not fit the criteria, ie the articles included combined CABG surgery with other heart surgeries such as valve, heart tumour removal, and congenital correction. As a result, eight studies were eligible and included in the final analysis. Figure 1 shows the study selection process, which resulted in eight studies. These studies were analyzed in this scoping review using the PRISMA flowchart.

Study Characteristics
Most studies analyzed in this review were retrospective cohort studies (n=7) and one case-control study. Most studies (n=7) were conducted in developed countries (see Table 1). The total number of participant data was 12,178. The total number of participants who experienced Prolonged Mechanical Ventilation (PMV) was 2,431 participants (19.96%). The prevalence of PMV ranges from 2.18% to 48.11%.[4,5] The results of the JBI analysis showed that most studies analyzed by the cohort method were of good quality (>70%). Most of the studies needed improvement in not including follow-up time, the reasons for defaulting not being explained, and the lack of strategies to overcome incomplete follow-up.

Definition of PMV
The time limit defined as PMV differed in each study: >12 hours, >24 hours and >48 hours. Most articles stated that PMV used mechanical ventilation for more than 24 hours (5 articles) (see Table 1). Most articles used 24 hours based on the threshold the Society of Thoracic Surgeons used to define PMV, which is the total time of mechanical ventilation after CABG surgery > 24 hours.[13,23,24]

Factors Affecting PMV
This review identified factors that significantly affect PMV in CABG patients. The analysis results in this review showed that the factors affecting PMV had heterogeneous results. Based on the analysis, demographic characteristics, clinical conditions before surgery, laboratory test results before surgery, comorbidities, surgical findings, use of intra-operative devices, complications, and clinical findings after surgery have a significant association with PMV in postoperative CABG patients. In order to simplify, we categorized these factors into three categories: preoperative, intraoperative and postoperative factors (see Table 1).

In this review, the factors related to PMV included in the category of preoperative factors were demographic characteristics (age and gender), preoperative clinical conditions (BMI, NYHA class, ejection fraction, emergency surgery, and EuroScore Logistic 2), comorbidities (renal dysfunction, COPD, and internal carotid artery stenosis), history of smoking, and laboratory test results (haemoglobin and CK-MB). Intraoperative factors include surgical findings (long duration of surgery and reoperation) and use of intraoperative devices (IABP, use of CPB machine, and intraoperative hemofiltration). Postoperative factors that significantly influenced PMV were complications (pleural effusion requiring drainage, acute kidney injury, delirium, and mediastinitis) and clinical findings after surgery (chest secretions after surgery, 24-hour systolic blood pressure, 24-hour respiratory frequency, PRBC transfusion, venous oxygen saturation < 60%, and inotropic use). The most dominant significant and included factors from the studies the authors analyzed were using a CPB machine or CPB time (n=4) and renal dysfunction (n=6).

Table 1 Characteristics of Study

Study	Design	Country	Type of Operation	PMV (Hour)	Sample		Findings		Critical Appraisal
					Size	Number PMV Patients (%)	Category of Factors	Factors of PMV	
[4]	Retrospective	Iran	CABG	> 24	2155	47 (2,18)	2 Categories (preoperative, intraoperative)	On-pump CABG (OR: 2.96, 95% CI: 1.10–6.57) ($p=0.029$)*** Duration of surgery (OR: 1.01, 95% CI: 1.003–1.014) ($p=0.002$)*** Preoperative renal failure (OR: 2.57, 95% CI: 1.09–6.07) ($p=0.03$)*** New York Heart Association (NYHA) class 4 (OR: 13.10, 95% CI: 1.28–133.18) ($p=0.03$)***	8/11 73%
[12]	Retrospective	Iran	CABG	> 24	1361	291 (21,38)	3 Categories (preoperative, intraoperative, postoperative)	History of baking bread (B: 1.005, OR: 2.7, 95% CI: 1.4–5.4) ($p=0.004$)*** History of obstructive pulmonary disease (B: 1.8, OR: 6.2, 95% CI: 1.2–3.1) ($p=0.025$)*** History of kidney disease (B: 0.763, OR: 2.1, 95% CI: 1.04–4.3) ($p=0.036$)*** Ejection Fraction rate before surgery (B: −0.035, OR: 0.965, 95% CI: 0.944–0.987) ($p=0.002$)*** Cardiac enzymes (CK-MB) before surgery (B: 0.124, OR: 1.1, 95% CI: 1.07–1.2) ($p=0.001$)*** Use of an intra-aortic pump (B: 1.08, OR: 3, 95% CI: 1.1–7.8) ($p=0.030$)*** Respiratory rate 24 h after surgery (B: −0.921, OR: 0.398, 95% CI: 0.341–0.465) ($p=0.001$)*** Systolic blood pressure 24 h after surgery (B: −0.079, OR: 0.924, 95% CI: 0.885–0.965) ($p=0.001$)*** Creatinine level 24 h after surgery (B: 1.8, OR: 6.4, 95% CI: 1.8–22.8) ($p=0.004$)*** Chest secretions after surgery (B: 0.001, OR: 1.001, 95% CI: 1–1.001) ($p=0.001$)***	8/11 73%
[16]	Retrospective	Colombia	CABG	> 48	812	204 (25,12)	3 Categories (preoperative, intraoperative, postoperative)	Presurgical: Chronic obstructive pulmonary disease (or: 1.85, 95% ci: 1.06–3.23) ($p=0.030$)*** chronic kidney disease (or: 1.90; 95% ci: 1.09–3.31) ($p=0.023$)*** Transurgical: The use of intra-aortic balloon pump (or: 3.63; 95% ci: 1.73–7.61) ($p=0.001$)*** Post-surgical: Venous oxygen saturation <60% (or: 2.00; 95% ci: 1.18–3.40) ($p=0.01$)*** Mediastinitis (or: 18.51; 95% ci: 4.06–84.40) ($p<0.001$)*** Inotrope use (or: 2.82; 95% ci: 1.77–4.48) ($p<0.001$)*** Pleural effusion requiring drainage (or: 3.57; 95% ci: 2.02–6.32) ($p<0.001$)*** Delirium (or 3.45; 95% ci: 1.91–6.25) ($p<0.001$)***	9/10 90%
[25]	Retrospective	Brazil	CABG	> 12	4165	783 (18,79)	2 Categories (preoperative, intraoperative)	Urgent/emergency surgery (OR: 2.79; 95% CI: 2.09–3.73) ($p<0.001$)*** CKD (OR: 1.98; 95% CI: 1.61–2.44) ($p<0.001$)*** Age ≥ 65 years (OR: 1.91; 95% CI: 1.62–2.24) ($p<0.001$)*** CPB ≥ 120 minutes (OR: 1.75; 95% CI: 1.42–2.16) ($p<0.001$)*** BMI ≥ 30 kg/m2 (OR: 1.49; 95% CI: 1.21–1.84) ($p<0.001$)*** COPD (OR: 1.43; 95% CI: 1.16–1.76) ($p=0.001$)***	8/11 73%

(Continued)

Table 1 (Continued).

Study	Design	Country	Type of Operation	PMV (Hour)	Sample		Findings		Critical Appraisal
					Size	Number PMV Patients (%)	Category of Factors	Factors of PMV	
[5]	Retrospective	Polandia	CABG	> 12	1904	916 (48,11)	3 Categories (preoperative, intraoperative, postoperative)	Age [years], (p<0.001)** Gender, male, (p<0.001)* Smoking, (p<0.001)* NYHA III and IV, (p=0.016)* Internal carotid artery stenosis, (p=0.013)* Acute renal failure, (p=0.032)* EuroScore Logistic 2 [%] (p<0.001) ** Preoperative factors: Hemoglobin [mmol/L] (p<0.001) ** GFR [mL/min/1.73 m2] (p<0.001) ** Intraoperative factors: Reoperation, (p<0.001)* Intraoperative hemofiltration, (p<0.001)* Postoperative factors: Creatinine [highest] day 1 [mg/dL] (p<0.001) ** GFR [lowest] day 1 [mL/min/1.73 m2] (p<0.001) ** PRBC transfusion, units (p<0.001) **	9/11 82%
[26]	Retrospective	USA	CABG	> 24	738	104 (14,09)	2 Categories (preoperative, intraoperative)	Body Mass Index (kg/m2) (OR: 1.10; 95% CI: 1.05–1.16) (p<0.001)*** Ejection fraction (OR: 0.97; 95% CI: 0.94–0.99) (p=0.01)*** Use of cardiopulmonary bypass (OR: 2.59; 95% CI: 1.21–5.97) (p=0.02)***	10/11 91%
[27]	Retrospective	Philippines	CABG	> 24	213	40 (18,78)	3 Categories (preoperative, intraoperative, postoperative)	Acute kidney injury (OR: 11.82; 95% CI: 1.03–135.35) (p=0.0470)***	9/11 82%
[18]	Retrospective	Turki	CABG	> 24	830	46 (5,54)	3 Categories (preoperative, intraoperative, postoperative)	Advanced NYHA Class (OR: 8.2; 95% CI: 1.5–43.5) (p=0.015)*** Chronic renal dysfunction (OR: 7.7; 95% CI: 1.3–47.6) (p=0.027)*** CPB duration (min) (OR: 3.5%; 95% CI: 1.8%-6.4%) (p=0.012)***	8/11 73%

Notes: *Chi-squared test or Fisher's exact test, **t-test or Mann–Whitney U, ***Multiple Logistic Regression.
Abbreviations: BMI, Body Mass Index; CABG, Coronary Artery Bypass Graft; CKD, Chronic Kidney Disease; CK-MB, Creatinine Kinase – Myocardial Band; COPD, Chronic Obstructive Pulmonary Disease; CPB, Cardio-Pulmonary Bypass; CI, Confidence Interval; ECMO, Extracorporeal Membrane Oxygenation; FIO2, a fraction of inspired oxygen; GFR, glomerular filtration rate; LVEF, Left Ventricular Ejection Fraction; MI, Myocardial infarction; NYHA, New York Heart Association; OR, Odd Ratio; PaO2, partial pressure of oxygen; PRBC, Packed red blood cells.

We categorize the factors affecting PMV into three levels based on OR values: low (OR value < 4), medium (OR value ≥ 4 to 8), and high (OR value > 8). Factors at the high level have the most substantial influence, based on the high OR value. On the other hand, factors with OR values below four were categorized as low. Most of the factors are at a low risk of influencing PMV. Factors included in the moderate level were renal dysfunction and COPD. Factors that strongly influence include NYHA class, mediastinitis and acute kidney injury after surgery.

Discussion

The review found various factors affecting PMV, which authors grouped into three categories: preoperative, intraoperative, and postoperative (see Table 2). Preoperative factors that most influence PMV are clinical conditions such as NYHA class III and IV.[4,18,23] High NYHA class indicates the patient's inability to tolerate early weaning due to poor cardiovascular reserve.[4] Patients with left ventricular dysfunction and low ejection fraction also take more time to

Table 2 Factors Affecting PMV Following CABG Surgery

Categories	Subcategories	Highest Ratio OR (95% CI) (PMV)	Lowest Ratio OR (95% CI) (PMV)	p-value	Level of Risk Factors	References
Preoperative	**Demographic Characteristics:**					
	Age ≥ 65 years	1.91 (1.62–2.24)	1.91 (1.62–2.24)		Low	[5,25]
	Gender			P<0,001	Uncategorized	[5]
	Body Mass Index	1.49 (1.21–1.84)	1.10 (1.05–1.16)		Low	[25,26]
	Smoking History			P<0,001	Uncategorized	[5]
	Clinical Conditions:					
	NYHA Class	13.10 (1.28–133.18)	8.2 (1.5–43.5)		High	[4,5,18]
	EuroScore Logistic 2			P<0,001	Uncategorized	[5]
	Ejection Fraction	0.97 (0.94–0.99)	0.965 (0.944–0.987)		Low	[12,26]
	CK-MB	1.1 (1.07–1.2)	1.1 (1.07–1.2)		Low	[12]
	Hemoglobin			P<0,001	Uncategorized	[5]
	Emergency Surgery	2.79 (2.09–3.73)	2.79 (2.09–3.73)		Low	[25]
	Internal Carotid Artery Stenosis			p=0.013	Uncategorized	[5]
	Comorbidities:					
	Renal dysfunction	7.7 (1.3–47.6)	1.90 (1.09–3.31)		Moderate	[4,5,12,16,18,25]
	COPD	6.2 (1.2–31.06)	1.43 (1.16–1,76)		Moderate	[12,16,25]
Intraoperative	**Surgical findings:**					
	Duration of surgery	1.01 (1.003–1.014)	1.01 (1.003–1.014)		Low	[4]
	Reoperation			P<0,001	Uncategorized	[5]
	Use of intra-operative devices:					
	Use of IABP	3.63 (1.73–7.61)	3 (1.1–7.8)		Low	[12,16]
	CPB machine usage (and CPB time)	2.96 (1.10–6.57)	1.75 (1.42–2.16)		Low	[4,18,25,26]

(*Continued*)

Table 2 (Continued).

Categories	Subcategories	Highest Ratio OR (95% CI) (PMV)	Lowest Ratio OR (95% CI) (PMV)	p-value	Level of Risk Factors	References
Postoperative	**Complications:**					
	Pleural effusion (requiring drainage)	3.57 (2.02–6.32)	3.57 (2.02–6.32)		Low	[16]
	Acute kidney injury (creatinine level)	11.82 (1.03–135.35)	6.4 (1.8–22.8)		High	[5,12,27]
	Delirium	3.45 (1.91–6.25)	3.45 (1.91–6.25)		Low	[16]
	Mediastinitis	18.51 (4.06–84.40)	18.51 (4.06–84.40)		High	[16]
	Laboratory test results:					
	SvO2 < 60%	2.00 (1.18–3.40)	2.00 (1.18–3.40)		Low	[16]
	Clinical findings:					
	Chest secretions after surgery	1.001 (1–1.001)	1.001 (1–1.001)		Low	[12]
	24-hour Systolic Blood Pressure	0.924 (0.885–0.965)	0.924 (0.885–0.965)		Low	[12]
	24-hour Respiratory Rate	0.398 (0.341–0.465)	0.398 (0.341–0.465)		Low	[12]
	SvO2 < 60%	2.00 (1.18–3.40)	2.00 (1.18–3.40)		Low	[16]
	PRBC transfusion, units			P<0,001	Uncategorized	[5]
	Inotropic use	2.82 (1.77–4.48)	2.82 (1.77–4.48)		Low	[16]

Abbreviations: CK-MB, Creatinine Kinase – Myocardial Band; COPD, Chronic Obstructive Pulmonary Disease; CPB, Cardio-Pulmonary Bypass; IABP, Intra-Aortic Balloon Pump; N/I, Not Information; NYHA, New York Heart Association; SvO2, Venous Oxygen Saturation.

achieve hemodynamic stability due to decreased end-diastolic volume and cardiac output, which leads to decreased cardiac preload and afterload. Therefore, patients may need a more extended period of mechanical ventilation to reach weaning criteria.[12] The prognostic role of cardiac reserve and the predictive value of parameters such as SYNTAX and EuroSCORE II scores are valuable for early detection of possible postoperative complications.[28–30] PMV patients have parameters similar to those with high SYNTAX and EuroSCORE II scores.[28,29] The combination of EuroSCORE II and SYNTAX scores is also helpful in predicting early major complications after CABG surgery.[31] High Euroscore scores are predictors of PMV, while low Euroscore 2 scores indicate faster extubation in cardiac surgery patients.[5,32]

Preoperative clinical conditions such as emergency surgery status and the presence of internal carotid artery stenosis may indicate poor patient condition even before surgery, which in turn can increase the risk of postoperative complications such as PMV.[5,25] Internal carotid artery stenosis in CAD patients can cause decreased cerebral perfusion and cognitive impairment such as delirium which makes it difficult for patients to wean ventilators. The risk of PMV after CABG surgery increases in patients with internal carotid artery stenosis, plus other risk factors such as advanced age, renal dysfunction, PPOK, CHF, and myocardial infarction.[33–35] Laboratory examinations such as cardiac enzyme CK-MB and haemoglobin before surgery can also provide helpful information to predict PMV.[5,12] Elevated CK-MB levels may indicate myocardial damage.[36] In contrast, preoperative low haemoglobin may reduce the body's ability to transport oxygen and increase stress on the cardiovascular system.[37] Both can potentially lead to complications such as respiratory failure requiring prolonged use of mechanical ventilation.[38] Other preoperative factors that have a significant influence on PMV are comorbidities such as renal dysfunction and COPD.[12,18] Renal dysfunction can lead to fluid and electrolyte imbalances, which can develop respiratory complications and prolonged need for mechanical ventilation.[39] The majority of COPD patients undergoing CABG are reported to require long-term mechanical ventilation or more than 48 hours due

to significantly reduced vital capacity, total lung capacity, and functional residual capacity, which also results in proportionally increased mortality.[40] Smoker status also has a significant impact on the post-CABG functional capacity decline, with active smokers more prone to prolonged ventilator use and atelectasis.[41] Smoking is one of the preoperative risk factors that may increase postoperative complications.[5,41]

Demographic characteristics such as age, gender, and high body mass index also influence PMV.[5,25,26] Older patients have an increased risk of low cardiac output syndrome (LCOS), which contributes to the occurrence of PMV after CABG surgery.[42] In addition, older age is associated with a higher probability of comorbidities such as diabetes, which can further complicate recovery and increase the risk of postoperative complications that require prolonged use of mechanical ventilation.[43] Women are reportedly more at risk of PMV than men.[1,44] The reason for the high incidence of prolonged mechanical ventilation among women is that women more often show symptoms of coronary heart disease at an advanced age (because it is associated with decreased levels of the hormone estrogen, which is said to inhibit atherosclerosis), so comorbid conditions are more often found.[45] A high body mass index may also increase the complexity of the surgical procedure and hinder postoperative pulmonary rehabilitation.[46]

Based on our review, events during surgery can also predict the occurrence of PMV after CABG surgery. Intraoperative factors that influence the occurrence of PMV include the initiation of the use of assistive devices during surgery, such as IABP and CPB machines.[4,12,16,18,25,26] This may be due to the worsening of the patient's condition during surgery, which requires invasive device support to stabilize their hemodynamics. However, the use of devices such as CPB machines can also trigger the release of inflammatory mediators due to the extracorporeal processing of blood, which ultimately contributes to pulmonary oedema so that respiratory failure and PMV can occur.[47] The use of CPB machines is the most dominant intraoperative factor in PMV. Longer CPB machine use increases the risk of PMV, whereas an increase of 1 minute above 82.5 minutes is associated with a 3.5% increased risk of PMV.[18] Intraoperative use of IABP has also been reported to increase the duration of mechanical ventilation three times longer.[12] This may be related to the unstable hemodynamics of patients with IABP, resulting in difficulty weaning patients from mechanical ventilation.[48]

Other intraoperative factors that affect PMV are the duration of surgery and reoperation. The long duration of CABG surgery is due to various factors, including the complexity of the surgical procedure, successful weaning of the heart from the cardiopulmonary bypass machine, and the surgeon's skill.[49] Research conducted by Totonchi et al (2014) reported that operating time> 4 hours affects the occurrence of PMV ($p<0,001$).[1] Reoperation also increases the risk of prolonged use of mechanical ventilation related to anatomical and physiological changes, such as the presence of scar tissue from previous surgery, which has the potential to cause longer operating times and increased trauma to surrounding tissues.[50] In addition, reoperation is often caused by complications such as bleeding or infection, which can further increase the inflammatory response, exacerbating postoperative complications such as respiratory distress and requiring prolonged ventilatory support.[51,52]

Clinical findings and postoperative complications of CABG were significant predictors of PMV. Postoperative acute kidney injury (AKI) increases the risk of PMV by 11 times.[27] with serum creatinine levels as a marker of diagnosis and prognosis.[53] Postoperative AKI characterized by elevated serum creatinine levels may be due to intraoperative hypotension and cardiac complications resulting in renal hypoperfusion and may also be a systemic inflammatory response and multiorgan dysfunction. AKI can lead to respiratory insufficiency and the need for prolonged ventilatory support.[53,54] The next most significant postoperative complication affecting PMV is mediastinitis. Patients with mediastinitis had an 18.51- times higher risk of PMV.[16] Gram-negative bacterial infections cause the majority of mediastinitis. However, in rare cases, it can also be caused by fungal infections such as Aspergillus, which can contribute to the complexity of treatment and potentially prolong the need for mechanical ventilation.[55,56] Delirium after CABG surgery may also increase the risk of PMV by 3-fold.[16] Delirium may result from increased inflammatory mediators, subclinical cerebral infarction, neurotransmitter changes, generalized hypoperfusion, and perioperative cellular hypoxia, which may be exacerbated by prolonged bypass time.[57] Pleural effusion requiring drainage increases the risk of PMV by 3.57 times.[58] Pleural effusion can increase intrathoracic pressure, decrease cardiac output, shock volume, and mean arterial pressure, resulting in respiratory distress requiring prolonged mechanical ventilation.[59]

Postoperative clinical findings such as bleeding requiring transfusion increased the risk of PMV by 23- times.[44] Bleeding after cardiac surgery can have severe consequences such as pericardial tamponade, infection, and organ dysfunction, making it difficult to wean patients from mechanical ventilation.[60] Anemia due to bleeding reduces oxygen delivery to body tissues, so patients experience hypoxic anaemia.[49] Furthermore, when postoperative bleeding occurs, the patient will require transfusions, which could potentially result in transfusion-related lung injury or circulatory overload due to massive transfusions to manage the bleeding.[7]

Another clinical parameter is the number of breaths in 24 hours, a protective factor. By increasing each unit of RR, PMV decreases by 0.921 hours.[12] In addition, the amount of chest secretions in the first hour and second hour after surgery also affects PMV, which is attributed to the establishment of proper chest drainage with the removal of secretions, preventing pressure on the heart and lungs.[12] The use of inotropic (including epinephrine, dobutamine or dopamine) as a post-surgical variable was shown to be a strong predictor for PMV after CABG.[1,16] Postoperative systolic blood pressure is associated with the duration of mechanical ventilation.[12] This could be because blood pressure is directly related to the amount of ventilation; it is understood that if blood pressure decreases or increases, the volume of blood exchanged with air in the lungs changes, which will result in a direct effect on the ventilation rate.[12]

Several laboratory results after CABG surgery may also be predictors of PMV. Studies have consistently shown that low levels of venous oxygen saturation, specifically central venous oxygen saturation (ScvO2) below 60%, are associated with unfavourable outcomes following cardiac surgery.[16,61] A low level of venous saturation reflects an imbalance between oxygen supply and demand, which can lead to inadequate tissue oxygenation and hemodynamic instability that ultimately causes the patient to require prolonged use of mechanical ventilation.[62]

Identifying risk factors is essential to optimize patient care and improve recovery after CABG surgery. Nurses are critical in assessing and managing risk factors to prevent PMV and related complications. By recognizing these factors early, nurses can implement targeted interventions such as respiratory care, mobilization, and early ambulation to reduce the risk of PMV. In addition, close monitoring and prompt intervention in patients with identified risk factors can contribute to improved postoperative outcomes and reduced healthcare costs.

Strengths and Limitations

The limitation of this scoping review is that it is difficult for the authors to group the factors and classify the level of factors into three categories. Because the articles the authors analyzed were quite heterogeneous, the results obtained in each article varied depending on the characteristics and variables used. In addition, the PMV time threshold used in these studies is not uniform, which may affect the findings in this article, so it becomes our limitation. Research on factors affecting PMV measured using the same time threshold can be conducted to obtain more specific and accurate results.

Despite some limitations, this review is a complete and up-to-date review that discusses PMV in CABG patients, categorizing factors into three stages: preoperative, intraoperative, and postoperative. In addition, this review used articles assessed using the JBI tool so that the articles analyzed in this review were of good quality. This review may provide a deeper understanding of the factors influencing PMV in CABG patients. Thus, it may help healthcare professionals allocate postoperative medical resources immediately after CABG surgery so that PMV can be prevented and managed correctly.

Conclusion

Based on the analysis of eight articles, various risk factors affecting the occurrence of PMV can be categorized into preoperative, intraoperative and postoperative factors. Factors that strongly influence PMV are NYHA class, mediastinitis and postoperative acute kidney injury. Among all the factors affecting PMV, the advanced NYHA class (3 and 4) was the most dominant factor from the articles studied. This makes incorporating NYHA class assessment before CABG surgery into CABG preoperative guidelines or checklists necessary. Evidence suggests that NYHA class evaluation can provide valuable insight into the functional status of patients and assist in PMV risk stratification after CABG surgery. In addition, results vary between studies, which may be due to differences in the number of factors examined, criteria, characteristics, and PMV cutoffs used. Therefore, it is essential to establish guidelines regarding the PMV time limit according to current conditions. Its use still takes into account patient characteristics and guidelines at each institution.

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