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Pulmonary complications after open heart surgery: A retrospective study

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Abstract

Despite significant advances in open heart surgery over the last two decades, postoperative pulmonary complications (PPCs) are considered the most important causes that contribute to patient morbidity, mortality and prolonged hospital stay. The ultimate goal of this paper was to investigate the risk factors which increasing the incidence rate of pulmonary complications after open heart surgery of Jordanian patients. A retrospective design using an existing coronary artery surgery database of adults (n = 200) who had undergone open heart surgery between August 2014 and July 2015 at a University Hospital in Jordan. A structured PPCs instrument was used to assess 'PPCs risk factors assessment sheet'. According to the results, the proposed model provides a preliminary indication of risk factors placing open heart surgical patients at risk of PPCs. Determining patients who are at risk of developing PPC's after cardiac surgeries are the first step towards its prevention. This reduces its burden in term of morbidity, mortality and cost.

Keywords: Jordan, open heart surgery, predictors, pulmonary complications, risk factors.

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1. Introduction

Coronary heart disease (CHD) is the main cause of death worldwide. It is the first killer in the United States and United Kingdom, and the most common class of heart disease. By 2020, it is estimated that CHD will be the main cause of death in all areas of the world (Alhalaiqa, Abu-shbeeb, Batiha, Masa'Deh & Amarneh, 2015; Go et al., 2014; World Health Organisation, 2010). In the Middle East, CHD is considered as one of the most serious health issues, which leads to a number of deaths. In Turkey, 170,000 deaths relating to CHD occur every year (Gaziano, Bitton, Anand, Abrahams-Gessel & Murphy, 2010). In Jordan, the mortality data showed that coronary artery disease (CAD) is the first killer that reached 4,545 deaths in the year 2006 (Batiha, Abu-Shaikha, Alhalaiqa, Jarrad & Ramadan, 2016; Montalescot et al., 2013). Open heart surgery is the gold standard treatment for both CAD and valvular heart disease (Go et al., 2014). Open heart surgery is an operation in which the patient chest is opened through a median sternotomy by using the cardiopulmonary bypass machine (Go et al., 2014). The reported postoperative pulmonary complications (PPCs), following coronary artery bypass graft (CABG) surgery, varies from 5% to 90% and they are considered the most important cause that contributes to patient morbidity, mortality and prolonged hospital stay (Sabate, Mazo & Canet, 2014). The highest rate of PPC after cardiac surgery was 39.6%, followed by thoracic (31.4%), abdominal (7.2%) and vascular procedures (5.8%) (Sabate et al., 2014).

PPCs have been defined as 'the development of one or more of following conditions: acute bronchitis, bronchospasm, atelectasis, pneumonia, adult respiratory distress syndrome, pleural effusion, pneumothorax, hemothorax, pulmonary embolism, pulmonary oedema, prolonged mechanical ventilation (>48 hours) and acute respiratory failure' (Sabate et al., 2014). The most important and morbid PPCs are atelectasis (Sabate et al., 2014), pleural effusion (Wang, He, Cheng, Wei & Min, 2013), pneumonia, respiratory failure, bronchitis and chronic lung disease (Sabate et al., 2014). Risk factors for PPCs are usually classified as factors relating to patients or procedures. Risk factors related to patients include age, patient's functional status, the existence of congestive heart failure (CHF) and chronic obstructive pulmonary disease (COPD). Risk factors which are related to procedure are mainly correlated to the site, duration and urgency of surgery (Wang et al., 2013).

Caused factors which increase PPCs were found to be developed by intraoperative, preoperative and postoperative factors (Sharma et al., 2016). Preoperative factors as the age at a time of surgery, gender, body mass index (BMI), smoking, the type of procedure, having diabetes, heart failure, hypertension, previous myocardial infarction (MI), angina, previous cardiac surgeries and history of lung diseases (Alhalaiqa, AL-Nawafleh, Batiha, Masa'Deh & AL-Razek, 2017; Batiha et al., 2015; Sharma et al., 2016). Intraoperative factors are total operative time, blood transfusion, total vessels bypassed in CABG patients and the name and number of valve repair or replacement in valvular heart surgery (Batiha & AlBashtawy, 2013; Wang et al., 2013). In addition, the postoperative factors are the length of time of mechanical ventilation, how long is the stay in intensive care unit and insertion of nasogastric tube (NGT). Identifying PPCs by Jordanian nurses will decrease the possibility of PPC after heart surgery by preventing and providing an early management in order to control or reduce the risk factors of PPC (Alhalaiqa et al., 2015). In Jordan, there are unavailable studies which studied the risk factors that are related to development of PPCs for CABG or valvular surgical patients. Hence, this study focused on investigating risk factors related to the development of PPCs in a cohort of CABG, valvular surgeries patients.

1.1. Objectives

1. To investigate the risk factors which raise the incidence rate of pulmonary complications after open heart surgery of Jordanian patients.
2. To identify incidence and predictors for pulmonary complications after open heart surgery.

2. Methods and materials

A descriptive, retrospective design using an existing open heart surgery database has been utilised for predicting risk factors for pulmonary complications after open heart surgery. The target population of the study was Jordanian patients with open heart surgery. The accessible population was 975 patients who underwent open heart surgery between 1 August 2014 and 31 July 2015. 975 patients' records were approached consecutively and 400 records of the total number included complete information that was required for the current study. Finally, 200 patients' records met with current study's criteria and reviews. The inclusion criteria were 18 years or older who had undergone CABG or valvular surgeries for the first time before hospital discharge. Exclusion criteria were based on a history of a stroke, cardiovascular instability or aneurysms, the existence of neuromuscular disease or a history of pulmonary surgery and the use of immunosuppressive treatments during 30-day preceding the surgery. About anaesthesia types, all eligible patients received only general anaesthesia.

2.1. Ethical considerations

Ethical approval of the study was granted by the institutional review board (IRB no. JUST- Nur-2015- 12). This study was conducted with consideration of the ethical implications at each phase of the study process.

2.2. Data collection

The tool for collecting data has been was developed by researchers on the basis of the literature review. It consists of three parts: preoperative, perioperative and postoperative risk factors. Researcher coded the tool's variables into 16 questions as binary cut-off points and 31 open-ended questions' operative risk factors consist of age of the patient, his/her sex, BMI and history of smoking, hypertension, heart failure, diabetes mellitus, MI and lung disease. The perioperative risk factors involved surgical techniques (valve surgery and/or CABG), number of coronary vessels bypassed and duration (anaesthesia, cardiopulmonary bypass). Postoperative risk factors documented the duration of ventilation, the presence of NGT and postoperative complications other than pulmonary such as bleeding, arrhythmias, renal insufficiency and infection. PPC included pleural effusion, atelectasis, pneumonia, hemothorax, pulmonary oedema, respiratory failure, pneumothorax and pulmonary embolus, which were recognised from diagnostic imaging, clinical examination, reports and laboratory reports. The tool was completed from patient's medical records by the researcher. Medical records were reviewed and evaluated to identify patients' demographic data and diagnosis, in addition to other issues such as all procedures carried out, management, the length of stay in ICU and outcomes.

2.3. Statistical analysis

The data collection was analysed using Statistical Package for the Social Sciences version 16. Descriptive statistics (mean, median, range and standard deviation) was used to describe patients' variables and types of pulmonary complications post-heart surgery. Inferential statistic and logistic regressions analyses was used to predict of PPCs after open heart surgery and chi-square test was used to descriptive of PPCs incidence rate.

3. Results

The age range of patients was between 19 and 80 years with a mean age of 56.20 ± 10.215 years. The sample consists of 72% males; the highest percentage (42%) represented patients who were more than 65 years. Regarding body weight, 44.5% of the patients were overweight. As for smoking habits, 61% of the patients were smokers. Participant's data revealed that some patients had more than one disease. 42.5% of the patients had a history of hypertension. 35.5% of the them had a history of DM.

In addition, 91% of the patients had angina, 24% of them had a previous MI and one patient had CHF. Regarding lung disease, 88.5% of the patients did not have a history of lung disease, while seven patients had pulmonary oedema, five patients had COPD, three patients had asthma, four patients had chronic bronchitis, four patients had pneumonia and three patients had tuberculosis. Finally, 81% of the patients had only CABG surgery, and 11% had only valve surgery, while 8% had both procedures.

In the intraoperative period, the cardiopulmonary bypass time was equal or less than 85 minutes for 58.5% of the sample studied. However, all patients had on-pump surgery except for one patient who had off-pump surgery. The length of total operation time ranged between 1.2 and 6 hours, the total duration was more than 120 minutes for 59.5% of the patients. Of the anaesthesia, duration ranged from 2 to 9 hours with the mean duration of 3 hours and 37 minutes or (3.62% hours), the duration of anaesthesia was around of (3.62% hours) or less for 59.5% of the patients. In relation to surgical data, 81% had CABG surgery, out of them, 69.5% had four vessels, 11.5% had three vessels, 8% had two vessels, and based on the type of conduit, 83% of the patients had both of saphenous and left interior mammary arteries (LIMA), 4.5% had saphenous, 0.5% had LIMA and 0.5% had radial grafting vessels. Regarding valve procedure with or without CABG surgery, 12.5% of the patients had mitral valve operation, 7.5% had aortic valve and 5% had a tricuspid valve. In addition, the finding of the study revealed that only 3.5% of the patients had a blood transfusion or its products in intraoperative time.

Regarding the distribution of postoperative risk factor, it was revealed that around 74% of the patients were ventilated 10 hours or less. Only 17.5% of the patients had a NGT, 69% of patients had been hospitalised for more than 7 days. 85.5% of the patients stayed more than 24 hours in the ICU. In addition, 88.5% of the patients learned to perform deep breathing exercises. Intra-aortic balloon pump procedure was done for only two patients.

3.1. Incidence of pulmonary complications

The occurrence of PPCs represented 75% from all sample studied. There were 150 participants who developed PPC out of 200 participants. Thus, PPC incidence rate among post cardiac surgery patients in the target hospital was 75%. It was found that, pleural effusion was the major pulmonary complications as it occurred in 67% of the patients, followed by atelectasis (11.5%), pneumothorax (6%), pneumonia (3.5%), embolism (1.5%), arrest (1.5%), bronchospasm (1%), the least complications were bronchitis (0.5%), pulmonary oedema (0.5%), pulmonary emphysema (0.5%), acute respiratory distress syndrome (ARDS) (0.5%) and hemothorax (0.5%). In relation to other PPCs, they did not occur in any patient (such as respiratory failure). See Table 1.

Table 1. Frequency distribution of the patients according to pulmonary complications (*N* = 200)

Variable		Percentage (%)
Pleural effusion	Yes	67
	No	33
Atelectasis	Yes	11.5
	No	88.5
Pneumothorax	Yes	6
	No	94
Pneumonia	Yes	3.5
	No	96.5
Arrest	Yes	1.5
	No	98.5
Pulmonary embolism	Yes	1.5
	No	100
Bronchospasm	Yes	1

	No	99
Pulmonary oedema	Yes	0.5
	No	99.5
Emphysema	Yes	0.5
	No	99.5
ARDS	Yes	0.5
	No	99.5
Bronchitis	Yes	0.5
	No	99.5
Hemothorax	Yes	0.5
	No	99.5
Respiratory failure	Yes	0
	No	0

ARDS: Acute respiratory distress syndrome.

The predictors of each PPC were analysed in terms of the presence of most common and high percentage of PPCs in this study cohort. These PPCs were pleural effusion (67%), followed by atelectasis (11.5%), pneumothorax (6%) and pneumonia (3.5%).

3.2. Predictors of postoperative pleural effusion

Regarding the relationship between pleural effusion and preoperative data, there was a statistical significant relationship between BMI and pleural effusion (c^2 = 7.158, p = 0.028), the most significant was found between patients who were overweight (33%) (c^2 =7.123, p = 0.028), those patients were (47.9% males, 35.7% females). However, BMI factor was only found to be significantly related to the presence of pleural effusion by using the univariate analysis.

Regarding blood or components transfusions, 45.5% of all patients, blood and/or blood components (platelet, plasma) were transferred them intra- or post-open heart surgery. As for the use of Chi-square test, there was a strong statistically significant relationship between blood or blood components transfusions and pleural effusion occurrence (p = 0.002, c^2 = 9.612). In addition, there was a statistically significant relation between blood transfusion only or plasma transfusion only and pleural effusion (p = 0.01, c^2 = 9.929, p = 0.008, c^2 = 11.884) respectively. See the Table 2.

Table 2. Intraoperative predictors of postoperative pleural effusion

Intraoperative variables		**Pulmonary complications(pleural effusion)**		
		Yes	**No**	**c^2 (p)**
		n%	***n%***	
Blood and/or components	Yes	9,145.5	2,914.5	9.612 (0.002*)
	No	4,321.5	3,718.5	
Blood only		63	10.5	9.929 (0.01*)
Plasma only		10.5	00	11.884 (0.008*)

Chi-square (χ^2), power value = p^* significant at α = 0.05.

By using a logistic regression test, only gender 'female', COPD history presence, duration of mechanical ventilator >10 hours and the presence of NGT remained significant predictors of atelectasis (Odds = 5.488, 17.875, 4.365, 5.763), respectively. See Table 3.

Table 3. Binary logistic regression (pleural effusion 'dependent variables' and other independent variables)

	B	SE	Wald	df	Sig.	Exp (*B*)	95.0% CI for EXP (*B*)	
							Lower	Upper
BMI	0.596	0.311	3.676	1	0.055	1.815	(0.99, 0.34)	
Blood and/or components	0.993	0.309	10.304	1	0.001	2.700	(1.47, 4.95)	
Blood. Intra	1.114	1.091	1.043	1	0.307	3.047	(0.36, 25.84)	
Blood. Post	0.735	0.308	5.701	1	0.017	2.085	(1.14, 3.81)	
Plasma. Intra	20.502	40,192.97	0.000	1	1.00	8.018	(0.000)	
Plasma. Post	1.299	0.419	9.604	1	0.002	3.666	(1.61, 8.34)	
Mechanical ventilator	1.265	0.420	9.094	1	0.003	3.544	(1.56, 8.07)	
Length of ICU stay	0.925	0.407	5.149	1	0.023	2.521	(1.13, 5.60)	
Constant	−0.884	0.460	3.696	1	0.055	0.413		

Variable(s) entered: BMI, blood and/or components, blood. intra, blood. post, plasma. intra, plasma. post, mechanical ventilator, length of ICU stay.
*Significant at $\alpha = 0.05$.

Besides, a logistic regression test was conducted to emphasise the previous finding about the predictors of postoperative pneumothorax. As a result, for the history of pneumonia, *p*-value was 0.005 and it was highly significant and odds ratio was equal to 18.6 and this means that the pneumothorax had developed in patients who had a history of pneumonia of 18.6-folds compared to patients who did not have history. Likewise, when logistic regression was carrid out, transfusion of platelet and presence of NGTwere statistically significant predictors. See Table 4.

Table 4. Binary logistic regression
(Pneumothorax 'dependent variable' and other 'independent variable')

	B	SE	Wald	df	Sig.	Exp (*B*)	95.0% CI for EXP (*B*)	
							Lower	Upper
Gender	0.268	0.634	0.179	1	0.672	1.308	(0.38, 4.53)	
COPD	−18.478	17,974.84	0.000	1	0.999	0.000	(0.000)	
History of pneumonia	2.923	1.051	7.730	1	0.005	18.600	(2.37, 146.03)	
Age	−0.887	1.062	0.699	1	0.403	0.412	(0.05, 3.29)	
Mechanical ventilation	0.377	0.635	0.353	1	0.552	1.458	(0.42, 5.06)	
Hospital length	0.852	0.790	1.162	1	0.281	2.344	(0.49, 11.03)	
Platelets	2.085	0.687	9.220	1	0.002	8.045	(2.09, 30.91)	
NGT	1.702	0.612	7.740	1	0.005	5.483	(1.65, 18.18)	
Constant	−4.041	0.876	21.281	1	0.000	0.018	-	-

Variable(s) entered: gender, COPD, History of pneumonia, Age, Mechanical ventilation, length of hospital stay, platelets and NGT.

As shown in the Table 5, using a logistic regression test, the relationship remained statistically significant between pneumonia and with age more than 65 years (p = 0.014, Odds ratio = 6.968) and with a history of bronchitis (p = 0.001, Odds ratio = 38.2). According to age as a predictor, that means the odds of patients' files which were documented yes. Those aged >65 years was 6.968 times higher for someone who was in the other age groups. Similarly, related to the history of bronchitis as a predictor, that means the odds of patients' files were documented yes. They had a history of bronchitis and it was 38.2 times higher for someone who reported having a history of bronchitis than a person who did not have a history of bronchitis.

Table 5. Binary logistic regression
(Pneumonia 'dependent variable' and other 'independent variable')

	B	SE	Wald	df	Sig.	Exp (*B*)	95.0% CI for EXP (*B*)	
							Lower	Upper
History of bronchitis	3.643	1.098	11.011	1	0.001*	38.2	(4.44, 328.50)	
Age	1.941	0.789	6.061	1	0.014*	6.968	(1.49, 32.68)	
Mechanical ventilation	1.456	0.834	3.047	1	0.081	4.291	(0.84, 22.02)	
Hospital length	18.148	4,677.06	0.000	1	0.997	7.613E	(0.000)	
Platelets	−18.682	9,625.7	0.000	1	0.998	0.000	(0.000)	
Constant	−22.287	4,677.08	0.000	1	0.996	0.000	(−22.29, −4,677.06)	

Variable(s) entered: history of bronchitis, age, mechanical ventilation, hospital length, platelets.
*Significant at α = 0.05.

4. Discussion

Historically, PPCs reported major open heart surgery postoperative morbidity (Agostini et al., 2010) and the general incidence of PPCs following open heart surgery varies from 5% to 90%. Similarly, the current retrospective study's incidence of PPCs is three-quarters of all study cohorts. This result is consistent with many previous studies (Choiniere et al., 2014; Sabate et al., 2014; Wang et al., 2013).

The types of PPCs which were revealed in this study were compatible with previous studies. Pleural effusion was the major pulmonary complication as it occurred in 67% of the patients. This result is supported by Vargas et al. (2002), who reported that pleural effusion occurred in immediate postoperative period in 66.7% of the patients after CABG surgery. The finding of both studies are sustained by Jensena and Yangb (2007) and Lee et al. (2001), who reported that 75.6% and 85%, respectively, of patients, develop pleural effusions after CABG surgery.

According to atelectasis, patients who developed that were 11.5% of total cohort hospitalisation. The majority of patients who developed atelectasis had both LIMA and saphenous grafting. This issue in agreement with Groeneveld, Jansen and Verheij (2007) and Foghsgaard et al. (2009), who reported that the most common postoperative respiratory complication is atelectasis, occurring in essentially in all clients who undergo open heart surgery and it is the major cause of the deterioration in lung function and this may be initiated during bypass. Other studies also stated that atelectasis represents the most common pulmonary complication following cardiac surgery with CPB (Lugg et al., 2016; Othenin-Girard, Grandjean, Monnard, Sotiriadis & Magnusson, 2014).

Pneumonia has been indicated as a common pulmonary complication in the postoperative period (Wang et al., 2013). In the current study, 3.5% open heart patients developed postoperatively.

4.1. Predictors of PPCs

The current study revealed that the age of more than 65 years was a predictor for postoperative pneumonia. This result is in agreement with the study of Croce (2000) who concluded that advanced age represents a risk factor for postoperative pneumonia. This is supported by Arozullah, Khuri, Henderson and Daley (2001) who suggested that age represented a significant risk factor associated with postoperative pneumonia. Rationally, that may be because an elderly patient has some alteration in the function and the structure of the respiratory system, lungs become gradually less compliant, and expiratory muscle strength diminishes resulting in decreased chest wall compliance. Conversely, the results of the current study disagree with Sharma (2016), who reported that age had not yet been identified as an independent risk factor for the development of PPCs.

The World Health Organisation (2017) reported that in all populations being overweight or obese increases the risk of CHD. In the current study, most of the Jordanian patients who underwent open heart surgery were overweight or obese based on the BMI, which is regarded as predictor for development of pleural effusion. The causes may be clarified by that obesity may adversely affect respiratory muscle function, patients having obesity have more fatty tissues in their chest area and they are perfused. This limits oxygen supply and decreases functional residual capacity (Craig & Fang, 2017). These results are consistent with other studies (Blouw, Rudolph, Narr & Sarr et al., 2003; Koenig, 2001).

Blood, plasma and intra- and postoperative transfusion, in the current study, were predictors for development of postoperative pleural effusion. Platelet postoperative transfusion was also a predictor for the development of atelectasis and pneumothorax. These results are consistent with the results of Offner's (2004) study, who reported that it has become increasingly evident that transfused stored red blood cells or its products may be responsible for clinically observed adverse events such as multiple organ failures and PPCs.

This study showed the four patients out of seven patients who developed pneumonia were under the effect of mechanical ventilation for more than 10 hours, but when logistic regression test was used, no statistically significance appeared. However, this result is supported by Bouza et al. (2003), who stated that patients undergoing heart surgery have a high frequency of ventilator-associated pneumonia after prolonged mechanical ventilation, and early oxygen discontinuation is effective in the improvement of outcome.

In the current study, 11.5% of the patients suffered from a history of lung diseases. Data revealed that positive history of pre-operative of COPD a significant effect on the development of atelectasis. This in agreement with Fuster et al. (2006), who reported that patients having COPD may be more exposed to the risk of PPCs. On the other hand, Kanat et al. (2007) found that the risk of PPCs did not increase among patients with COPD. Furthermore, the entire cohort of this study had at least a history of chronic diseases (hypertension, diabetic mellitus, MI, angina or heart failure). These results are in line with the characteristics resulting in the study by Rosborough (2006), who reported that patients who underwent open heart surgery have greater number of co-existing diseases, which make them at high risk for morbidity and mortality after surgery, and these require professional, high skills and expert critical care nurse to take care of these patients and prevent the potential PPCs.

Regarding gender differences in the occurrence of PPCs, although demographic and other risk factors for men and women undergoing CABG differ greatly, several researchers concluded that smaller body surface area and coronary artery size represent the factors which are mainly or directly linked to higher mortality among women. Similarly, women were more prone to development of atelectasis around 5.48 times than men, and logistic regression confirmed the same. This result was compatible with Woods et al. (2003), who reported that women had significantly increased mortality, intraoperative complications and pulmonary complications, and women had developed pulmonary complications more than males.

The current study, although only 35 (17.5%) open heart patients had used the NGT, significantly contributes to the development of both atelectasis and pneumothorax. On the other hand, references are limited about the relationship between NGT and postoperative atelectasis and pneumothorax, but the relationship may be due to the procedure of open heart surgery which may lead to atelectasis and pneumothorax rather than the NGT itself.

History of smoking was considered a risk factor for many cases that were related to mortality or morbidity of patients. In this study, however, all developed PPCs did not associate with smoking habit, except statistically. Bronchitis was one complication that occurs after open heart surgery. Only one patient developed bronchitis, and this patient was classified as a just quit less than 6 months group (≤6 months). These results are inconsistent with the study's result of Al-Sarraf (2008), who found that smoker patients may be exposed more to PPCs than non-smoker patients.

In the other words, according to the current study, these results might be due related complication did not develop early after surgery or within hospital stay. Another supportive study is conducted by Hulzebos et al. (2003). It concluded that one of many factors was positive cigarette smoking history. This had an association with the development of PPCs with the help of logistic regression analysis, but the authors did not investigate types of PPCs which are affected.

4.2. Limitations of the study

The collected data were limited to a single institute, which may affect generalisation of the study results. The second limitation is related to the data collection method. All medical records were not computerised. In addition, patients' records were not placed on special shelves in the archives department. Scarcity of statistical references constitutes another limitation; this can go back to unavailable database. Most patients' records did not document all information, such as the time of mechanical ventilation, except routine nursing progress notes, but also in any time may these notes loosed.

4.3. Implications

The study result revealed the importance of knowledge about an opportunity to identify predictors for PPCs. As known, to nurses contribute significantly the care of patients with respiratory problems by taking a comprehensive history, performing a thorough physical examination, and monitoring laboratory and diagnostic studies. Postoperatively, more attention should be provided to patients who were ventilated over 10 hours. About preoperatively, predictors need to be closely monitored for probable development of PPCs.

Critical care nurses play an essential role in detecting and preventing or reducing the occurrence of PPCs through assessing risk factors for developing PPCs, identifying patients at high risk for developing them, providing the appropriate care and performing the preventive strategies according to the predicted risks.

The obtained knowledge from this study may allow critical care nurse to build a database to detect fitting changes in the patient's condition and intervene at appropriate time to provide optimal nursing care for open heart surgical patient, especially high-risk ones. Doing this will assist nurses to be more confident and will encourage them to be professional nurses. Future research is needed to cover the limitations of this study.

5. Conclusion

Open heart surgery has rescued thousands of people afflicted by the coronary artery and valvular heart disease. Pulmonary complications after open heart surgery are common. This study aimed to investigate incidence, types of pulmonary complications and the predictors of pulmonary

complications after sternotomy open heart surgery for Jordanian patients. PPCs were common and contribute to prolonged stay at intensive care unit. The majority of open heart surgery patients (75%) developed PPCs, most of them were with pleural effusion or atelectasis or pneumothorax or pneumonia. Few of them had bronchitis, bronchospasm or pulmonary oedema. Thus, the predictors which may contribute to the development of PPCs in this study were advanced age, excess weight (BMI), history of bronchitis or pneumonia or COPD, duration of mechanical ventilation >10 hours, type of compound procedure (CABG and valvular), female gender, blood and components transfusion and NGT presence.

Knowledge of risk factors influencing PPCs will enable critical care nurses to anticipate pulmonary complications in risk patients, and develop proper care plan to prevent these complications and consumption of hospital resources. Furthermore, the results of this study will help nurses acquire new knowledge or develop new skills that enable nurses to predict and identify the patient at higher risk for PPCs, and provide appropriate care and perform preventive strategies according to risk predictors including manoeuvres such as incentive spirometry and chest physiotherapy, including deep breathing exercises, cough, turn frequently, chest percussion and vibration, suctioning and assistance in kinetic exercises. In addition, these results will open new fields of nursing research and evidence-based practice, which will be reflected on nurses' confidence, experiences, roles and quality of care.

This study targets Jordanian patients after open heart surgeries. Understanding and decreasing of PPC by nurses after open heart surgery will reduce patients and their families, physiological and psychological suffering, help patients to return quickly to their normal life style and avoid readmission, treatments of PPCs and their costs, thus improving patients' quality of life after open heart surgery.

Hospitals will have basic data to understand and prevent of PPCs which will that reduce the job overload among healthcare staff and increase hospitals capacity through avoiding prolonged hospitalisation. Furthermore, it will diminish costs incurred by patients of the care provided by hospital.

Conflict of interest

The authors declares that they do not have any conflicts of interest with respect to the research writing and/or publication.

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