Nurse Media JOURNAL OF NURSING

Nurse Media Journal of Nursing
e-ISSN: 2406-8799, p-ISSN: 2087-7811
https://medianers.undip.ac.id
12(2):249-257, August 2022
https://doi.org/10.14710/nmjn.v12i2.45394

CASE STUDY

Application of Breathing Exercises Using Ida Jean Orlando's Dynamic Nurse-Patient Relationship Model in Overcoming Postoperative Hypoxia (POH) after Coronary Artery Bypass Grafting: A Case-Series

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Article Info

Article History:
Received: 24 March 2022
Revised: 15 August 2022
Accepted: 18 August 2022
Online: 31 August 2022

Keywords:
Breathing exercise; CABG; Ida Jean Orlando; nursing care; postoperative hypoxia

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Abstract

Background: Postoperative hypoxia (POH) is a complication that often occurs in patients after Coronary Artery Bypass Grafting (CABG). Breathing exercises are considered effective in overcoming POH after CABG. However, this intervention has not been implemented using the dynamic nurse-patient relationship model from Ida Jean Orlando. The dynamic nurse-patient relationship model is expected to improve the quality of nursing care after cardiac surgery.
Purpose: This study aimed to describe the application of breathing exercises in postoperative hypoxia after CABG using the dynamic nurse-patient relationship model.
Methods: This study was the summary of the case presentation along with the interventions on three patients after CABG through the dynamic nurse-patient relationship model approach with the main intervention focusing on breathing exercises.
Results: After three days of implementing the intervention, most patients showed improvement in POH. This condition was evidenced by an increase in the PaO_2/FiO_2 ratio from less than 200 to above 200, with an average increase of 89.3. The blood gas analysis results supported the results from a respiratory alkalosis condition to a normal PH and a $PaCO_2$ value from <35 mmHg to the normal range (35-45 mmHg). Also, X-rays of the patients showed pulmonary atelectasis improvement.
Conclusion: Applying breathing exercises in postoperative hypoxia after CABG using the dynamic nurse-patient relationship model can improve POH in post-cardiac surgery patients. We recommend using the model theory approach because this theory can see patients' psychological and physical changes dynamically in post-CABG patients.

How to cite: Fahmi, I., Nurachmah, E., Dyaningtyas, H. E., Kamal, M., & Ganefianty, A. (2022). Application of breathing exercises using Ida Jean Orlando's dynamic nurse-patient relationship model in overcoming postoperative hypoxia (POH) after coronary artery bypass grafting: A case-series. *Nurse Media Journal of Nursing, 12*(2), 249-257. https://doi.org/10.14710/nmjn.v12i2.45394

1. Introduction

Coronary artery bypass grafting (CABG) is a method of cardiac surgery and invasive coronary reperfusion interventions in coronary heart disease (American Heart Association, 2018; PERKI, 2015; Thielmann et al., 2017). Patients undergoing cardiovascular surgery using general anesthesia, mechanical ventilation machines, and cardio-respiratory bypass machines have a high potential for postoperative pulmonary complications (Wynne & Botti, 2004). Postoperative pulmonary complications include impaired gas exchange function, atelectasis, decreased ability to cough effectively, pneumonia, respiratory muscle weakness, and sputum retention (Badenes et al., 2015; Ranucci et al., 2014; Sutton et al., 2014; Yousefshahi et al., 2019).

The prevalence of pulmonary complications after thoracic surgery, including CABG such as atelectasis, pleural effusion, and phrenic nerve paralysis, is estimated at 2-4% (Shakuri et al., 2015). As a result of pulmonary complications, patients generally experience postoperative hypoxia (POH) (30%), and about 2% have acute respiratory distress syndrome (Ranucci et al., 2014; Wynne & Botti, 2004). This condition can increase the length of stay in the intensive care unit (ICU), and use prolonged mechanical ventilation, thereby increasing hospital costs (Badenes et al., 2015).

In recent years, to speed up postoperative recovery, the Early Recovery After Surgery (ERAS) program (Kołodziej et al., 2019), was developed to improve treatment outcomes (Nicholson et al., 2014). The ERAS guidelines are integrated into perioperative care, which refers to a series of evidence-based perioperative care processes to achieve rapid recovery (Li et al., 2018). In the postoperative phase, breathing exercises become the standard of postoperative care in post-cardiac surgery patients (Noss et al., 2018). No previous studies have implemented a breathing exercise intervention using the dynamic nurse-patient relationship model from Ida Jean Orlando. However, this theory is considered to produce quality nursing care.

Nurses have an essential role in the physical, psychological, social, and spiritual conditions in the peri-operative care of heart surgery. Currently, specialist nurses have been widely introduced as specialist nursing care providers to provide more quality and specific nursing services (Lopatina et al., 2017). Based on this, the dynamic nurse-patient relationship model concept is a primary theory in providing nursing care to post-cardiac surgery patients. This theory uses the basic principles of critical thinking, a client-centered and goal-oriented approach, and evidence-based nursing intervention recommendations (Butler, 2019). Social information processing models enhance understanding of how nurses respond to patients and further develop nursing theories. In combination, the theories help develop research into nurse-patient communication (Sheldon & Ellington, 2008). The nursing intervention and the dynamic nurse-patient relationship model will produce quality nursing care.

In post-CABG patients, communication becomes an essential component carried out by nurses and patients (Hardin & Kaplow, 2019). Also, in performing interventions, one of which is breathing exercises, one must use good communication. This is necessary so patients can follow the nurse's instructions properly and produce optimal outcomes. Orlando's theory of the dynamic nurse-patient relationship provides a theoretical framework for understanding that communication (Gaudet & Howett, 2018). This study aimed to describe the application of breathing exercises in postoperative hypoxia after CABG using the dynamic nurse-patient relationship model.

2. Case presentation

A case series with an observational research design approach was used in this study. The cases were three patients after CABG in the ICU of a single hospital in December 2019. The inclusion criteria in this study included the adult patients who experienced POH with $PaO2/FiO2<200$ and impaired gas exchange as a nursing diagnosis (code D.0003). In addition, the patients were conscious and followed orders. The exclusion criteria in this study were patients using mechanical ventilation. When post-CABG patients were admitted to the ICU, the researcher selected patients who met the inclusion and exclusion criteria of the study. After that, the researcher informed the patients of the study. When the patient agreed, the researcher explained the procedure and initiated the research intervention.

2.1 Case history before the intervention

The three male patients, aged 57, 56, and 56 years old, underwent respiratory monitoring intervention, and the supporting intervention is acid-base management. The specific history of each client is shown in Table 1.

2.2 Interventions

Each patient involved in this study gave voluntary written informed consent and consented to publication. The purpose of nursing interventions with nursing problems, in this case, refered to Indonesian nursing output standards, expected that gas exchange would increase with the criteria for improving blood gas analysis results. The primary interventions were respiratory monitoring and breathing exercise, while the supporting intervention was acid-base management. The breathing exercises were carried out using incentive spirometry four times a day, 15-20 minutes per session for three days of the intervention.

Table 1. Patient's health history

Name (Age)	Health history
Mr. (57)	Admitted to the ICU Cardiac surgery with a diagnosis of three grafted post CABG and Aorta Valve Replacement (AVR). The patient had secondary diagnosis of obesity with BMI>30.4 and was a heavy smoker. The 3rd day of hospitalization after CABG and AVR surgery, the patient was put on a simple oxygen mask of 6 liters/minute. The patient was having a shortness of breath accompanied by an increase in Work of Breathing (WOB). There were fine crackles on the right and left lungs, Blood Pressure (BP) of 110/60 mmHg, Mean Arterial Pressure (MAP) of 70 mmHg, Heart Rate (HR) of 110 beats/minute, Respiratory Rate (RR) of 24 breaths/minute, and patient peripheral saturation of 90%. The patient was decided to undergo a chest X-ray, lung ultrasound, and blood laboratory examination. The X-ray examination results found left lung atelectasis, pneumonia, and pleural effusion. Lung ultrasound examination revealed right and left lung atelectasis. The results of blood laboratory examination blood gas analysis were: pH 7.47; PO2 74.5; PCO2 33.9; HCO3 29.7; actual BE 6.4; lactate 0.9; Hb 11.2 gr/dl; Ht 37.4%; leukocytes 22,000/ul; platelets $406x10^3$; urea/creatinine 32.50/1.28; Glomerulus filtrate rate (GFR) 58%; Current blood sugar 141; Sodium (Na) 140 mmol/L; Potassium (K) 3.7 mmol/L; Chloride (Cl) 105 mmol/L; Calcium (Ca) total 2.34 mmol/L; Magnesium (Mg) 1.8 mmol/L; diuresis 0.4 ml/kgBW/hour. PaO2/FiO2 was 191.
Mr. (56)	Admitted to the ICU Cardiac surgery with a diagnosis of three grafted post CABG and secondary diagnosis of obesity with BMI of 31. On the third day, the patient complained shortness of breath and increasingly ineffective breathing, so a simple oxygen mask of 8 liters/minutes was put on the patient. Physical examination found abnormal BP of 100/60 mmHg, MAP of 70 mmHg, HR of 100-110 beats/minute, RR of 25 breaths/minutes, and patient peripheral saturation of 92%. The patient underwent a chest X-ray and blood laboratory examination. Left lung atelectasis was found and blood gas analysis showed pH 7.49; PO2 95.3; PCO2 17.9; HCO3 13.8, and actual BE -6.6. Other laboratory results showed potassium 3.7,;Na/CL 147/106; and Ca/Mg 0.78/0.35. PaO2/FiO2 was 200.To improve the respiratory status, the patient received simple mask oxygen therapy. The X-ray examination results found left lung atelectasis.
Mr. (56)	Admitted to ICU Cardiac surgery with four grafted post CABG diagnosis and a BMI of 26.4. The patient has had heart problems for five years. Three days after surgery, the patient complained of heavy breathing, cough, and difficulty in expelling phlegm. The patient had done deep breathing and coughing exercises, but not optimal (short breaths and ineffective cough). The physical examination showed abnormal BP of 124/86 mmHg, regular HR of 109 beats/minutes, RR of 24 breaths/minutes, oxygen saturation of 92% with nasal oxygen of 4 liters/minutes, CRT of <2 seconds, and an installation of substernal and intra-pericardium drain connected to the water shield drainage system, to assist the clearance of blood, serous fluid, and air for preventing post-operative complications. X-ray examination results found left lung atelectasis. Blood gas analysis showed pH 7.46, PaO2 145.2, PaCO2 38.2, HCO3 22.6, BE -1.1, potassium 3.8, Na/CL 145/105, Ca/Mg 0.88/0.40, and lactate 2.8 mmol. PaO2/FiO2 was 197.6.

The intervention was carried out by identifying the patients according to the inclusion and exclusion criteria of the study. After obtaining consent from the patients, the patients were positioned in a semi-fowler's position by holding the respirometer upright. The researcher placed the mouthpiece in the patient's mouth and then instructed the patients to close the mouth around the mouthpiece tightly. The researcher then advised the patients to inhale slowly and deeply with the lips tightly closed on the mouthpiece. After the patients had inhaled as deeply as possible, they held their breaths for 3 seconds and then exhaled to lift the three balls according to the patient's ability. Finally, the patients were asked to remove the mouthpiece from the patient's mouth and exhaled normally. The procedure was repeated 10 to 15 times per session.

The application of breathing exercise was combined with the theory of Ida Jean Orlando. The communication process was prioritized, like conveying the steps of breathing exercises and paying attention to changes in the psychological condition that occured in patients. Orlando's theory of the dynamic nurse-patient relationship was to identify the strategies for teaching the patients to apply the effective nursing practice, including communication. The theory was expressed in simple language that broke down the communication between the nurse and the patient into two primary categories, automatic and deliberative action. When a deliberative action took place, the patient's immediate need was met after validation and discussion between the nurse and the patient. Meanwhile, automatic action was carried out without any discussions or inputs from the patients. A helpful, trusting relationship was established if the nurse used a deliberative approach and validated the patient's distress or unmet need. This process is described in Table 2. In applying breathing exercises to post-CABG patients, good communication should be used. This was necessary so patients could follow the nurse's instructions properly and produced optimal outcomes. Three cardiovascular specialist nurses and one ICU consultant physician were involved in this process.

Table 2. The dynamic nurse-patient relationship model of Ida Jean Orlando

Component	Actions
The function of professional nursing	Nurses find out and meet patient needs
The patient's presenting behavior	The nurse identifies the patient's verbal and nonverbal expressions.
The immediate reaction Automatic responder Perceptions Thoughts Feelings ↓ Nursing Action (Does not validate the patient) Deliberative responder Perceptions Thoughts Feelings ↓ Nursing Action (Validate patients using a deliberative process)	Spontaneous response by the nurse covering three sequential aspects: Perceptions, Thoughts, Feelings
Deliberative nursing process The nursing care process involves the patient by asking the patient to validate or invalidate what the nurse has done (Perceptions, Thoughts, Feelings) to determine nursing interventions further.	a. The nurse conveys the results of verbal and nonverbal observations directly to the patient b. The patient validates or invalidates the nurse's immediate reaction c. The nurse plans nursing interventions based on patient validation
Nursing Product	As a basis for evaluating the fulfillment of patient needs, the nurse notes whether or not there is improvement in the behavior changes that the patient shows.

2.3 Patient's conditions after the intervention

The description of the symptoms and patients' conditions after three days of interventions are presented in Table 3.

2.4 Evaluation

There was an improvement in lung function in the ventilation-perfusion process. It is noted that the body did not carry out a compensatory mechanism, as evidenced by a decrease in body pH from a respiratory alkalosis condition to a normal pH and a $PaCO_2$ value from <35 mmHg to the normal range (35-45 mmHg). Based on Guyton's theory in the oxygen dissociation curve, oxygen will be difficult to bind to hemoglobin under alkalosis conditions. Therefore, the PaO2 state will indicate hypoxemia.

Furthermore, after the 3rd day of the intervention, the Pao2 value improved the alkalosis condition that caused hypoxemia. This condition was evidenced by an increase in the PaO2/FiO2 ratio from less than 200 to above 200, with an average increase of 89.3. In the first patient (57 years), PaO2/FiO2 increased from 191 to 269.7. In a second male patient aged 56 years, the PaO2/FiO2 rose from 200 to 288.5. Finally, similar to the previous two patients, the third male patient, who was also 56 years old, also experienced an increase in PaO2/FiO2 from 197.6 to 298.2. Also, the X-ray showed an improvement in the state of pulmonary atelectasis.

Table 3. Symptoms and patients' conditions after intervention

Name (Age)	Symptoms and patients' conditions
Mr. (57)	Complaints of reduced shortness of breath, respiratory rates 20 breaths/minutes, no WOB found, vesicular breath sounds on the right and left lung from the auscultation of the voiced breath, ABP 100/70 MAP 80, Heart Rate (HR) 98 beats/minutes, RR 18 breaths/minute, patient peripheral saturation 95%. The results of blood laboratory examination blood gas analysis: PH 7.45; PO2 89; PCO2 36.8; HCO3 23.1; actual BE 2.4; lactate 0.9; Sodium (Na) 145 mmol/L; Potassium (K) 3.3 mmol/L; Chloride (Cl) 98 mmol/L; Calcium (Ca) total 2.34 mmol/L; Magnesium (Mg) 1.6 mmol/L; diuresis 0.6 ml/kgBW/hour. X-Ray examination revealed no pulmonary atelectasis. PaO2/FiO2 was 269.7.
Mr. (56)	Complaints of reduced shortness of breath, ABP 100/60 MAP 70, Heart Rate (HR) 90 beats/minute, RR 20 breaths/minutes, patient peripheral saturation 96%. blood gas analysis (PH 7.44 PO2 95.2 PCO2 35.2 HCO3 22.3 actual BE -2.2, The X-ray examination results did not find left lung atelectasis. PaO2/FiO2 was 288.5.
Mr. (56)	Complain of reduced shortness of breath, ABP 118/82 mmHg, HR 88 beats/minutes regular, oxygen saturation 96% , RR 18 breaths/minutes regular, CRT < 2 seconds, T, X-ray examination results not find left lung atelectasis. Blood gas analysis examination PH 7.42 PaO2 98.4 PaCo2 44.2 HCO3 22.9 BE -2, 1, Potassium 3.1 Na/CL 143/103Ca/Mg 0.88/0.40, lactate 2.0 mmol. PaO2/FiO2 was 298.2.

3. Discussion

This study used the dynamic nurse-patient relationship model to describe the application of breathing exercises in postoperative hypoxia after CABG. After three days of implementing the intervention, most patients showed improvement in POH. This condition was evidenced by an increase in the PaO2/FiO2 ratio from less than 200 to above 200, with an average increase of 89.3. The blood gas analysis results support the results from a respiratory alkalosis condition to a normal PH and a PaCO2 value from <35 mmHg to the normal range (35-45 mmHg). Also, X-rays of the patients showed pulmonary atelectasis improvement.

Postoperative hypoxia is a condition that often occurs in after CABG patients which has the potential to increase morbidity and mortality (Stephens et al., 2013; Sutton et al., 2014); one study explained that POH occurs in 30% of cases post CABG (Ranucci et al., 2014). In the most severe cases, POH will increase the time to use mechanical ventilation to require insertion of a tracheostomy, increase the length of stay in the intensive care unit, and increase the cost of care (Ranucci et al., 2014). In addition, these conditions will result in a decrease in lung expansion capacity, an increase in the alveolar-arterial oxygen difference, and an increase in the intrapulmonary shunt fraction (Stephens et al., 2013; Sutton et al., 2014). All changes that occur due to POH can cause a decrease in the ratio between arterial oxygen pressure (PaO2) and the fraction of inspired oxygen (FiO2) (PaO2/FiO2) (Ranucci et al., 2014).

The patient described the POH condition, where there was a desaturation condition. The saturation value became <95%, and the arterial oxygen pressure value became <90 mmHg after CABG. Pathophysiologically, this condition can occur because a systemic inflammatory reaction occurs after CABG so that it can cause alveolar dysfunction; the occurrence of leukocytosis in patients evidences this. In addition, there is the release of various pro-inflammatory cytokines such as TNF-a, IL-1, IL-2, IL-6, IL-8, and endotoxins during CABG, which can lead to neutrophil entrapment in the pulmonary capillaries. After that, there will be swelling of endothelial cells, plasma, extravasation of proteins into interstitial tissue, the release of proteolytic enzymes, congestion of alveoli with plasma, erythrocytes, and inflammation (Hussain & Harky, 2019).

Weight factors play a role in POH conditions in these patients. Research conducted by Ranucci et al., 2014 explains that obesity has a high risk of POH. Pathophysiologically, the work of breathing is significantly higher in obese than in lean patients. This primary mechanism that causes an increase in work of breathing is a decrease in functional residual capacity and an increase in respiratory resistance due to the reduction in lung expansion (Ranucci et al., 2014). Two patients in the case presentation showed obesity, so it was suspected that it could affect the condition of POH after CABG surgery. Although the patient has a history of smoking, it is explained that patients with a history of smoking will reduce vital lung capacity so that they are at high risk of experiencing POH after CABG (Guan et al., 2016). One of our patients is a heavy smoker.

Various respiratory modalities and respiratory physical therapy have been proposed to improve blood gas values, pulmonary function and prevent or treat pulmonary complications after CABG (Corley et al., 2011; El-Kader, 2018). We provided breathing exercise intervention to patients four times a day using incentive spirometry, 15-20 minutes each session for three days after CABG surgery. The results of a study show that incentive spirometry can improve blood gas values for patients in phase I of a cardiac rehabilitation program after CABG (El-Kader, 2018).

Incentive spirometry can encourage the patient's breath to reach total lung capacity and maintain maximum inflation that can open the alveoli to prevent atelectasis and overcome postoperative hypoxemia conditions to increase lung expansion after lung expansion major thoracic surgery (Yazdannik et al., 2016). Other literature explains that breathing exercises using incentive spirometry can increase the resistance in the respiratory muscles and consist of hyperventilating for an extended period so that it can have an additional effect on respiratory muscle endurance to be more efficient (Eltorai et al., 2018).

Communication is a major component in the success of the nursing process (Salifu et al., 2022). We used the Orlando's theoretical interpersonal approach to the case, assuming that, as cardiovascular nurses, we would be able to discover the hidden needs of the patient. This discovery will undoubtedly result in appropriate therapeutic nursing interventions for patients. In the Orlando model, nurses' behavior is required to observe, report, record, and act. Using this approach can help organize and classify the information needed by patients in the hospital (Abdoli & Safavi, 2010). When the nurse-patient relationship is dynamic, patients can better meet their needs. Effective nursing interactions and processes increase patient comfort and reduce stress on them. In this theory, the emphasis of nursing care on patients suffering from distress and care related to perceptions, thoughts, and feelings of pain and nursing is carried out through strategic steps (Abdoli & Safavi, 2010). No research has explained the effect of Orlando's theory on the approach to doing breathing exercises. Still, a study presents that patients undergoing endoscopy experience decreased anxiety levels with the Orlando nursing theory approach (Yekefallah et al., 2017).

In the theoretical concept of the dynamic nurse-patient relationship model, Orlando describes the dynamic relationship between nurses and patients (Butler, 2019; Rosenthal, 1996). To put the theory into practice, the nurse derives the patient's need for assistance based on observation and patient behaviors, including a need for help or improvement. Patients who are cognitively or physically impaired cannot express their needs. The nurse determines the need for support by observing the patient's behavior, such as restlessness or an adverse change in vital signs. Nursing interventions are carried out in stages, and we continue to apply the dynamic nurse-patient relationship at each intervention step (May, 2013). In this case, as cardiovascular specialist nurses, we provided nursing care following our disciplines. We explained to patients that we are not just an extension of the doctor's delegator, cardiovascular specialist nurses who carry out nursing care. Orlando is a "professional nursing authority" (Rosenthal, 1996).

4. Implication and limitation

We recommend breathing exercises in perioperative cardiac surgery patients to prevent pulmonary atelectasis and POH. In addition, we recommend using a dynamic nurse-patient relationship model approach in critical post-CABG patient situations in the intensive care unit because this theory can dynamically see the psychological and physical changes of patients.

The limitation of this research is that the sample is small and only uses a single center. So that a multicenter study is needed in order to be able to generalize the results of the investigation. In addition, no measurement of pulmonary function test was performed to assess overall respiratory status.

5. Conclusion

Combining the breathing exercises nursing intervention and a dynamic model of the nurse-patient relationship improved lung function and pulmonary atelectasis to solve the postoperative hypoxia (POH) in post-CABG patients. The intervention can enhance the quality of nursing care in post-cardiac surgery patients. We recommend using the model theory approach because this theory can see patients' psychological and physical changes dynamically in post-CABG patients.

6. Consent

The nursing committee of the hospital study site had approved this research. Moreover, the patients agreed to be involved in the study.

Acknowledgment

The author would like to thank the patients for participating in this study.

Author contribution

All authors contributed to the final manuscript. In addition, IF, AG, EN designed the study, wrote, and revised the manuscript. HE and MK were involved in data collection.

Conflict of interest

The authors declared no conflict of interest.

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