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NAVIGATING AIRWAY CHALLENGES IN POST-CABG CARE: A CROSS-SECTIONAL STUDY FROM TERTIARY CARE HOSPITALS OF KARACHI

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ABSTRACT

Background: After coronary artery bypass grafting (CABG) surgery there is restriction of chest movement due to sternal incision which results in the inability of coughing appropriately to clear up the secretion plugged into the respiratory tract. This complication can lead to ineffective airway clearance (IAC), a common nursing diagnosis observed in patients' post-CABG. Unrecognized and untreated, IAC may progress to significant pulmonary sequestration or even death. By using NANDA-I Taxonomy II, the person who would be able to recognize clinical clues is a nurse. The role of nurses in reversing this condition cannot be overstated.

Aims: The purpose of this study was to evaluate the most common laboratory indicators in patients undergoing IAC following CABG. For early diagnosis there may be signals for the clinical devastation due to infective endocarditis.

Methodology: A total of 113 patients were enrolled after CABG surgery from Dow University Hospital (DUH), Ojha campus and Tabba Heart Institute (THI) Karachi. Cross-Sectional study design was used to conduct this study. To check the statistical accuracy of clinical indicators of IAC, statistical analysis was performed by predictive value, sensitivity, specificity. Moreover, the likelihood ratio, diagnostic odds ratio, area under the ROC curve and accuracy were calculated with statistical formula.

Results: The clinical indicators, Ineffective cough, adventitious breath sounds, and excessive sputum, showed more than 80% accuracy while identifying the IAC correctly. While calculating the sensitivity of the clinical indicators, adventitious breath sounds showed the highest value of 84%, and Ineffective cough and excessive sputum were found with 81% sensitivity, respectively. It was also found that all clinical indicators showed more than 90% positive predictivity.

Conclusion: This study showed three clinical indicators with higher sensitivity to diagnose IAC in post CABG patients that includes adventitious breath sounds, ineffective cough, and excessive sputum.

Keywords: Ineffective airway clearance, CABG, Clinical indicators and Nursing Diagnosis

INTRODUCTION

Heart attack has become the leading cause of death globally. Mostly heart attacks occur due to coronary heart disease which leads to invasive intervention. Though, surgical interventions are the top management to preserve life from a heart attack immediately. Coronary Artery Bypass Grafting (CABG) is a major surgical procedure performed by a cardiothoracic surgeon. In this surgery, the congested coronary artery relates to a healthy artery or vein or grafted which bypasses (goes around) the blocked segment of the coronary artery and generates a new path to deliver blood with oxygen to the heart muscle. [1] A recent study has indicated incidence of postoperative respiratory changes 20% to 65% among cardiac surgery patients. [2] One study claimed that the incidence of respiratory complications includes prolonged mechanical ventilation, pleural effusion, atelectasis, diaphragmatic paralysis, and pneumonia in post-CABG has reached 40% now. [3]

In the postoperative period of CABG patients may develop multiple health problems which need to identify timely and accurately. The pulmonary system may be at risk of injury due to lung collapse and disruption of pleural functions. [3] In Post CABG unit nurses are the first person who recognizes patient's health problems. They repeatedly interact with the patients and assess them frequently to report their condition with the cardiac surgeon collaboratively. One of the studies in 2016 revealed that nurses can minimize the incidence or severity of respiratory complications through an appropriate health examination, assessments and can identify nursing diagnoses early related to the specific health issue. [4] The most accuracy in diagnosing patients' responses to basic health problems will offer better health outcomes.

NANDA – I have defined the nursing diagnosis as a clinical judgment concerning an undesirable human response to a health condition/life process that exists in an individual, family, group, or community. NANDA International Inc. (NANDA – 1) is a professional organization of nurses officially founded in 1982 internationally. However, the first conference was held in 1973 to classify nursing knowledge and launch a classification system to be used for computerization. According to this conference, the nursing leaders have established a system of nursing diagnosis according to the domains of different human responses. It has standardized nursing terminology that develops research, disseminates and refines the nomenclature, criteria, and taxonomy of nursing diagnoses. NANDA – 1 has published the indicators (defining characteristics of specific nursing diagnoses) to identify nursing diagnoses that address the specific health issue.[6]

After CABG surgery there is restriction of chest movement due to sternal incision which results in the inability of coughing appropriately to clear up the secretion plugged into the respiratory tract. It ultimately leads to ineffective airway clearance. Since this problem can cause severe respiratory complication which causes mortality it needs to identify as early as possible. Common factors that can cause IAC are prolonged surgery, prolonged intubation and the effects of general anesthesia medications. If IAC is not identified timely and reversed immediately may lead to respiratory complications or death. Since CABG is major surgery, postoperative care is also very important to bring back patients to a normal healthy lifestyle without complications.[4-6]

The frequent nursing diagnoses in postoperative CABG period include ineffective breathing patterns, impaired gas exchange, Ineffective airway clearance (IAC), decreased cardiac output, and risk of infection, etc. In the postoperative period of CABG majority of patients encounter these undesirable health conditions. IAC is a respiratory problem considered among the most frequent nursing diagnosis in postoperative CABG patients. [2, 5, 15] In 1980, IAC was included in NANDA – I nurse diagnosis list with the nursing diagnosis code number 00031. It incorporated in domain number 11 (safety/protection) in its second class (physical injury). It is defined as an inability to clear secretions or obstructions of the respiratory tract, to maintain a clear airway. Early detection of a respiratory problem is possible by a nurse specialist with standardized clinical indicators.[6-7]

In this research, the nine clinical indicators were assessed in post CABG patients for the presence of ineffective airway challenges. There are five indicators that are dependent on other clinical indicators includes cyanosis, adventitious breath sounds, alteration in the respiratory pattern, restlessness and orthopnea. However independent clinical indicators are ineffective cough, dyspnea, excessive sputum, and alteration in respiratory rate[6-8]. These all-clinical indicators were assessed through

physical assessment of post-operative CABG surgery explained in Appendix I. The assessment findings were incorporated in the assessment tool for statistical analysis. The nine clinical indicators of IAC in this study are defined as the following:

An ineffective cough means there is any obstruction of secretions in air passages unable to be removed during coughing which is the direct indication of IAC as evident by patient's cough without bringing forth mucus and clearing the lungs.

Dyspnea is 'difficulty in breathing' it is due to chest incision of CABG as well and indicates IAC. It is a subjective and objective feeling as evident using accessory respiratory muscles

Alteration in respiratory rate and *alteration in respiratory pattern* are also direct indicators of IAC in CABG patients due to sternotomy as evident by alteration in rate, rhythm (regular, irregular), depth (shallow, increased decrease, variable, asymmetrical) and type of breathing (splinted/guarded, use of accessory muscles).

Orthopnea is painful breathing, common in CABG patient due to pain in chest incision during inhalation and exhalation as evidence by the patient's subjective feeling.

Cyanosis and restlessness may or may not be present to observe IAC in CABG patients. Cyanosis is improper of oxygen reaching end extremities as evident by purplish/bluish of fingers, toes, nails, lips, and buccal mucosa and $SPO_2 < 94$.

Excessive sputum, a symptom of IAC can be present due to complication of anesthesia medications as evident by the presence of secretion in air passages (adventitious breath sounds) or spit out through cough (effective cough)

Adventitious breath sounds are the abnormal breathing sounds like crackles/rales (exudates in alveoli, excessive mucus, and retained secretions), wheezing/rhonchi (obstructed airway, narrowing of the air passages). These breath sounds can be heard through auscultation (Appendix I).

Many of these clinical indicators are associated with each other. To diagnose IAC in CABG patients these indicators/symptoms need to be assessed first. According to published studies, few studies have shown the same results; it depends on the patient's condition which illustrates more than two clinical indicators together. At the same time, other patients can demonstrate only one of those clinical indicators of IAC.[3-5]

American and European countries have conducted few studies to analyze the indicators of nursing diagnosis 'Ineffective Airway Clearance' in different clinical situations but unfortunately, there has not a single study been carried out in the Asian region. This study will propose the most frequent IAC indicators in patients after CABG in tertiary care hospitals and contribute guidance to plan early intervention in the whole Asian region.

Studies suggested a significant relationship between cardiac surgery and postoperative pulmonary complications. [8-10] Identification of these complications is practiced differently in different hospitals in Pakistan. Many hospitals adopted the nursing process to identify patient's altered health condition to manage appropriately to prevent complication. IAC is the most frequent nursing diagnosis noted in the post mechanical ventilation period. During surgery and after CABG patients are on mechanical ventilation and are gradually weaned off from a ventilator. Therefore, they are more prone to develop IAC and could end up with major pulmonary complications.

Since the nurses can identify the clinical indicators of IAC timely, they can appropriately manage and prevent patients from getting into a worse state. The utilization of frequent clinical indicators with higher predictive power contributes to the true classification of nursing diagnoses.[4-6], unfortunately, there are no studies, to date, conducted on IAC in the Asian region.

IAC is a significant health condition distinguished after CABG if not identified on time and managed correctly, can lead to complex respiratory complication and may cause mortality. There are many clinical indicators to diagnose IAC. However, there are ambiguous data for the most frequent and appropriate indicators of IAC in CABG patients, especially in the Asian population. In the postoperative time of CABG, patients are at higher risk of developing respiratory complications. These complications and their symptoms may arise if the indicators are missing during the nursing process.

There is a need to establish this study to equip the nurses and health care professionals to know the most frequently occurring clinical indicators to diagnose IAC. So, IAC will be detected as early as possible to stay away from unwanted results.

The intention of this study was to find accuracy in the assessment of the most frequent clinical indicators to diagnose IAC in patients who have undergone CABG. One major assumption of this study is that the nurse will diagnose IAC early in patients after CABG. Another assumption is that the patient will be prevented from respiratory complications.

During practicing at clinical site nurses needed organized and dynamic patient care and guarantee patients' safety, protection and quality care. The nurses who are working at the cardiothoracic unit are required to utilize their skillful attitudes towards diagnosing patients' early signs of health issues to prevent future adverse events. These complications primarily linked to unavoidable exposures to risks encountered by patients in clinical settings during their stay at the hospital. Therefore, nurses need to act efficiently, by applying their critical thinking to the nursing process, and endeavor to curtail such complications.[6]

Accurate Nursing assessment and implementation play a major role to maintain airway patency to prevent life-threatening complications. Nurses are the key professionals who constantly stay with the patients. If they perform a perfect clinical judgment (nursing diagnosis) of human responses, it can contribute towards quick recovery without critical complications. It has been shown by many researchers that the majority of the CABG patients show minor to major pulmonary complications in postoperative recovery periods. These are the most serious early postoperative problems result in prolonged hospitalization, increase death rate, and increase the cost of care. [7-12, 23] The most frequent clinical judgments noticed by doctors and nurses in patients after cardiothoracic surgeries include atelectasis, ineffective airway clearance, impaired gas exchange, impaired breathing pattern, and pneumonia. Studies have shown these impairments of respiratory function are caused by chest incision, insertion of the pleural drain, prolonged mechanical ventilation, and diaphragmatic dysfunction due to phrenic nerve reflex dysfunction as a result of cold cardioplegic solution. [9, 13, 14] These clinical responses need to be identified at the earliest.

The nurses are the most approachable health care professionals who can diagnose the patient's early signs of major complications. They achieve their goals of patients' care through applying their standardized critical care thinking model known as the nursing care plan. This model consists of The Standards of Professional Nursing Practice as shown in the diagram on the next page (figure no. 1) with two main standards; the Standards of Practice and the Standards of Professional Performance.[15] The first standard, 'the standards of Practice' is the nursing process that illustrates an expert level of nursing care by nurses. The nursing process consists of six main components including assessment, diagnosis, outcomes identification, planning, implementations, and evaluation [6]. This model certifies the nurses to demonstrate the professionally skilled level of behavior and attitude while assessing patients holistically according to the second standard of Nursing Care Plan; the standards of professional performance'.[15] This includes activities that are associated with ethics, communication, culturally congruent practice, collaboration, quality of practice, leadership, evidence-based practice and research, resource utilization, professional practice evaluation, education, and environmental health. The nurses are expected to perform professional roles/activities, including leadership, appropriate to their position and education. Licensed nurses are liable for their professional actions to their Patients, their colleagues, and ultimately to the public.[15]

This model guides in assessing, diagnosing, planning, implementing and evaluating the patient's problem vigorously. This process makes the nursing care safe and competent.[4-5] A nursing diagnosis is a clinical judgment about healthcare patients' response to actual or potential health conditions or their needs. Nursing diagnosis guide nurses towards achievable goals to solve patients' problems by applying specific nursing intervention and preventing the patient from unwanted effects.[2, 5, 15]
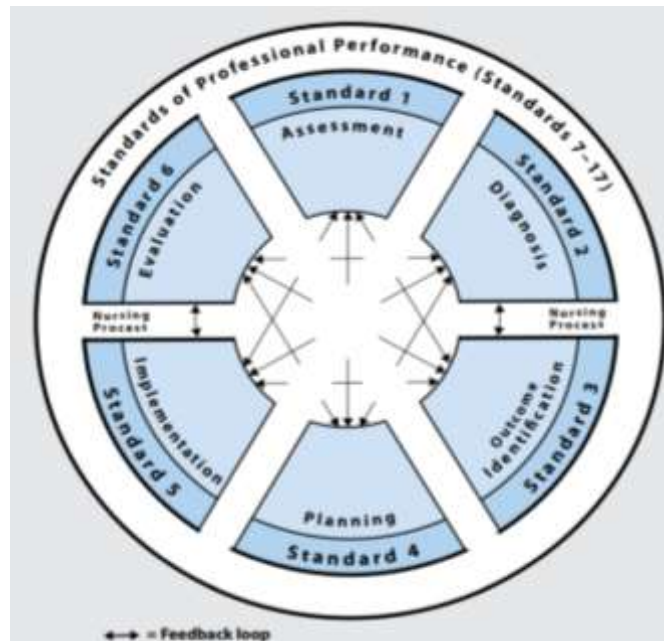
Figure 1: The Nursing Process and the Standards of Professional Nursing Practice

The patients after major surgeries like cardiothoracic and abdominal surgeries get almost similar experiences and a similar pattern of signs and symptoms (clinical Indicators) which may lead to respiratory problems. This always happens in the above-mentioned conditions due to large skin incisions on the chest or abdomen. The respiratory system works more effectively if there is no hindrance during the inhalation and exhalation process of respiration. However, the incision at the abdomen and chest serves as an obstacle during the respiration process. Furthermore, the drugs used during anesthesia are contributing factors that cause relaxing of the respiratory muscles and can cause unsuccessful breathing and hold secretions. As a result, an ineffective airway clearance occurs that may direct the patient towards major complications and eventually death occurs.[2, 11, 22, 32] Inability of clearing secretions or obstructions through the respiratory zone to sustain a clear airway is called as 'Ineffective airway clearance'.[5 - 7, 8, 24]

 Since IAC is a nursing diagnosis and has been claimed to be one of the most occurring problems in recent studies that have shown a great impact on patient and organizational outcomes. Few recent studies suggest that IAC has become one of the most serious problems if not reversed; it causes severe breathing difficulties and may lead to death. [5, 14, 25-27]

It was proposed in 1980 to include 'Ineffective Airway Clearance" in NANDA – I Taxonomy I officially. Later, it has been suggested for modification in 1996 – 1998. [5, 31] Initially, IAC was compiled of 29 defining characteristics (clinical indicators) which were reduced to 12 indicators in 1995 – 1996 after a validation study. Afterward, it was increased to 13 clinical indicators during a conference by the Nursing Diagnosis Extension Project, in 1998 and coded as 00031 in North American Nursing Diagnosis Association - International (NANDA – I) Taxonomy II. [13] Categorization has been done by NANDA – I Taxonomy II; into domains and classes to standardize the nursing process. The NANDA – I terminology illuminate the diagnostic indicators for accuracy and timely diagnosing the patient's problem by supporting the clinical reckoning skills of nurses. [5, 30]

The clinical indicators (defining characteristics) of IAC have been validated vigorously 3 times. Nurses gained the maximum confidence after this validation process while identifying IAC accurately with listed indicators in NANDA – I Taxonomy II. The clinical facts and the utilization of well-organized clinical indicators are an integral part of the establishment of a nursing diagnosis. As far as this study is concerned, only nine clinical indicators were incorporated to diagnose IAC due to the clinical situation of CABG patients. Two studies were conducted in post-cardiac surgery patients for the occurrence of IAC; and found 29.6 % and 63.6 %. [2, 16]

During the nursing process, a nurse assigned the importance to an alarming indicator or a group of indicators that validates the diagnostic conclusion accuracy and influences the nursing management.

An effective clinical judgment (nursing diagnosis) is not possible without its indicators. Hence, a nurse requires clinical indicators which are authentic and more frequent in nature to diagnose that nursing diagnosis. The most relevant American study was done in Brazil with 98 patients to analyze the clinical indicators of IAC in patients during postoperative cardiac surgery. This study claimed four indicators which have shown the high accuracy level by statistical conclusion includes adventitious breath sounds, dyspnea, retained secretion, and ineffective cough. [2] Studies have suggested that the different clinical situations involve different clinical indicators, so, continues studies are needed to find out accuracy in defining characteristics. [6, 14, & 16] In addition, one study found respiratory rate and alteration in respiratory pattern with good predictive ability whereas the same study claimed the high specificity of cyanosis, excessive sputum, adventitious breath sounds, restlessness, difficulty vocalizing, restlessness, orthopnea, ineffective cough, and wide-eyed.[4]

All the studies conducted on IAC have used NANDA – I Taxonomy I & II identified clinical indicators (defining characteristics or signs & symptoms) to collect the data. The NANDA – I taxonomy II nursing diagnoses act in accordance with the International Standards Organization (ISO) terminology model for nursing diagnosis. It is also affiliated with Health Level Seven International (HL7), a health care informatics standard, as a terminology to be used in electronic messages among clinical information systems for identifying nursing diagnoses. [2, 5, 15-19]

The diagnostic process of nursing diagnosis and its predictive capacity of defining characteristics depend upon nurses' degree of certainty. To find out the key indicators for good clinical judgment an efficient nursing assessment required. However, in different clinical sitting different clinical indicators can be found; as studies have shown, the diverse prevalence rate of IAC in patients with surgery as compared to the patients with medical conditions [2, 4-8, & 16].

METHODOLOGY

Analytical Cross-Sectional study design was used to conduct this study. This study was conducted among post CABG patients from the Critical Intensive Care Unit (CICU) of Dow University Hospital (DUH) Ojha campus and Tabba Heart Institute (THI) Karachi. A total of 113 Post CABG surgery patients within 24 hours of extubating with age between 40 – 70 years of were included in this study. Non-probability consecutive sampling was used to select the patients. The data collected in duration of seven months from 2020 to reach targeted sample size. The calculation of the sample size was performed by the WHO online software OpenEpi.[18] By using prevalence from a previous study of IAC patients as 88.2%[2], confidence interval 95%, level of significance 5% the calculated sample size came out to be 112 patients. However, we were able to collect data from 113 patients

This study includes demographic variables and nine defining characteristics (clinical indicators). The three demographic variables include Patient research ID, Age, and Gender. The nine Clinical indicators are Ineffective Cough, Dyspnea, Orthopnea, Alteration in respiratory rate, Alteration in the respiratory pattern, Cyanosis, Adventitious breath sounds, Excessive sputum, and Restlessness. The research synopsis was submitted to the institutional review board (IRB) and the scientific committee of DUHS for approval to conduct this research (Appendix IV - VI). Approval from DUH and THI hospital was taken as well to collect data from the postoperative cardiac surgery unit (Appendix VI). The confidentiality was maintained of the collected data. Informed consent from the research participants was also taken at the time of the patient's admission for CABG surgery. (Appendix II and III).

Research data were collected from patients who had undergone CABG surgery and fulfilled the inclusion criteria. The data collection tool was adopted from a previous study with the permission of the author and modified according to the regional implementation to collect the required information.[2] The tool consisted of three demographic variables and nine clinical indicators (defining characteristics) of IAC (Appendix I). Data were collected through relevant history taking and specific physical assessment related to the IAC determination process. The standard assessment techniques of the respiratory system were followed. It consisted of inspection, palpation, percussion and auscultation. The inspection includes critical observation, whereas in palpation, touch was used to assess abnormal findings of chest expansion. Striking the chest techniques were used in percussion

to find out chest expansion. However, while auscultation brought about listening to and construing sound transmission via stethoscope through the lung's fields. It helps to distinguish breath sounds from normal to adventitious breath sounds[33, 38-41] (Appendix 1). Special consideration was given to the well-lighted, private, warm and quiet environment, to conduct the examination of each patient while maintaining a comfortable and suitable position throughout the assessment. [2, 32-38].

The data were collected by the researcher herself from each hospital THI and DUH. The assessment was done within 24 hours, weaning off from mechanical ventilation after CABG surgery. Statistical Package of Social Sciences (SPSS) 21.0 version was used for data analysis. Descriptive statistics were calculated to illustrate the demographic and clinical conditions through frequency distributions, mean and standard deviation (SD). The association of clinical indicators with ineffective airway clearance was determined through the Fisher Exact Test. P-value ≤ 0.05 was considered as significant. By using standard formula (Appendix VII) epidemiological measures were calculated. Sensitivity, specificity, predictive values (+ve and –ve), odds ratio, likelihood ratio, accuracy, area under ROC curve (AUROC) has been measured of all the indicators (variables) to calculate the accuracy of these indicators. The variables of IAC indicators include ineffective cough, dyspnea, excessive sputum, alteration in respiratory rate, cyanosis, adventitious breath sounds, and alteration in the respiratory pattern, restlessness and orthopnea.

RESULTS

The clinical indicators, Ineffective cough, adventitious breath sounds, and excessive sputum, showed more than 80% accuracy while identifying the IAC correctly. While calculating the sensitivity of the clinical indicators, adventitious breath sounds showed the highest value of 84%, and Ineffective cough and excessive sputum were found with 81% sensitivity, respectively

Figure 2 represents the sensitivity and specificity of the clinical indicators. Blue color bars show the sensitivity *(probability of the presence of a clinical indicator in presence of IAC)* and green color bars express the specificity *(probability of absence of a clinical indicator when a patient has no IAC)*.

Figure 2. Sensitivity and Specificity
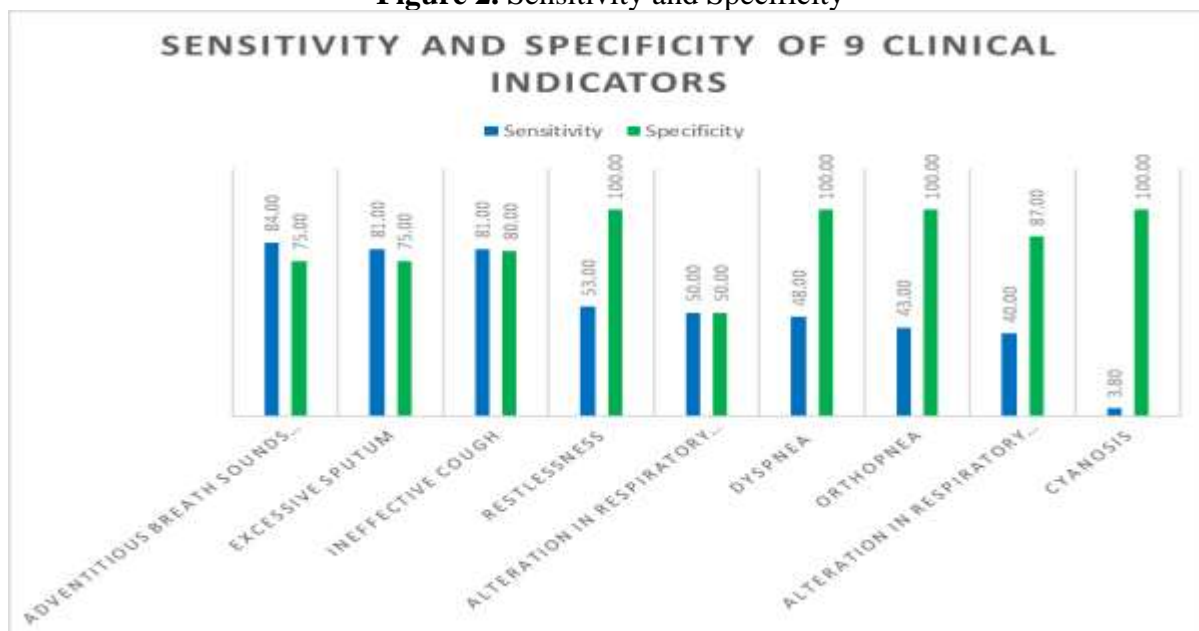
Since the graph shows the highest sensitivity of the clinical indicator ABS that is 84% whereas the specificity of ABS is 7.5%. It means that the probability of the presence of ABS is higher in IAC diagnosed patients. Whereas there are fewer chances of ABS to not being present if a patient is not having IAC. The sensitivity of excessive sputum and ineffective cough is 81% for both, however; the specificity of excessive sputum and ineffective cough is 75% and 80% respectively. According to the above graph specificity of four indicators Restlessness,
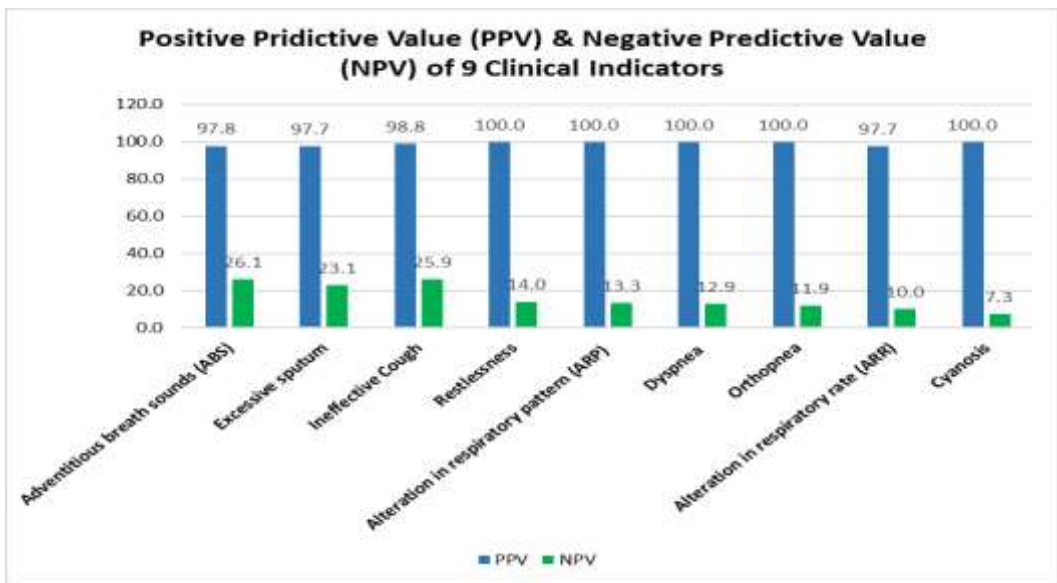
Figure 1. PPV & NPV

Dyspnea, Orthopnea, and Cyanosis is 100 % which indicates that these symptoms are always absent in patients who do not have IAC. Nevertheless, the sensitivity of these four clinical indicators Restlessness, Dyspnea, Orthopnea, and Cyanosis are 53%, 48%, 43%, and 3.8% respectively. In this graph the alteration in respiratory pattern shows 50% sensitivity and 50% specificity. Lastly, Alteration in respiratory rate shows the sensitivity of 40% and specificity of 87%.

The above figure 3 shows negative predictive value (NPV) and positive predictive value (PPV). Blue color bars show the PPV, and green bars express the NPV. PPV indicates that the presence of the clinical indicator signifies the probability of getting IAC. However, NPV specifies that the absence of the clinical indicator signifies the probability of not getting IAC.

The above graph indicates that all the clinical indicators have PPV more than 90%. It means that all the patients who have been presented with these clinical indicators have higher chances of getting IAC. However, NPV is vice versa. The clinical indicators which show 100% PPV are restlessness, alteration in the respiratory pattern, dyspnea, orthopnea, and cyanosis however NPV of these indicators are 14%, 13.3%, 12.9%, 11.9% and 7.3% respectively. Three clinical indicators, adventitious breath sounds, excessive sputum, and ineffective cough show the NPV 26%, 23%, and 25.9% respectively.
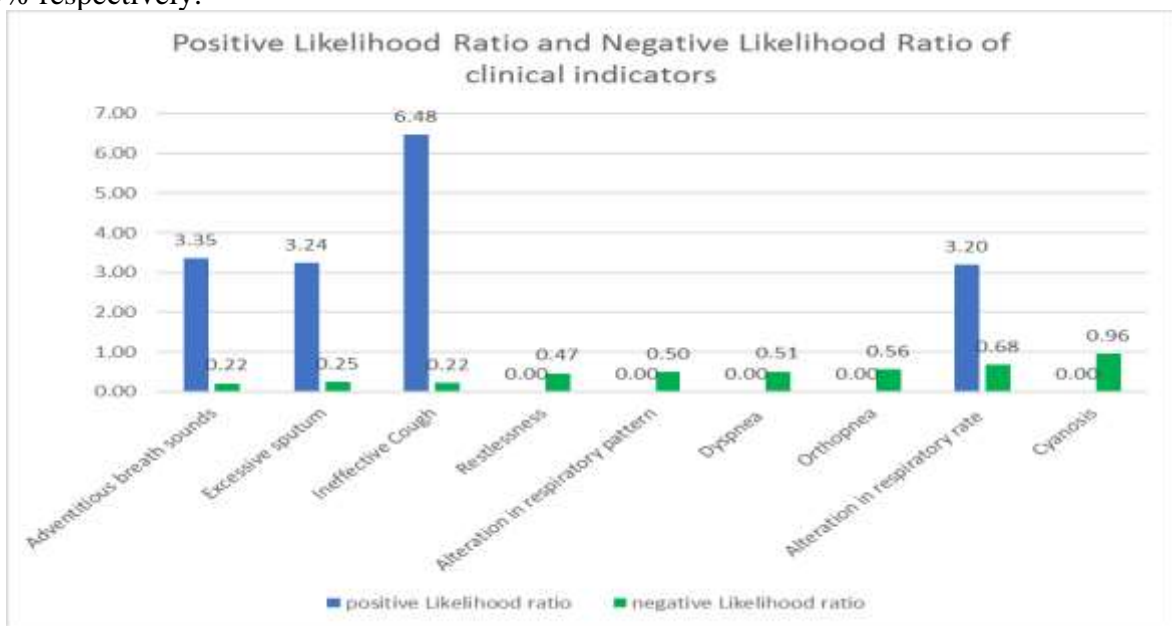

Figure 2. Likelihood Ratio

The above Figure 4 represents the positive and negative likelihood ratio of all the clinical indicators. Blue color bars show the LR+ and green bars express the LR-. Highest LR+ in the above graph demonstrated by ineffective cough 6.5 which shows that the patients with IAC have 6.5 times more chances of having an ineffective cough than those patients who do not have IAC. Meanwhile, LR– of Ineffective cough is 0.22 that means that the patients with IAC have the probability of not developing an ineffective cough is about one-fifth that of those without the IAC.

Above graph shows that three clinical indicators ABS, Excessive sputum (ES) and ARR shows almost the same value of LR+ as 3. That means these three indicators have 3 times more chances to be present in patients with IAC in comparison to those without IAC. The LR-, the chances of the absence of ABS and ES for the patients with IAC are 0.22 and 0.25 times or about one-fifth of that of those without IAC. On the other hand, the chances of the absence of an ARR for patients with IAC are 0.68 times those without IAC. Since Figure 4 shows 0 LR+s of five clinical indicators; Restlessness, ARP, Dyspnea, Orthopnea and cyanosis it represents insignificant results. Through this analysis we identified that there are very fewer chances of these five indicators to not being positive in patients with IAC compared to the patients without IAC.
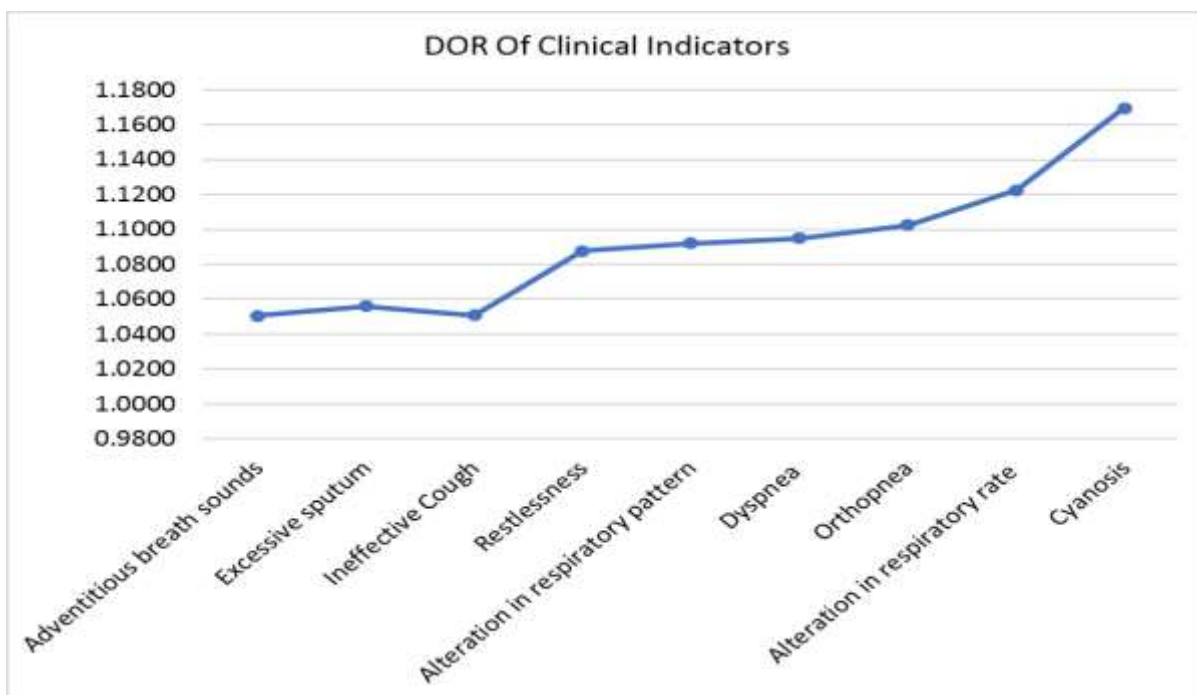

Figure 3. Diagnostic odds ratio

Figure 5 shows the Diagnostic Odds Ratio (DOR) of all the clinical indicators. The DOR is calculated at the level of significance of 5%. This expresses the highest DOR of Cyanosis 1.17 which shows the stronger relationship of Cyanosis with IAC. However, DOR of all the clinical indicators is above 1 shows positive relationship with IAC.

Table 2. Accuracy of Clinical Indicators

Clinical indicators	Adventitious breath sounds	Excessive sputum	Ineffective Cough	Restlessness	Alteration in respiratory pattern	Dyspnea	Orthopnea	Alteration in respiratory rate	Cyanosis
Accuracy	0.83	0.81	0.81	0.56	0.54	0.52	0.47	0.43	0.11

In this study, accuracy of Ineffective cough, adventitious breath sounds, and Excessive sputum was found to be > 80% while identifying the IAC correctly as shown in Table 2. Whereas restlessness, alteration in respiratory pattern and dyspnea have shown approximately 50 % accuracy for diagnosing IAC correctly in post CABG surgery patients.
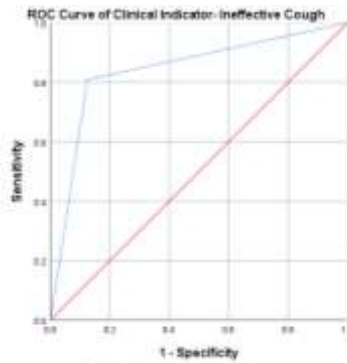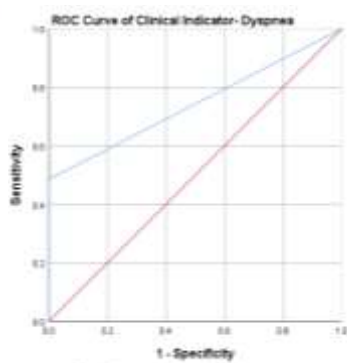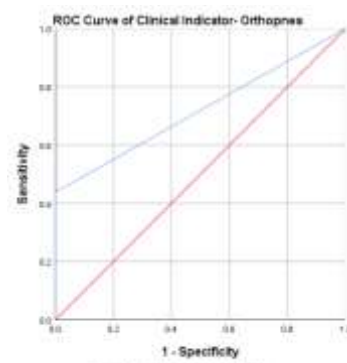

Figure: 6.1	**Figure: 6.2**	**Figure: 6.3**
Figure: 6.4	**Figure: 6.5**	**Figure: 6.6**
Figure: 6.7	**Figure: 6.8**	**Figure: 6.9**
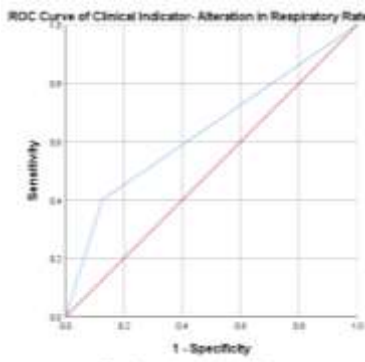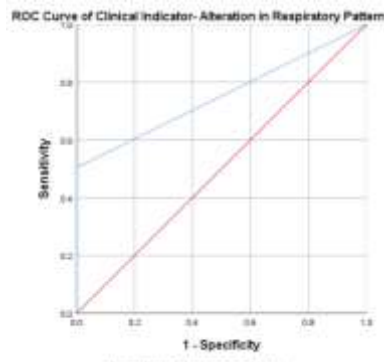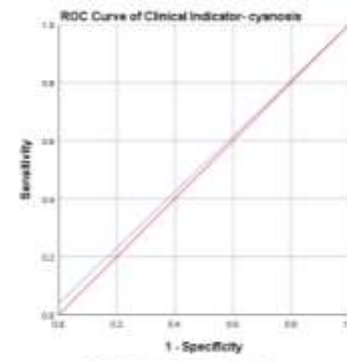
Figure 4: AUROC of clinical indicators

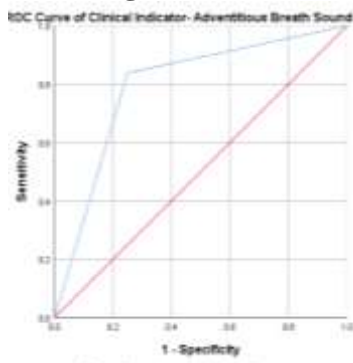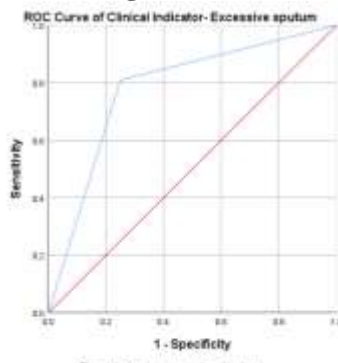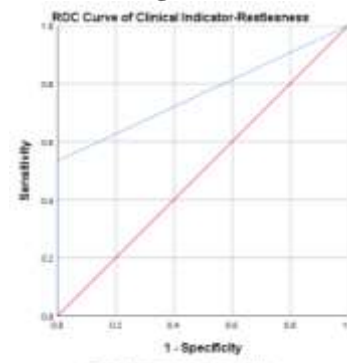Above graphs 6.1 – 6.9 in above figure 6 shows the Receiver Operating Characteristics (ROC) Curve shows the score of true positive against the score of false positive of each clinical indicator. Analysis of ROC curves at the level of 5% confidence interval; graphs 6.1, 6.7 and 6.8 are more toward the left upper corner. This signified that adventitious breath sounds, Ineffective cough, and Excessive sputum are the most significant clinical indicators to rule out IAC in Post CABG surgery Patients

DISCUSSION
This study aimed to establish the accuracy of clinical indicators among post-CABG patients. The results showed a strong relationship between a few clinical indicators with IAC among the respondents, and early diagnosis and management of this condition become very critical in preventing such complications as infective endocarditis. Several studies support this, each pointing to the

susceptibility of post-CABG patients to respiratory complications because of surgical trauma, protracted anesthesia, and restricted movements. [43]

In the context of postoperative CABG surgery, the presence of IAC among a high proportion of patients may be driven by several ensuing risk factors, including but not limited to decreased lung compliance, postoperative pain, and impaired mucociliary clearance. In turn, early detection of those signs by timely measurement of respiratory function and laboratory indicators will help reduce the risk of developing complications. According to D'Agostino et al. (2019) [44], the general laboratory indicators of increased risk from respiratory postoperative complications are CRP, ESR, and WBC count. These indicators were evaluated in the present study for their inclusion in the diagnostic criteria of IAC, thus proving their clinical relevance.

In general, nurses play an important role in the management of patients with IAC after cardiac surgery. The high incidence of IAC suggested in this study may indicate a lapse in the delivery of efficient airway care management, such as pulmonary rehabilitation and chest physiotherapy, which have so far proven to improve respiratory outcomes. Indeed, Jage and Thakur (2022) [45] and Mali and Haghaninejad (2019) [46] identify that training nurses to conduct early and precise assessments and apply tailored interventions could minimize the incidence of IAC and enhance the recovery processes of the patients.

Besides physiological causes, a variety of psychological factors, such as anxiety and depression, have also been reported to exacerbate respiratory problems after surgery, thus causing ineffective airway clearance. [47] These could be addressed through comprehensive nursing care plans toward optimizing the management of post-CABG patients to reduce hospital stays and healthcare costs. The results of the study confirm a multidisciplinary approach in the management of the post-CABG patient to achieve optimum respiratory function.

Additional studies will be required to integrate advanced respiratory therapy and pharmacological intervention to further reduce the incidence of IAC. Moreover, the formulation of evidence-based nursing protocols for airway management may contribute to further standardization of care practices and the improvement of patient outcomes. [48]

Present-day nurses need to be more efficient in caring for patients and to make nursing care plans effectively. This study has contributed to the quick assessment of the post-CABG surgery patients in the diagnosis of IAC. There are 13 indicators of IAC, however, we studied nine indicators related to post-cardiac surgery patients. In our study, we found the incidence of IAC was 92.2%. In contrast, IAC is 46.73% of the sample in patients after thoracic or abdominal surgery[4]. However, De Sousa VE. et al. (2013) also studied post-cardiac surgery patients; and claimed that 29.6% sample positive for IAC[2]. A study conducted by Rocha et al. (2006) found a 63.6% prevalence of IAC in patients after CABG in the postoperative period. [17] The incidence of IAC among post-cardiac patients found in our study is on higher side about previous studies. One reason for the higher incidence might be the greater number of patients above 60 years of age in comparison to previously published studies. Advanced age is one of the reasons for slow recovery after surgery. In addition, another reason may be due to different clinical setups or the protocol of the patient assessment/management in the local medical facility.

Inoue et al., 2013 explained in their study that cardiothoracic surgeries have major contributions to causing airway obstruction, superficial ventilation due to chest pain, abdominal breathing pattern, hyper-secretion, muscle dysfunctions, and chest and lung restriction[21, 42]. De Sousa VE et al. 2013 clarified by relating to the previous study that the management of clinical indicators of IAC may elicit further complications[2].

Nine clinical indicators were analyzed in this study for frequent occurrence in patients either with IAC or without IAC. Previous studies have shown that the prominent prevalence of clinical indicators of IAC was found as excessive sputum present in 54.1%, adventitious breath sounds present in 36.7%, diminished breath sounds present in 34.7%, and dyspnea present in 27.6%[2,4]. In this study, it was found that the incidence of adventitious breath sounds, excessive sputum, and ineffective cough were 79.6%, 77.0 %, and 76.1% respectively. In comparison to this, some studies reported these clinical manifestations at relatively lower frequencies of 36.7%, 54.1%, and 27.6%, respectively. [49] This high

prevalence among the subjects requires an increased level of vigilance and early intervention amongst post-CABG patients to avoid complications like atelectasis and pneumonia.

As shown in Figure 2 this study shows the sensitivity > 80% of three clinical indicators adventitious breath sounds, excessive sputum, and ineffective cough to detect IAC in patients after CABG surgery patients. Despite this, in the previous study, the clinical indicator adventitious breath sounds are the only indicator that has shown > 60% sensitivity.[2,4] The specificity of three clinical indicators; restlessness, alteration in respiratory rate, and ineffective cough was > 90% in the present study. Similarly, other studies have also claimed the same levels of specificity of these three indicators[2, 16]. This indicates that the absence of these clinical indicators >90% correctly discriminates the patients who will not have IAC in post-CABG surgery patients.

Our analysis showed that the likelihood ratio (Figure 4) that post-cardiac surgery patients with IAC have higher chances of showing up the four clinical indicators in comparison to those who do not have IAC. These four clinical indicators are ineffective cough, adventitious breath sound, excessive sputum, and alteration in respiratory rate. In contrast to a recent study, the likelihood ratio is higher among the clinical indicators; wide eye-opening, adventitious breath sounds, and dyspnea[2]. Adventitious breath sounds and dyspnea are common in both studies.

The previous studies [2, and 4] indicated that IAC has more possibility to arise with dyspnea, adventitious breath sounds, and ineffective or no cough who has less ability to expel sputum. One previous study claimed that changes in respiratory rate and changes in respiratory rhythm present are better predictors of diagnosing IAC[4]. On the other hand, in this study, the clinical indicators that show 100% PPV are restlessness, alteration in the respiratory pattern, dyspnea, orthopnea, and cyanosis. Though the analysis of the rest of the indicators is also near 95%; it indicates that all indicators are a good predictor of presenting IAC. It is also clear that if a patient after CABG surgery, will suffer from any of these indicators can suffer from IAC.

Such a wide variation in the incidences of these clinical indicators may be due to variations in the patient population, surgical procedures, and policies of postoperative care in various institutions. [50] For instance, the high incidence of adventitious breath sounds in our study may have been partly explained, first, by the relatively long duration of intubation, and second, by general anesthesia, with these factors probably leading to the retention of excessive mucus and causing impaired ciliary function. [51] Additionally, the incidence of excessive sputum in 77.0% of cases may indicate inadequate airway clearance or poor and/or delayed mobilization following surgery.

In comparison to prior literature, the results of this study place greater emphasis on a comprehensive approach to IAC indicators such as subjective and objective findings like diminished breath sounds and dyspnea, among others, allowing for better recognition of at-risk patients and appropriate therapeutic intervention. [52] For example, inefficient cough coupled with excessive secretion of sputum may warrant the use of aggressive airway clearance techniques like chest physiotherapy, incentive spirometry, and early ambulation. [53] Further, dyspnea, as manifested by subjects in our research population at 27.6%, is consistent with previous studies pointing to dyspnea as a symptom that has been crucial in IAC and a predictor of poor respiratory outcome. [54] The postoperative dyspnea related to atelectasis and pleural effusions usually needs urgent evaluation and management to prevent further deterioration in the breathing pattern.

The high frequency of these clinical indicators, as shown in the current study, may also represent the complexity of the patient population, many having multiple comorbidities, such as COPD or diabetes mellitus, which are known to heighten respiratory complications in the post-surgery period. [55] Addressing these comorbid conditions through individualized care plans may, over time, reduce the burden of IAC and enhance overall positive patient outcomes.

One relevant study has shown the statistical significance and > 80% negative predictive value of the ineffective cough, adventitious breath sounds, and dyspnea. [2] However, adventitious breath sounds, dyspnea, and ineffective cough have shown a negative predictive value < 30% with statistical significance at a level of 5% confidence interval. It represents that there is less than a 30% chance of not having IAC in the absence of these clinical indicators.

In this study, the accuracy of Ineffective cough, adventitious breath sounds, and Excessive sputum was found > 80% while identifying the IAC correctly. However, one study has assessed the accuracy of IAC's clinical indicators which claimed accuracy of> 80% of one clinical indicator that is; ineffective cough.[2]

Moreover, six indicators have shown the DOR above 1.0 including Dyspnea 1.09, ARP 1.09, Restlessness 1.08, Ineffective cough 1.05, Excessive sputum 1.05, and ABS 1.05 in previous studies. [2, 16] In contrast to these findings, it represents DOR of all the Clinical indicators above 1.

This study also reported ROC curves at the 5% level of significance, three clinical indicators are the best indicators to detect patients with IAC including ineffective cough, adventitious breath sounds, and excessive sputum. Analysis of ROC curves (graphs 6.1, 6.7, and 6.8) confirms that the ineffective cough, adventitious breath sounds, and excessive sputum are the most significant clinical indicators to rule out IAC in Post CABG surgery Patients. Similar to the most recent study, it proved that the four indicators three with the values for the area under the ROC curve. According to that, the indicator adventitious respiratory sounds better predicts the patient is free from IAC. Yet ineffective cough is the best predictor of IAC when compared with dyspnea[2].

Due to excessive sputum in the airspaces, the air passages narrow down reduce the flow of air and increase pressure inside airspaces. It leads to adventitious breath sounds. [13, 18] Major problems can occur due to excessive or retained lung secretions in post-CABG surgery patients. This can decrease the quality of breathing patterns and can cause susceptibility to infection. If these symptoms are associated with an ineffective cough, it is important to consider that the patient could get into complications. Cough is mostly stimulated by retained secretions; frequent attempts to clear the secretions in post-thoracic surgery patients may lead to fatigue and pain.

Our study found the three clinical indicators that have shown higher values of sensitivity, positive likelihood ratio, and accuracy are adventitious breath sounds, excessive sputum, and ineffective cough. Furthermore, these three indicators have shown a greater area under the ROC curve significantly as well. These results show that these indicators are the good predictor for IAC and can help the nurse to diagnose IAC at its initial stage. One study claimed that the clinical indicators, Ineffective cough, adventitious breath sounds, and dyspnea are the most accurate clinical indicators with high specificity, DOR, LR-, LR+ and efficacy more than 70% to predict correctly IAC.[2]

Results of this study identified all clinical signs of IAC post-CABG surgery to be of diagnostic importance in this patient population, as demonstrated by a DOR above 1.0 for each clinical sign rate. Opposed to previous studies that indicated that signs of dyspnea, adventitious respiratory pattern, restlessness, ineffective cough, excessive sputum, and adventitious breath sounds had DORs at slightly over 1.0, which varied between 1.05 and 1.09. In the light of the higher DORs obtained in the present study, these indicators seem very promising for correctly identifying IAC in post-CABG patients and may indicate a closer link of these clinical signs with the presence of IAC.

Three of the major clinical indicators, ineffective cough, adventitious breath sounds, and excessive sputum, were also confirmed using ROC curve analysis at 5% significance level. Indeed, these indicators confirmed their reliability in detecting IAC consistently with the highest AUC. Especially, ineffective cough has been identified as one of the cardinal signs of IAC because it impairs a patient's capability for airway secretion clearance, enhancing a patient's chances of complications such as atelectasis and pneumonia. Adventitious breath sounds, and excessive sputum also serve as strong indicators in relation to mucus accumulation and decreased airway patency, critical contributors to IAC. [56,57]

High DORs and AUC values for these indicators may result from the wide-ranging assessment and rigor of methodology applied in this research, the results of which could be objectively measured by a standardized protocol for clinical evaluation. This contrasts with previous studies where subjective variability in assessments may have given inconsistent findings. [58] Furthermore, the large DORs for all the clinical indicators evaluated herein would indicate that IAC probably has wider symptomatology than hitherto appreciated, and thus the need for the adoption of holistic approaches in the clinical review.

These findings have implications for clinical practice, in that their use in informing the development of evidence-based assessment protocols may provide improved early detection and management of IAC in patients post-CABG. Incorporation of DOR and ROC analysis into routine nursing assessment could yield improved sensitivity and specificity in the detection of IAC. Furthermore, targeted interventions such as early mobilization, respiratory physiotherapy, and administration of pharmacological agents like mucolytics could be indications that should receive precedence in patients presenting with these high-risk indicators.

Considering the high incidence of IAC and considering the significant association of clinical indicators with respiratory complications, further investigation through longitudinal studies is warranted, monitoring the progressions of IAC, as well as in validation through larger and various patient groups. The latter might enable investigation into the sequential relation of the clinical indicators and onset of IAC, thereby allowing the deployment of predictive models for early intervention.

One of the limitations is that all previous studies in relation to this topic were conducted in US and made this study hard to conduct and apply NANDA-I Taxonomy II. Another limitation is that this study was conducted in only two tertiary care hospitals; to make study findings more generalizable similar study may be conducted at multi-centers. A few studies have been conducted with lack of measuring accuracy, predictive powers and likelihood ratios. This made the discussion remain limited for presenting and comparing findings.

Since this kind of the study is first time being conducted in Pakistan so it will assist researchers who conduct similar studies to compare in future. The findings of this study will facilitate nurses to assess patients for the clinical indicators of IAC accurately and provide greater safety and protection to post CABG surgery patients. It will assist them during their clinical practice to contribute quality care nursing. Unlikely, a few studies have discussed the predictive power and likelihood ratios of Ineffective Airway Clearance which made the statistical analysis more complex to compare with the relevant studies.

Cardiothoracic and abdominal surgeries are the major surgeries that can elicit a cluster of clinical signs and symptoms that can further cause IAC. It is highly important for medical professionals to determine which clinical indicator is most important to look for the individual response. In this study, we assessed 113 patients of post-cardiac surgery and found the higher incidence of IAC 92.2 %. In this study, there are three clinical indicators that were most prevalent; adventitious breath sounds 79.6%, excessive sputum 77.0%, and ineffective cough 76.1 %. Based on statistical findings these three indicators found good indicators to diagnose IAC with an increased likelihood ratio. It is recommended to healthcare professionals; to assess for these three the most frequent clinical indicators; adventitious breath sounds ineffective cough and excessive sputum. Consequently, it will direct the doctors and nurses to diagnose IAC at its early stage in post CABG surgery patients to manage and prevent life-threatening conditions. Since this study found a higher incidence of IAC in post CABG surgery patients so this is recommended that more attention is needed in preoperative teaching of deep breathing and coughing techniques by nurses.

Authors' Contribution

Grant Support & Financial Disclosures

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