



Ineffective breathing pattern in cardiac postoperative patients: Diagnostic accuracy study



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ABSTRACT

Purpose: The aim of this study was to analyze the accuracy of the defining characteristics of ineffective breathing pattern (IBP) in postoperative cardiac patients.

Methods: A diagnostic accuracy study was performed with 98 patients. Measures of sensitivity, specificity, predictive values, likelihood ratios, diagnostic odds ratio, and area under the ROC curve were calculated.

Results: IBP was present in 23.5% of the patients. Alterations in depth of breathing (sensitivity 96%, negative likelihood ratio 0.11%) and pursed-lip breathing (sensitivity 99%, negative likelihood ratio 0.07%) were the most sensitive defining characteristics for IBP, while altered chest excursion (specificity 97%, positive likelihood ratio 11.41%) and prolonged expiration phase (specificity 99%, positive likelihood ratio 42.39%) were the most specific.

Conclusion: Some clinical indicators were more related to the presence or absence of IBP than others. Knowledge of such measures can help nurses to assess patients more accurately.

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1. Introduction

The identification of human responses to health problems or events from the life cycle, also known as nursing diagnoses, is the basis for nurses' decisions (Herdman & Kamitsuru, 2014). To define appropriate interventions and monitor the effects of these, it is necessary to establish an accurate representation of the phenomenon of interest. Thus, it is known that the identification of the real health state of the patient contributes to a more efficient care plan (Sousa et al., 2013).

Postoperative respiratory events are expected for almost all cardiac surgical patients. This kind of dysfunction is usually well tolerated when the patient has an adequate pulmonary reserve, but for patients with a history of respiratory disease, postoperative pneumonia, or

cardiogenic pulmonary edema, the respiratory function can be impaired severely. Postoperative respiratory events are caused by multiple factors including: general anesthesia, use of central respiratory depressants, sternotomy, use of drainage tubes, cardiopulmonary bypass, blood-derivative transfusion, diaphragm dysfunction, chronic obstructive pulmonary disease, and obesity (Stephens, Shah, & Whitman, 2013).

Postoperative respiratory problems can be early detected based on consistent defining characteristics. Some of these problems represent nursing diagnoses like ineffective breathing pattern (IBP), for which specific actions should be taken. IBP was introduced in the NANDA-I taxonomy in 1980, and passed through three revisions, being the last one dated in 2010. IBP describes a condition in which the inspiration and/or the expiration do not provide adequate ventilation (Herdman & Kamitsuru, 2014), and it has been investigated in a number of studies (Beltrao, Silva, Araujo, & Oliveira Lopes, 2011; Pascoal et al., 2014; Zeitoun, Barros, Michel, & Bettencourt, 2007). However, there is a lack of studies focusing on the defining characteristics of IBP in cardiac surgery adult patients.

The diagnostic reasoning involves several cognitive tasks that result in the establishment of a diagnostic hypothesis. Usually, a single clinical datum is not sufficient to establish a diagnosis with certainty (Lopes, Silva, & Araujo, 2012). Thus, the knowledge about the accuracy of

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Table 1
Operational definitions for the defining characteristics of ineffective breathing pattern.

Defining characteristics	Operational definitions
Alterations in depth of breathing	Increased or decreased thoracic expansion or abnormal retraction of the rib cage during breathing cycles. Alterations in depth of breathing can be evaluated by inspection of the thoracic expansibility and by diaphragmatic expansibility measurements.
Altered chest excursion	Asymmetry of the movements of the thoracic cage. Altered chest excursion can be evaluated by inspecting the chest movements with breathing for symmetry.
Bradypnea	Number of breathes (inhales and exhales) per unit of time that is lower than 12 breaths per minute. Bradypnea can be evaluated by inspection.
Dyspnea	Labored or difficult breathing. Dyspnea can be evaluated by patients' report of "shortness of breath" or that they "can't get enough air".
Increased anterior–posterior diameter	Anteroposterior diameter that is greater than the latero-lateral diameter. Increased anterior–posterior diameter can be evaluated by measuring the chest diameters and by verifying a relationship between anteroposterior and transverse diameter greater than 1:2.
Orthopnea	Appearance of worsening of dyspnea while in horizontal position. Orthopnea can be evaluated by inspection or asking about the position adopted by the patient.
Prolonged expiration phase	A ratio between the inspiratory and expiratory time that is greater than 1:2. Prolonged expiration phase can be evaluated by inspection.
Pursed-lip breathing	A respiratory pattern characterized by breathing in through the nose and out by means of pursed lips. Pursed-lip breathing can be evaluated by inspection and require the examiner to ask if the patient was taught to breathe using pursed-lips breathing.
Tachypnea	Number of breathes (inhales and exhales) per unit of time that exceeds 20 breaths per minute. Tachypnea can be evaluated by inspection.
Use of accessory muscles to breathe	Contraction of the trapezius, sternocleidomastoid, internal intercostal, scalene, pectoralis major, or abdominal muscles during with breathing. Use of accessory muscles to breathe can be evaluated by inspection.

defining characteristics is important, as it increases the nurses' ability to discriminate between patients with and without a specific nursing diagnosis. This study aimed to analyze the accuracy of the defining characteristics of IBP in cardiac surgery adult patients.

2. Materials and methods

2.1. Design and setting

An accuracy study was carried out in the heart surgery ICU of a 349-bed referral hospital in a large city located in north-eastern Brazil. This unit is exclusive for adult patients in the post-operative period and most patients remain in the unit for 48 hours or more after surgery. At this hospital, the documentation of nursing diagnoses is paper-based and consists in a checklist of potential nursing diagnoses.

To ensure a more precise identification of IBP, the list of nursing diagnoses inferred by the nurses in this ICU was not used. The method used to identify IBP in this study was based in conceptual and operational definitions, as described further in the [Data collection](#) section.

2.2. Sample

Consecutive sampling was adopted in this study. Sample size was calculated using the formula for single test accuracy studies (Zhou, Obuchowski, & McClish, 2002) with a confidence level of 95% desired width of one half of 95%, confidence interval of 10%, and a conjectured sensitivity of 85%, leading to a total of 98 patients. Patients aged 18 years and older, who were in the period between 24 and 48 hours following cardiac surgery, and who had a level of consciousness that would enable data collection were included.

For safety reasons, exclusion criteria for this study included mechanical ventilation, heart transplantation, and end-stage comorbidities. Ethical approval for the study was granted by the appropriate local research ethics committee and all participants signed an informed consent form.

2.3. Data collection

Data collection was carried out by two nurse researchers who individually assessed the patients and reviewed their medical records for complementary information, when necessary. A third researcher was responsible for observing and supervising the data collection, and for making the diagnostic inferences. This third researcher was chosen

as an expert for having a high level experience with respiratory diagnoses from the NANDA-I taxonomy gained during 10 years participation in a research project on nursing diagnoses, interventions and outcomes, and for authoring several publications focusing on respiratory nursing diagnoses.

A data collection instrument was created for use in this study and comprised three sections: respiratory symptoms and measures of pulmonary function, a guide for the respiratory assessment of the patients, and a list of operational definitions for each defining characteristic of IBP, as listed in the NANDA-I taxonomy 2012–2014 (the current version at the time data collection was carried out). Presently, the NANDA-I taxonomy 2015–2017 is the current version. However, there are no differences regarding the 2012–2014 and 2015–2017 versions of the NANDA-I taxonomy in regard to the defining characteristics of IBP. Operational definitions were extracted from the literature (Seidel et al., 2011; Swartz, 2010) and can be seen in [Table 1](#).

The respiratory assessment did not include a spirometry test, because the clinical condition of the patients was not compatible with it. Thus, the following defining characteristics that are suggested by NANDA-I for the assessment of IBP were not assessed in this study: decreased expiratory pressure, decreased inspiratory pressure, decreased minute ventilation, and decreased vital capacity. The defining characteristic "nasal flaring" that is also present in the NANDA-I taxonomy was not assessed for being seen mostly in infants and younger children (Seidel et al., 2011). The defining characteristic "use of three-point position" was not assessed because, at this hospital unit, the patients are recommended to be laid down on bed during the entire postoperative period, except during procedures and physical therapy.

2.4. Data analysis

All analyses were performed using the R software version 3.0.2 (R Core Team, 2014). After the inferential process, measures of statistical accuracy were calculated for each defining characteristic. In this study, sensitivity (Se) can be understood as the probability of correctly identifying the presence of a defining characteristic in patients with IBP. Specificity (Sp) represents the opposite, i.e. the probability of correctly identifying the absence of a defining characteristic in patients without IBP. The positive predictive value (PV+) represents the probability of having IBP in patients with a defining characteristic, while the negative predictive value (PV−) represents the probability of the

Table 2
Prevalence of Ineffective breathing pattern and its defining characteristics in the sample.

Variables	Presence	%	Absence	%
Ineffective breathing pattern	23	23.5	75	76.5
Defining characteristics				
Alterations in depth of breathing	68	69.4	30	30.6
Tachypnea	30	30.6	68	69.4
Dyspnea	27	27.6	71	72.4
Orthopnea	25	25.5	73	74.5
Prolonged expiration phase	14	14.3	84	85.7
Altered chest excursion	9	9.2	89	90.8
Pursed-lip breathing	4	4.1	94	95.9
Bradypnea	7	7.1	91	92.9
Increased anterior–posterior diameter	1	1.0	97	99.0
Use of accessory muscles to breathe	1	1.0	97	99.0

absence of IBP in patients without a defining characteristic (Lopes et al., 2012).

The likelihood ratio (LR) is the probability of the presence/absence of a defining characteristic in patients with IBP divided by the same probability in those without IBP. Likelihood ratios can be calculated for the presence of a defining characteristic (LR+) and for the absence of a defining characteristic (LR−). Under most circumstances, likelihood ratios greater than 10 and less than 0.1 hold strong evidence to confirm or deny diagnoses, respectively (Deeks & Altman, 2004).

The diagnostic odds ratio (DOR) measures the chance of a patient being diagnosed with IBP when a defining characteristic is present. Statistical significance is established for both the LR and the DOR at a 95% confidence interval that does not include the numeral 1. Finally, the area under the receiver operating characteristic (ROC) curve is used to summarize the accuracy of various defining characteristics. Values for the area under the ROC curve that is close to 1 indicate high accuracy (Zhou et al., 2002).

3. Results

The patients were predominantly male (55.1%) and either married or cohabitating (70.4%), and 76.5% were low-educated (i.e. elementary education). The patients' mean age was 55.9 years (SD 13.4). The most prevalent medical diagnoses were angina/coronary artery disease (37.8%), and the most frequent types of surgery were coronary artery bypass grafting (59.1%) and valve replacement (37.8%). With regard to personal habits, 54.1% of participants were currently or had been smokers at some point in their lives. No changes were found in the assessment of vital signs and oxygen saturation.

In accord with the specialist's inferences, the nursing diagnosis of IBP was present in 23.5% of the sample. The most frequent defining characteristics can be seen in Table 2.

Among the 10 defining characteristics that could be legitimately connected to IBP, only 3 had positive or negative LRs that were not significant (i.e. their 95% confidence interval included the numeral 1):

Table 3
Accuracy measures of the defining characteristics of ineffective breathing pattern^a.

Defining characteristics	Se	Sp	PV+	PV−	LR+	LR−	DOR	ROC
Alterations in depth of breathing	95.65	38.67	32.35	96.67	1.56 [1.24–1.95]	0.11 [0.02–0.78]	12.07 [2.32–298.45]	0.671
Altered chest excursion	30.43	97.33	77.78	82.02	11.41 [2.79–46.76]	0.71 [0.54–0.94]	14.64 [3.10–116.58]	0.638
Bradypnea	17.39	96.00	57.14	79.12	4.35 [1.35–14.03]	0.86 [0.71–1.04]	4.89 [0.95–28.52]	0.567
Dyspnea	56.52	81.33	48.15	85.92	3.03 [1.73–5.30]	0.53 [0.33–0.86]	5.51 [2.02–15.74]	0.689
Increased anterior–posterior diameter	98.68	8.00	76.53	66.67	1.07 [0.93–1.24]	0.16 [0.02–1.74]	6.01 [0.47–194.41]	0.533
Orthopnea	52.17	82.67	48.00	84.93	3.01 [1.68–5.40]	0.58 [0.37–0.90]	5.07 [1.84–14.49]	0.674
Prolonged expiration phase	56.52	98.67	92.86	88.10	42.39 [5.94–302.66]	0.44 [0.28–0.70]	79.41 [13.57–2074.52]	0.775
Pursed-lip breathing	98.68	20.00	78.95	83.33	1.23 [1.01–1.51]	0.07 [0.01–0.54]	16.37 [2.35–450.61]	0.593
Tachypnea	56.52	77.33	43.33	85.29	2.49 [1.49–4.19]	0.56 [0.35–0.91]	4.34 [1.62–12.07]	0.669
Use of accessory muscles to breathe	98.68	8.00	76.53	66.67	1.07 [0.93–1.24]	0.16 [0.02–1.74]	6.01 [0.47–194.41]	0.533

^a Se: Sensitivity; Sp: Specificity; PV: predictive value; LR: likelihood ratio; DOR: diagnostic odds ratio; ROC: area under ROC curve.

bradypnea, increased anteroposterior diameter, and use of accessory muscles to breathe. Alterations in depth of breathing and pursed-lip breathing were the most sensitive defining characteristics (high Se, PV− and DOR values, LR− below 0.1, and ROC close to 1). On the other hand, altered chest excursion and prolonged expiration phase were the most specific (high Sp, PV+ and DOR values, LR+ above 10, and ROC close to 1) (Table 3).

Analysis of the area under the ROC curve confirmed the other results and showed that alterations in depth of breathing and pursed-lip breathing are sensitive defining characteristics (high true positive and false positive rates), while the absence of altered chest excursion and prolonged expiration phase are specific (high true positive and low false positive rates) (Fig. 1).

4. Discussion

The most important finding from this study is that some defining characteristics were more closely related with IBP than others, hence the importance of diagnostic accuracy studies for facilitating the identification of nursing diagnosis. Alterations in depth of breathing and pursed-lip breathing behaved as sensitive defining characteristics of IBP, while altered chest excursion and prolonged expiration phase behaved as specific.

Assessment of respiratory depth stands out among the main activities performed by nurses for patients with respiratory problems (Sousa et al., 2013). Depth of breathing is related to the tidal volume, which is the amount of air inspired during normal, relaxed breathing. Conditions that affect the mechanics of lung and chest wall (like heart surgery), have a direct impact on the tidal volume and hence in the depth of breathing (Ali, Weisel, Layug, Kripke, & Hechtman, 1974).

Pursed-lip breathing was one of the highly sensitive defining characteristics of IBP. No studies were found on adult cardiac patients that addressed this defining characteristic. However, in a study performed on children with congenital heart diseases, pursed-lip breathing was one of the seven defining characteristics that presented statistically significant differences between patients with and without IBP (Beltrao et al., 2011).

Assessment of pursed-lip breathing was caution-oriented in this study, since this is also a nursing intervention to promote respiratory comfort. When performing the patients' assessment, the expert nurse ensured that the patients who were breathing with pursed lips were acting spontaneously, and not using a breathing teaching that was taught to them.

Altered chest excursion is usually associated with unilateral ventilation problems (Sole, Klein, & Moseley, 2013) which are common even following minimally invasive cardiac surgical procedures (Tutschka, Bainbridge, Chu, Kiaii, & Jones, 2015). In spite of being frequent, this type of adverse event carries significant morbidity and requires early detection and intervention. Although altered chest excursion was closely related to IBP in the study, the same may not be true in patients that are still under mechanical ventilation, as reported elsewhere (Zeitoun et al., 2007).

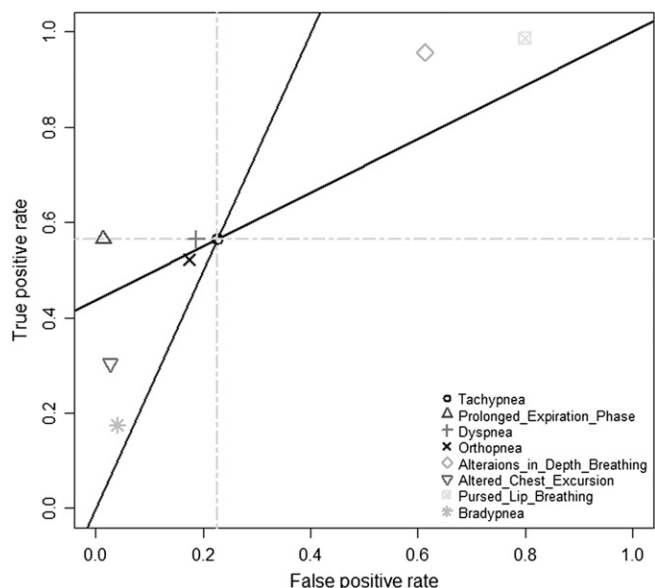


Fig. 1. Performance comparison of defining characteristics with the largest area under the ROC curve.

Prolonged expiration phase is defined as an increase in the time taken to exhale air (Beltrao et al., 2011). This sign manifests itself in patients having difficulty breathing in order to maintain a high airway pressure (Singer, 2009). No studies were found concerning this defining characteristic, which may reflect a literature gap.

The high percentage of smokers (corresponding to 54.1%) was of particular interest. Although other investigations would be necessary to establish relationships between this and other findings, it is known that smoking increases the risk of developing respiratory complications in the postoperative period (Lee et al., 2015).

The findings indicate the importance for nurses to maintain skills in physical examination, especially in postoperative units. The availability of sophisticated technology can lead nurses to underuse clinical examination data, which are essential for the correct identification of nursing diagnoses. In addition, a revision of the defining characteristics of IBP that are listed in the NANDA-I taxonomy would be beneficial to facilitate the assessment of this nursing diagnosis by nurses. For example, NANDA-I recommends the use of measures such as expiratory and inspiratory pressures, minute ventilation, and vital capacity that are helpful to the assessment of IBP, but require a physician's order or prescription. We believe that defining characteristics that can be assessed by nurses, in an independent manner, should receive more emphasis.

It is important for nurses to understand and exercise clinical skills within the nursing domain when evaluating the patients' responses instead of basing their clinical assessment on results from tests that require medical technology. The improvement of clinical nursing skills is crucial for autonomous nursing care and for the effective assessment of postoperative patients, leading to early detection of complications and effective care management (Brier et al., 2015).

4.1. Limitations

This study has two main limitations. First, only one expert nurse was responsible for making the diagnostic inferences, which is recognized to be an imperfect gold standard. At the time the study was developed, theories and most rigorous methods for establishing the accuracy of defining characteristics were still under development. These new methodologies were recently published and represent a new trend in research on nursing diagnoses (Lopes, Silva, Araujo, & Silva Filho, 2015; Lopes et al., 2012).

Second, while associations between some defining characteristics and IBP have been demonstrated for the sample of cardiac surgical patients, the ability of the physical assessment to identify respiratory compromise in more critically ill patients remains to be determined. As stated before, safety issues were an obstacle for the inclusion of patients with a wider range of physical responses in the sample. There would be benefit in conducting additional research involving patients with different clinical profiles.

5. Conclusions

This study showed that alterations in depth of breathing, altered chest excursion, prolonged expiration phase, and pursed-lip breathing are accurate defining characteristics of IBP in cardiac surgery adult patients. Knowledge of the accuracy of the defining characteristics of respiratory nursing diagnoses can guide nurses to a more appropriate diagnostic inference, which directly impacts the patient safety and the quality of the nursing care.

6. Implications for research, practice and policy

The results of this study have implications for research, clinical practice, and policy. The methods that were used to estimate the accuracy of the defining characteristics of IBP can be replicated by researchers interested in accuracy assessments of other defining characteristics or even other nursing diagnoses.

The accuracy values that are documented here may be useful for nurses working in the cardiac postoperative setting, since they reduce the subjectivity that is common in the clinical assessment of patients.

With regard to policy, the accurate assessment of postoperative events like ineffective breathing pattern can impact the detection of respiratory complications and increase the scope of decision-making by policy-makers.

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