

Effect of PDCA Evidence-Based Nursing Practice on Arterial Blood Gas Analysis in the Respiratory Department

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Abstract: *Objective* To explore the effect of PDCA evidence-based nursing intervention on arterial blood gas analysis in the respiratory department. *Methods* Sixty patients who underwent blood gas analysis in our hospital from February 2021 to March 2021 were selected as the control group; while the same number of patients who underwent blood gas analysis from July 2021 to August 2021 were selected as the observation group to implement PDCA evidence-based nursing practice. The effects of one-time success rate, qualified specimen rate, incidence of redness, swelling and ecchymosis at puncture point, sample turnover time and nurses' knowledge level were compared between the two groups. *Results* The success rate of one-time puncture and the qualified rate of specimens in the observation group were higher than those in the control group ($P < 0.05$). Meanwhile, the incidence of redness, swelling and ecchymosis at the puncture point and the turnover time of specimens in the observation group were lower than those in the control group ($P < 0.05$). After the implementation of the improvement plan, the nurses' knowledge levels in the observation group were significantly increased compared with the control group ($P < 0.05$). *Conclusion* PDCA evidence-based nursing practice can effectively improve the knowledge level of nurses, shorten the sample turnover time, increase the success rate of one-time puncture and the qualified rate of samples, reduce the incidence of adverse events such as redness, swelling and ecchymosis at the puncture point, and improve the quality of clinical nursing.

Keywords: PDCA, Evidence-based Nursing, Respiratory Department, Blood Gas Analysis

1. Introduction

Arterial blood gas analysis provides an important basis for the monitoring of respiratory failure and acid-base imbalance as well as the evaluation of treatment response to mechanical ventilation. It can be used to detect the severity of respiratory diseases and a variety of critical diseases [1]. At present, the effectiveness of arterial puncture blood collection methods has been widely studied. Due to different types of observational research designs and methods, such as age, disease conditions and individual physiological conditions, the obtained findings may be varied [2-5]. How to rapidly and effectively collect arterial blood and minimize the impact and damage caused by the operation to patients are worthy of our consideration and await further research. Therefore, this study aimed to determine the effect of PDCA evidence-based nursing practice on arterial blood gas analysis in the respiratory department, which might shorten the sample

turnover time, improve the puncture success rate and reduce the incidence of redness, swelling and ecchymosis at the puncture point.

2. Data and Methods

2.1. Clinical Data

Using a convenient sampling method, 60 patients who underwent blood gas analysis in our hospital from February 2021 to March 2021 were selected as the control group, including 39 males and 21 females. For the observation group, 60 patients who underwent blood gas analysis from July 2021 to August 2021 were selected, including 47 males and 13 females. The average age was (66.78 ± 15.99) years for control group, while (66.42 ± 15.57) years for observation group. There were no significant differences in gender and age between the two groups ($P > 0.05$).

2.2. Nursing Procedure

Routine nursing practice was implemented in the control group, while PDCA evidence-based nursing practice was implemented in the observation group. The specific measures are as follows:

2.2.1. Make a Plan (p-plan)

To investigate the current situation, analyze the causes and

determine the problems, a specific team consisting of two head nurses, three team leaders and four responsible nurses was established. As shown in Table 1, the common clinical problems occurred during arterial blood gas analysis were identified among 60 patients in the control group. For the evidence-based process, the relevant literature was searched, and the obtained evidence was combined with professional nursing skills, clinical experience and patients' needs. The nursing plans and outcome measures were formulated.

Table 1. Analysis of the influencing factors of blood gas analysis in 60 patients from February to March, 2021 (%).

Existing problems	Incidence rate
The patient is restless.	5 (3.42%)
Poor coordination of patients with pain.	6 (4.11%)
The patient's body position is not appropriate.	18 (12.33%)
Nurses are not proficient in arterial puncture.	23 (15.75%)
Inappropriate vascular selection.	10 (6.85%)
Multiple puncture injury of blood vessels.	20 (13.70%)
Poor compression.	24 (16.44%)
Specimen solidification.	5 (3.42%)
Bubble formation in the specimen.	3 (2.05%)
Extension of inspection time.	32 (21.92%)

2.2.2. Implementation Plan (d-do)

After collective learning and operation, the established evidence-based nursing related measures were strictly implemented and continuously improved. Training was conducted for all department staff, including the guidelines on arterial blood gas analysis, sharing of relevant articles, standard operating procedure, arterial blood gas sampling and measurement, etc. The operational procedure was formulated and incorporated into clinical practise, and random inspection

was conducted from time to time. The position of blood gas analyzer was adjusted to make it more convenient for nurses to operate. Our respiratory department actively participated in various competitions related to arterial blood gas analysis, including lecture competition, operation demonstration, publicity and education, so as to enable multiple ways of learning and improve the theory mastery of arterial blood collection and standardized operating practise among all staff nurses.

Table 2. Formulation of the evidence-based nursing practice intervention measures.

Clinical problems	Detailed description	Evidence-based nursing practice measures
The patient was restless, painful and uncooperative.	The nurses did not communicate well in advance. Those who received sedatives and/or analgesics did not assess their state of consciousness before operation, the nurses' operation technique was not standardized, the skin was not tight, and the needle holding method and needle entry angle were not appropriate.	The nurse shall communicate before operation, inform the patients and their family members regarding the relevant precautions for blood gas analysis, patiently explain to the patients, distract the patients' attention and eliminate their fear. The patients who received sedatives and/or analgesics were required to evaluate their state of consciousness and subjected to physical restraint when necessary. Standardize the nurses' arterial blood collection methods, tighten the patient's skin during puncture, select the correct needle holding method and needle entry angle according to different blood vessels, and reduce the stimulation of the needle tip obliquely facing the patients [6, 7].
Nurses were unskilled in arterial puncture, poor posture and inappropriate vascular selection.	The clinical practice did not strictly implement the operation technical specifications of arterial blood collection, did not master the operational and technical procedures, the pre-employment training was not comprehensive, and there was no specific positioning method during puncture. Nurses often chose blood vessels based on their own preferences.	Strengthen the admission training of new nurses in the Department, standardize the arterial blood collection methods [8], use simple and easily understandable steps to strengthen memory, examine blood vessels, locate their positions, evaluate the strongest part of arteries, disinfect, puncture and press on the wound. Selection of puncture angle: radial artery 30° - 45°; brachial artery 45°; dorsalis pedis artery 15°; femoral artery 90°; scalp artery 20° - 30° [6]. Body position: for radial artery [9], depending on the patient's condition, the flat or semi lying position is adjusted, the elbow is relaxed naturally at 45° - 60° abduction, and a pillow is placed on the back of the patient's wrist to keep the wrist extended and positioned. For brachial artery [10], the arm is fully extended, the palm is upward, and a small pillow is placed on the elbow to make the elbow as straight as possible. For femoral artery, the supine position is fixed, the arteries of the lower limb is straightened, the abduction and external rotation position is selected, and the joint is slightly bent outward [11]. For dorsalis pedis artery [12], in the patient's supine or sitting position, the dorsalis pedis at the puncture side is fully exposed, stretched and tightened. The recommended arterial sequence for vascular selection is as follows: radial artery - brachial artery - dorsalis pedis artery - femoral artery [13].

Clinical problems	Detailed description	Evidence-based nursing practice measures
Multiple puncture wounds and poor compression.	The positioning methods might not be suitable. The operation skills and effective pressing consciousness needed to be improved.	Nurses should practice more and select a correct position according to the operation standards. For radial artery [14], a transverse finger (about 1-2 cm) from the transverse stria of the wrist and 0.5-1 cm from the outside of the arm, where the arterial pulse is the strongest. For brachial artery [15], the pulsation of the brachial artery can be touched at the inner side of the elbow fossa, and the strongest pulsation point is selected as the puncture point for operation. For dorsalis pedis artery [14], from the midpoint of the line between the medial and lateral malleolus of the dorsalis pedis to the midpoint of the first metatarsal space, the pulse of the artery is the most obvious. For femoral artery [11], the intersection between the midpoint of the groin and the midline of the pubic symphysis is located, and blood from the strongest pulse of the femoral artery is collected. Selection of pressing method: the puncture wound is immediately pressed with dry sterile gauze or cotton swab for 3-5 minutes after pulling out the needle, and the bandage is change to stop bleeding [6].
Abnormal coagulation function.	The patient's coagulation function was not evaluated before operation.	The patient's medical history and relevant examination results should be reviewed and evaluated before operation [16].
Specimen quality problems.	Improper mixing could lead to blood coagulation or small clot, air bubbles were not removed in time, and a standard process was not formulated.	A specific arterial blood collector can be used for blood collection. The sample is fully mixed with anticoagulant in the blood collector according to the requirements of the product user manual. If air bubbles are formed during the blood collection process, the bubbles should be removed immediately. According to the arterial blood gas inspection guidelines provided by the Department, the blood sampling procedure should be completed within 30 minutes [17].

2.2.3. Quality Monitoring (c-check)

The quality controller of the project improvement team was set up. The quality controller was assumed by the chief nurse and the personnel above the team leader in the project improvement team. They provided technical guidance, training and quality monitoring to the group members, and analyzed the problems during blood sample collection. In addition, the arterial blood gas analysis, blood collection process, regular and irregular assessments were evaluated, and then correlated with personal performance based on the assessment results.

2.2.4. Processing Phase (a-adjust)

To standardize arterial blood gas analysis among the responsible nurses, discuss and analyze the problems existing in each inspection stage, identify the causes, make continuous improvement, praise those with good improvement, offer performance-based rewards, and support or supervise those with poor improvement, a meeting was held every Monday morning after shift handover. The continuous improvement of arterial blood gas analysis, collection process and sample quality was achieved.

2.3. Observation Indicators

The observation indicators are as follows: (i) the sample turnover time (refers to the time from collecting enough arterial blood to issuing the test report results), (ii) the success rate of one-time puncture (a needle is successfully punched at one puncture point, and sufficient arterial blood volume is withdrawn to obtain accurate blood gas assessment results), (iii) the qualified rate of samples (correct venous blood, sufficient arterial blood volume, no coagulation and no mixed bubbles in the sample, which may lead to incomplete testing, a large deviation in the test

results or a requirement for test repetitions), and (iv) the occurrence of redness, swelling and ecchymosis at the puncture point.

2.4. Statistical Analysis

SPSS13.0 software was used for statistical analysis. The categorical data were compared by χ^2 test, while the continuous data were compared by t-test. A *p*-value of <0.05 was considered statistically significant.

3. Results

3.1. Comparison of the Arterial Blood Gas Analysis Indexes Between the Two Groups

Approximately 46.7% of the patients in the control group had a sample turnover time of less than 30 minutes, while all patients (100%) in the observation group had a sample turnover time of less than 30 minutes. The one-time success rate of the control group was, whereas that of the observation group was. The qualified rate of specimens in the control group was, while that in the observation group was. The incidence of redness, swelling and ecchymosis at the puncture point was in the control group, whereas in the observation group. There were significant differences in these parameters between the two groups ($P < 0.05$; Table 3).

3.2. Comparison of the Nurses' Knowledge Levels Before and After Nursing Practise Improvement

Before nursing practise improvement, the nurses' knowledge level was assessed with (69.35±12.64) points, after nursing practise improvement, the nurses' knowledge level was assessed with (91.09±3.98) points. There was a significant difference between the two groups ($P < 0.05$).

Table 3. Comparison of the arterial blood collection indexes between the two groups (%).

Group	Cases	Turnover time (<30 minutes)	Disposable puncture success rate	Qualified rate of specimen	Rate of redness, swelling and ecchymosis
Observation group	60	60 (100)	48 (80.0)	47 (78.3)	8 (13.3)
Control group	60	28 (46.7)	37 (61.7)	24 (40.0)	28 (46.7)
χ^2			4.881	18.247	15.873
<i>P</i>		0.00	0.02	0.00	0.00

4. Discussion

4.1. Impact of Novel Coronavirus Pneumonia on the Quality of Arterial Blood Gas Analysis

Chronic diseases, such as chronic obstructive pulmonary disease, bronchiectasis and chronic bronchitis, are the top 10 diseases among the patients in the respiratory department [18]. These patients often have recurrent attacks and needed for repetitive medical treatment. Some symptoms and signs are relatively similar to those of new coronavirus (COVID-19) pneumonia patients, while COVID-19 has a longer incubation period. The main clinical manifestations are fever, dry cough and fatigue, and mild patients can have no pneumonia. COVID-19 patients in the incubation period are often asymptomatic, but they are infectious, which may increase the risk of infection among medical staff in the respiratory department [19]. Arterial blood gas analysis is the most reliable index for clinical judgment of whether there is acid-base balance disorder and respiratory failure [20]. The pneumonia caused by COVID-19 can increase the difficulty of nursing operation. The main transmission route of COVID-19 pneumonia is respiratory droplet and contact transmission. In a relatively closed environment, long-term exposure to high concentrations of aerosols exists the possibility of COVID-19 transmission [21]. Therefore, higher requirements are put forward for clinical nurses in the respiratory department. The procedures of arterial puncture and blood collection should be conducted in a more rapid and accurate way, so as to ensure a high success rate and improve patient satisfaction.

4.2. PDCA Evidence-Based Nursing Practice Can Improve the Quality of Clinical Nursing in the Respiratory Department

In this study, PDCA circulation combined with continuing nursing practice was effectively used to formulate the best nursing intervention measures for patients. The key steps of arterial blood collection were employed and the nurses' operation skills were strengthened to enable the best nursing intervention measures of arterial blood gas analysis. The most optimal blood collection methods were selected to improve the speed and accuracy of blood collection. An effective communication between nurses and patients was performed to reduce patient's stress before blood collection, and achieve a positive cooperation with different patients. The duration of arterial blood collection and sample analysis

was standardized, which greatly shortens the sample turnover time and provides more accurate results for clinical diagnosis and treatment [22]. To meet the current medical demand, accurate examination results are very crucial, while improving the one-time puncture success rate and qualified specimen rate is also of great importance for saving medical resources. In addition, PDCA evidence-based nursing practice could reduce the incidence of redness, swelling and ecchymosis at the puncture point, improve patient satisfaction, reduce the incidence of complications, and greatly enhance the clinical nursing quality in the respiratory department.

4.3. PDCA Evidence-Based Nursing Practice Can Improve the Knowledge Level and Problem-solving Ability of Respiratory Nurses

By carrying out the project improvement of PDCA evidence-based nursing practice, nurses were taught the ability to identify and analyze problems at work and solve problems based on research evidence combined with nursing practice. Nurses' professional knowledge and thinking ability could also be enhanced. This is conducive to better utilizing scientific research and clinical nursing experience to conduct more professional and reliable nursing operations for patients, thus improving the quality of patient care. Our department won the first prize in the hospital teaching competition with the theme of "arterial blood collection", the second prize in the municipal teaching competition with the theme of "arterial blood collection", and the runner-up prize in the local competition of arterial blood sampling skills.

5. Conclusion

In conclusion, this study reveals that arterial blood gas analysis can be improved by PDCA evidence-based nursing practice in the respiratory department, which shortens the sample turnover time, increases the success rate of one-time puncture and the qualified rate of samples, reduces the incidence of redness, swelling and ecchymosis at the puncture point, and improves the nurses' theoretical knowledge level. However, this study was conducted only at the respiratory ward of a third class general hospital in Dongguan, and the patients' satisfaction and pain feelings were not assessed. Moreover, the sample size needs to be further expanded. In the future, we will further explore the patient's pain experience and the embodiment of qualitative changes in arterial blood gas analysis.

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