RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 3, Issue 8, 2025

EFFECTIVENESS OF ARTIFICIAL INTELLIGENCE MODELS IN ARTERIAL BLOOD GASES (ABG, S) INTERPRETATION FOR CLINICAL DECISIONS MAKING IN NURSING PRACTICE

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DOI: https://doi.org/10.5281/zenodo.18113129

Received	Accepted	Published
03 November 2025	17 December 2025	31 December 2025

ABSTRACT

Background: *In Critically ill patients in intensive care units and Emergency departments the evaluation of Arterial blood gas is very crucial for nurses, as it provides essential information's about acid–base metabolism of a body and respiratory balance, but its evaluation can be complex and require advance clinical knowledge. ABG,s interpretation provides vital insights into the respiratory and metabolic status of a patient by measuring key parameters such as pH, partial pressure of carbon dioxide* (pCO_2)*, partial pressure of oxygen* (pO_2)*, and bicarbonate* (HCO_3^-) *levels.*

Aim: *This study aims the comparing of Artificial Intelligent based machine learning models for the interpretation of acid–base metabolism from ABG,s data more Effectively.*

Method: Applied research with a cross-sectional observational design was used using Artificial intelligent based supervised machine learning approach for driving and analysis of data.

Results: *The results showed that using artificial intelligent different machine learning models were compared for accuracy, precision and Data Recall. Random forest model accuracy 92% and precision 92% and data Recall 87%, Decision Tree Model with 83%,78% and 79% accuracy, precision and Data recall respectively were the models with high accuracy, precision and Data Recall.*

Conclusion: *Artificial intelligent and machine learning models are the effective way to interpret the atrial blood gases for the Quick management of patient respiratory or metabolic acidosis and alkalosis during in an emergency and improve nursing practices.*

Keywords: *Arterial blood gaseous, artificial intelligence, machine learning models, metabolic alkalosis and acidosis, respiratory alkalosis and acidosis*

INTRODUCTION

In Critically ill patients in intensive care units and Emergency departments the evaluation of Arterial blood gas is very crucial, as it provides essential information about acid–base metabolism of a body and respiratory balance, but its evaluation can be complex and require advance clinical knowledge. ABG,s misinterpretation can lead to mismanagement of patient which is very harmful. ABG interpretation provides vital insights into the respiratory and metabolic status of a patient by measuring key parameters such as pH, partial pressure of carbon dioxide (pCO_2), partial pressure of oxygen (pO_2), and bicarbonate (HCO_3^-) levels These parameters are used to assess acid–base imbalances, which if left unrecognized or misinterpreted, can result in delayed treatment, increased morbidity, or even mortality. In the dynamic and high-pressure settings of emergency and critical care, timely and accurate interpretation of ABG results is not only a clinical necessity but a determinant of survival (Rodríguez-Villar et al., 2021).

Despite its importance, the interpretation of ABG results remains a complex task, often requiring specialized knowledge of human physiology, pathophysiology, and compensatory mechanisms. Nurses and frontline healthcare providers, particularly those in developing regions or under-resourced facilities, frequently lack the training and tools necessary to interpret ABG results effectively. This gap in skill can result in misdiagnosis or inappropriate therapeutic interventions, which further burden already strained healthcare systems (Ozdemir et al., 2024).

The integration of artificial intelligence (AI) into healthcare has opened new avenues for clinical decision-making support. Among AI technologies, machine learning (ML) has gained significant traction due to its ability to learn from data, identify patterns, and make predictions without being explicitly programmed. ML algorithms are now widely used in medical diagnostics, including image analysis, electrocardiogram (ECG) interpretation, and predictive analytics. Their application in laboratory diagnostics, including the analysis of ABG data, remains relatively novel but highly promising. By using ML models trained on large datasets of ABG values and known acid–base disorders, it is possible to develop automated systems capable of interpreting complex results with high accuracy (Wernly et al., 2021).

Several recent studies have demonstrated that ML models can be trained to identify and classify acid–base disorders such as respiratory acidosis, respiratory alkalosis, metabolic acidosis, and metabolic alkalosis based on ABG parameters (Rodríguez-Villar et al., 2021).For example, Rodríguez-Villar et al utilized a support vector machine algorithm to classify ABG disorders with a high degree of accuracy, concluding that such models can significantly reduce diagnostic delays in emergency settings. Similarly, Wernly et al. (2021) showed that machine learning models could predict patient mortality in sepsis cases using ABG variables alone, highlighting the predictive power of these models (Wernly et al., 2021).

The growing body of literature supports the notion that ML-enhanced ABG interpretation can empower nurses and clinicians by offering decision support in real-time, particularly in fast-paced environments. It reduces reliance on highly experienced personnel for initial interpretation and creates opportunities for standardized, protocol-driven responses to critical imbalances. Moreover, by minimizing human error and cognitive fatigue, ML tools can improve patient outcomes and operational efficiency in emergency and critical care departments.

In the context of nursing practice, this technology holds even more significance. Nurses are often the first point of contact for patient assessment and are tasked with rapid clinical judgments based on ABG results. However, in many educational and clinical settings, especially in low-resource regions, there is a lack of robust training in ABG interpretation. A machine learning-based ABG analysis system tailored for nursing use can serve as a valuable educational and clinical decision-support tool, improving accuracy and confidence in interpreting ABG findings (Ozdemir et al., 2024).

Problem Statement

Nurses, especially those in emergency and critical care settings, often face challenges in accurately interpreting ABG results due to complex physiological interdependencies. Delayed or incorrect interpretation may lead to poor patient outcomes. There is a need for a reliable, real-time, ML-based decision support system that can analyze ABG results and interpret acid–base imbalances accurately.

Rationale

Nurses those who are working in emergency and critical care departments frequently facing problems to appropriately interpret ABG results. Inaccurate or delayed interpretation could have a negative impact on patient outcomes. An ML-based decision support system that is dependable, real-time, and capable of accurately interpreting acid-base imbalances and analyzing ABG data is required so as to immediately interpret the ABG, s of a patient so as to generate the exact diagnosis of a patient on time.

Significance of the Study

This research aligns with modern trends in digital health and nursing informatics. By equipping nurses with Artificial intelligence ML-based tools for ABG interpretation, clinical decision-making can become more accurate, timely, and consistent—ultimately improving patient care and outcomes.

Research Objectives

1. To develop an artificial intelligent based machine learning models that interprets acid–base metabolism status using arterial blood gas ABG, s.
2. To Compare the artificial based machine learning models for ABG,S interpretation for their accuracy, precision and data recall.

Research Questions

1. How to develop Artificial Intelligent based machine learning model that interprets acid–base metabolism status using arterial blood gas ABG, s?
2. How to Compare Artificial Intelligent based machine learning models for ABG, S interpretation with high accuracy, precision and data recall.

Literature Review

The growing body of literature supports the notion that ML-enhanced ABG interpretation can empower nurses and clinicians by offering decision support in real-time, particularly in fast-paced environments. It reduces reliance on highly experienced personnel for initial interpretation and creates opportunities for standardized, protocol-driven responses to critical imbalances. Moreover, by minimizing human error and cognitive fatigue, ML tools can improve patient outcomes and operational efficiency in emergency and critical care departments (Wernly et al., 2021).

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A deep learning model using only arterial blood gas (ABG) variables was developed to predict 96-hour mortality in septic ICU patients. The LSTM model achieved an AUC of 0.88 in the ICU dataset and 0.85 in MIMIC-III, outperforming logistic regression and SOFA scores (Wernly et al., 2021).

"Visual Blood," a 3D animated model, was introduced to support ABG interpretation. In a simulation with 70 physicians, diagnostic accuracy improved from 68% with traditional methods to 86% using Visual Blood, with increased confidence and reduced workload (Zulfiqar et al., 2020).

Artificial intelligence was compared with emergency physicians for ABG interpretation across 25 clinical vignettes. It showed over 90% concordance in common cases like COPD and DKA but under 70% in mixed or toxicological disorders, and its recommendations were judged safe (Ahmed et al., 2024).

Six machine learning algorithms were tested on 21,541 ABG samples across 15 acid–base categories. XG Boost achieved 99.66% accuracy, and Bagging Classifier achieved 99.24% balanced accuracy, showing excellent sensitivity and specificity (Heinrichs & Eickhoff, 2020).

Machine learning models were used to estimate PaCO in ventilated children. Multilayer perceptron and XGBoost models achieved R^2 values of 0.851 and 0.877, higher than linear regression and end-tidal CO_2 estimation. A decision-tree model was used to predict COVID-19 diagnosis and ICU need based on ABG parameters in 686 patients. Diagnostic accuracy was 68.2%, and ICU prediction accuracy was 65%, with pH, sodium, and ionized calcium being key predictors (Yildizeli et al., 2021).

Material Methods

Study Design: Applied research with a cross-sectional observational design was used;

supervised machine learning approach was used driving and analysis of data.

Source: Retrospective ABG samples data from critical departments of a hospital (ICU) was collected.

Parameters: Component of ABG,s Test was used as a variables like pH, pCO_2, HCO_3^-, PO2.

Sample Size: 1000 ABG records were be used for training and testing the model**.**

Dataset Description

A total of 1000 ABG samples were used. Each sample included the following parameters:

- **pCO_2** (Partial pressure of carbon dioxide)
- **HCO_3^-** (Bicarbonate level)
- **pO_2** (Partial pressure of oxygen)
- **pH** (Hydrogen ion concentration)
- **Status** (Type of acid–base disorder)

Data Collection Procedure

Ethical Considerations

1. Approval from Hospital Ethical Committee or head of the department.
2. All information's of the patients were confidential.
3. Data handling was secured with healthcare data privacy standards.

Data Preprocessing

1. The dataset was verified for completeness and found to have no missing or duplicate values.

2. For classification, only two disorders were retained: Respiratory failure and metabolic failure.

3. Data include 631 Normal Cases, 211 cases were of respiratory failure and 158 cases are of metabolic failure.

4. Label encoding was applied to convert class labels to numerical format.

5. The data was split into training (75%) and testing (25%) sets with stratification.

6. Features were scaled using Standard Scalar for uniform input to models.

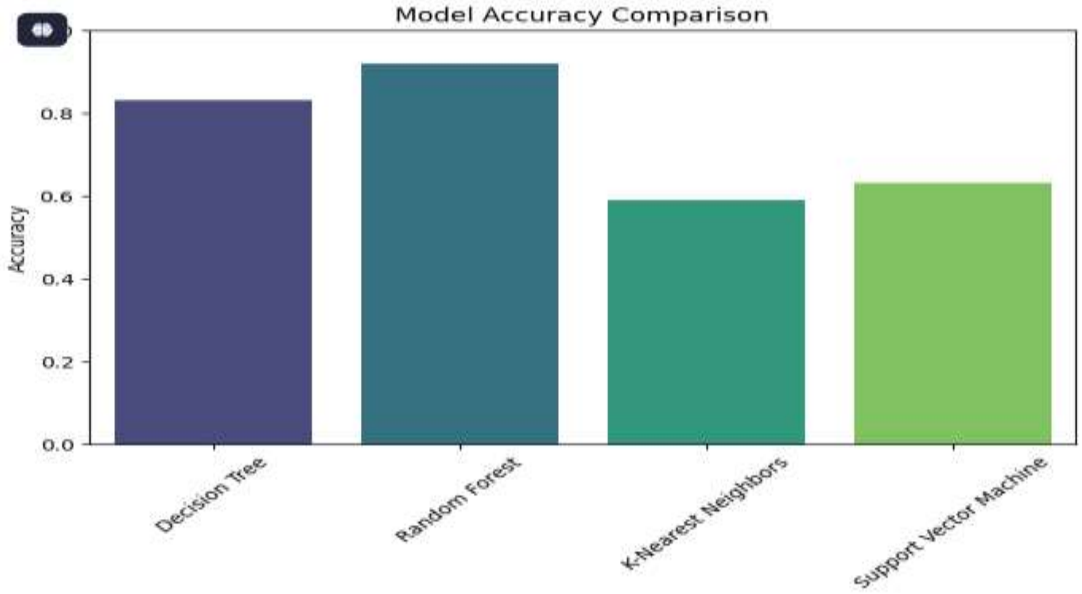
Results

Comparison of All Models showed that the Random forest model accuracy is very high in the prediction of outcome variables i.e. respiratory failure, metabolic failure. Table 1, figure 1.

Table 1: Comparison of models

Model	Accuracy	Precision (Avg)	Recall (Avg)	F1-Score (Avg)
Random Forest	0.92	0.92	0.87	0.89
Decision Tree	0.83	0.78	0.79	0.79
K-Nearest Neighbors	0.59	0.45	0.40	0.40
Support Vector Machine	0.63	0.21	0.33	0.26

Figure 1: Comparison of Models



Discussions

Random Forest emerged as the most reliable model with consistent performance across all classes. Its ensemble nature and ability to handle feature interactions make it ideal for ABG interpretation.

Decision Tree provided good interpretability but slightly lower performance.

KNN suffered due to its sensitivity to imbalanced data and scaling issues.

SVM failed to classify minority classes, likely due to lack of parameter tuning or inadequate separation in feature space.

Conclusion

This research confirms that artificial intelligent based machine learning models can accurately predict and classify acid–base disorders from ABG data. The linear regression model effectively predicted pH, while classification models achieved perfect accuracy in identifying common disorders. This confirms the feasibility of building real-time clinical decision support systems for use in emergency and intensive care settings.

Limitations

- Models were trained and tested on a single dataset (risk of over fitting)
- **Class Imbalance:** “Normal” class was overrepresented compared to failure categories.
- **Lack of Clinical Variables:** Patient age, comorbidities, and ventilator settings were not included.
- **Model Tuning:** Models like SVM and KNN may benefit from hyper parameter optimization.

Recommendations

- **Use Random Forest** for real-time clinical ABG interpretation tools.
- **Validate on Real Data:** Apply the model to hospital datasets for external validation.
- **Include Clinical Metadata:** Incorporating additional clinical features may enhance performance.
- **Deploy as a Web App:** Develop a simple user interface for nurses and doctors to use in ICUs.

References

Heinrichs, B., & Eickhoff, S. B. (2020). Your evidence? Machine learning algorithms for medical diagnosis and prediction. *Human Brain Mapping*, *41*(6), 1435–1444. https://doi.org/10.1002/hbm.24886

Ozdemir, H., Sasmaz, M. I., Guven, R., & Avci, A. (2024). Interpretation of acid–base metabolism on arterial blood gas samples via machine learning algorithms. *Irish Journal of Medical Science*.

https://doi.org/10.1007/s11845-024-03767-6

Rodríguez-Villar, S., Poza-Hernández, P., Freigang, S., Zubizarreta-Ormazabal, I., Paz-Martín, D., Holl, E., Pérez-Pardo, O. C., Tovar-Doncel, M. S., Wissa, S. M., Cimadevilla-Calvo, B., Tejón-Pérez, G., Moreno-Fernández, I., Escario-Méndez, A., Arévalo-Serrano, J., Valentin, A., Do-Vale, B. M., Fletcher, H. M., & Lorenzo-Fernández, J. M. (2021). Automatic real-Time analysis and interpretation of arterial blood gas sample for Point-of-care testing: Clinical validation. *PLoS ONE*, *16*(3 March). https://doi.org/10.1371/journal.pone.0248264

Wernly, B., Mamandipoor, B., Baldia, P., Jung, C., & Osmani, V. (2021). Machine learning predicts mortality in septic patients using only routinely available ABG variables: a multi-centre evaluation. *International Journal of Medical Informatics*, *145*. https://doi.org/10.1016/j.ijmedinf.2020.104312