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ORIGINAL RESEARCH

Evaluation of an AI-Assisted Diagnostic Tool in Differentiating Bacterial and Viral Respiratory Infections in Emergency Care Settings at Patna Medical College and Hospital, Patna

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ABSTRACT

Background: Rapid and accurate differentiation between bacterial and viral respiratory infections is critical in emergency care to ensure appropriate treatment and reduce unnecessary antibiotic use. Conventional diagnostic methods are time-consuming and may lead to empirical antibiotic prescriptions. Artificial Intelligence (AI)-assisted diagnostic tools offer a promising solution by analyzing clinical data to support swift decision-making. This study aims to evaluate the effectiveness of an AI-based diagnostic system in distinguishing bacterial from viral respiratory infections in the emergency department of Patna Medical College and Hospital. **Materials and Methods:**This was a prospective observational study was conducted over 6 months from March 2024 to August 2024 in the Emergency Medicine Department, Patna Medical College & Hospital, Patna. A total of 300 patients presenting with acute respiratory symptoms were enrolled. The AI-assisted diagnostic tool analyzed patient data, including symptoms, vital signs, complete blood counts, C-reactive protein (CRP), and procalcitonin levels. The AI predictions were compared against standard laboratory-confirmed diagnoses (culture, PCR) to assess accuracy, sensitivity, specificity, and diagnostic time. Statistical analysis was performed using SPSS v25. **Results:** Out of 300 patients, 180 cases were confirmed as viral infections and 120 as bacterial infections based on standard diagnostics. The AI tool demonstrated an overall accuracy of **91.3%**, with a sensitivity of **89.2%** for bacterial infections and **92.7%** for viral infections. Specificity was recorded at **94.1%**. The average diagnostic time using AI was **7 minutes**, significantly lower than the conventional diagnostic process (**24 hours**, $p< 0.001$). The AI tool reduced unnecessary antibiotic prescriptions by **38%** compared to routine clinical judgment. **Conclusion:** The AI-assisted diagnostic tool proved to be a reliable and efficient method for differentiating bacterial from viral respiratory infections in emergency care settings. Its high accuracy and rapid processing time suggest potential for improving patient management and promoting antibiotic stewardship. Integration of such AI systems could enhance clinical decision-making, particularly in resource-constrained environments.

Keywords: Artificial Intelligence, Respiratory Infections, Bacterial vs Viral Diagnosis, Emergency Medicine, Diagnostic Accuracy, Antibiotic Stewardship, Clinical Decision Support.

Introduction

Acute respiratory infections (ARIs) remain one of the leading causes of morbidity and mortality worldwide, particularly in emergency care settings where rapid diagnosis is crucial for effective management (1). Differentiating between bacterial and viral etiologies is a significant clinical challenge due to overlapping symptoms such as fever, cough, dyspnea, and fatigue (2). Inaccurate or delayed diagnosis often leads to the overuse of antibiotics, contributing to the growing global threat of antimicrobial resistance (AMR) (3,4). The World Health Organization (WHO) has emphasized the urgent need for strategies that optimize antibiotic use through accurate diagnostic approaches (5).

Traditional diagnostic methods, including microbial cultures, polymerase chain reaction (PCR), and biomarker assessments like C-reactive protein (CRP) and procalcitonin levels, though effective, are often time-consuming, resource-intensive, and not always readily available in emergency settings (6,7). These limitations frequently compel clinicians to rely on empirical treatment decisions, increasing the risk of inappropriate antibiotic prescriptions (8).

Recent advancements in Artificial Intelligence (AI) and machine learning have introduced innovative diagnostic tools capable of analyzing complex clinical data to support rapid decision-making (9). AI-assisted diagnostic systems utilize algorithms trained on large datasets to identify patterns and predict disease etiologies with high accuracy (10). Several studies have demonstrated the potential of AI in differentiating infectious diseases, thereby

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enhancing diagnostic precision and reducing unnecessary interventions (11,12).

In India, where the burden of respiratory infections is substantial and healthcare resources are often constrained, integrating AI-driven diagnostic solutions could play a pivotal role in improving patient care outcomes (13). However, limited data exist regarding the clinical utility and effectiveness of AI-assisted tools in emergency departments within Indian healthcare settings.

This study aims to evaluate the performance of an AI-assisted diagnostic tool in distinguishing bacterial from viral respiratory infections among patients presenting to the emergency department at Patna Medical College and Hospital. By assessing diagnostic accuracy, efficiency, and its impact on antibiotic stewardship, this research seeks to explore the potential of AI in addressing diagnostic challenges in acute care environments.

Materials and Methods

This was a prospective observational study was conducted over 6 months from March 2024 to August 2024 in the Emergency Medicine Department, Patna Medical College & Hospital, Patna.

A total of 300 patients presenting with symptoms of acute respiratory infection, such as cough, fever, sore throat, shortness of breath, and chest discomfort, were enrolled consecutively. Inclusion criteria included patients aged 18 years and above, presenting within 7 days of symptom onset. Patients with known immunosuppressive conditions, chronic respiratory diseases (e.g., COPD, asthma), or recent antibiotic use within the past 72 hours were excluded.

AI-Assisted Diagnostic Tool

The AI diagnostic system used in this study was a machine learning-based clinical decision support tool designed to analyze patient data and predict the likelihood of bacterial versus viral infection. The tool incorporated variables such as patient demographics, clinical symptoms, vital signs, complete blood count (CBC), C-reactive protein (CRP), and procalcitonin levels.

Data Collection Procedure

Upon presentation, clinical data were recorded, and relevant laboratory investigations were performed as per standard emergency care protocols. The AI tool processed this data and provided a diagnostic prediction within minutes. Simultaneously, standard diagnostic methods, including microbial cultures and PCR testing, were conducted to establish definitive diagnoses, which served as the reference standard.

OutcomeMeasures

The primary outcome was the diagnostic accuracy of the AI tool in distinguishing bacterial from viral respiratory infections. Secondary outcomes included sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and time taken for diagnosis. Additionally, the impact on antibiotic prescription rates was assessed.

Statistical Analysis

Data were analyzed using SPSS software version 25. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean ± standard deviation. Diagnostic performance metrics of the AI tool were calculated by comparing its predictions to the reference standard. The difference in diagnostic time between AI and conventional methods was assessed using paired t-tests. A p-value of <0.05 was considered statistically significant.

Results

A total of 300 patients presenting with acute respiratory symptoms were enrolled in the study. The mean age of participants was **42.6 ± 15.3 years**, with **58%** being male and **42%** female.

Based on standard diagnostic methods (culture and PCR), **120 patients (40%)** were confirmed to have bacterial respiratory infections, while **180 patients (60%)** were diagnosed with viral infections.

The AI-assisted diagnostic tool demonstrated a high level of accuracy in differentiating between bacterial and viral infections. The overall diagnostic performance metrics are summarized in **Table 1**.

The AI tool achieved an accuracy of **91.3%**, with a sensitivity of **89.2%** for detecting bacterial infections and **92.7%** for viral infections. Specificity was recorded at **94.1%**.

The average time taken for diagnosis using the AI tool was significantly lower compared to conventional diagnostic methods (**7 ± 2 minutes** vs. **24 ± 3 hours**, $p< 0.001$), as shown in **Table 2**.

Furthermore, the AI tool contributed to a notable reduction in unnecessary antibiotic prescriptions. Among patients with viral infections, empirical antibiotic use was reduced by **38%** when AI support was utilized, compared to routine clinical judgment alone (**Table 3**).

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Table 1: Diagnostic Performance of AI-Assisted Tool Compared to Standard Diagnostics (n = 300)

Parameter	Value (%)
Accuracy	91.3
Sensitivity (Bacterial)	89.2
Sensitivity (Viral)	92.7
Specificity	94.1
PPV (Bacterial)	90.5
NPV (Viral)	93.8

Table 2: Comparison of Diagnostic Time Between AI Tool and Conventional Methods

Method	Mean Diagnostic Time
AI-Assisted Diagnosis	7 ± 2 minutes
Conventional Diagnostics	24 ± 3 hours
p-value	<0.001

Table 3: Impact of AI Tool on Antibiotic Prescription in Viral Infections (n = 180)

Parameter	Without AI (%)	With AI (%)
Antibiotic Prescriptions	65	27
Reduction Rate	—	38

The results clearly indicate that the AI-assisted diagnostic tool provided a significant improvement in diagnostic efficiency and accuracy (Table 1 and Table 2). Moreover, its implementation led to a substantial reduction in inappropriate antibiotic use among patients with viral respiratory infections (Table 3).

Discussion

The findings of this study demonstrate that the AI-assisted diagnostic tool significantly enhances the differentiation between bacterial and viral respiratory infections in emergency care settings. With an overall accuracy of 91.3%, the AI tool outperformed many conventional clinical decision-making approaches, aligning with previous studies that highlight the potential of AI in improving diagnostic precision for infectious diseases (1,2).

Rapid identification of the infection type is critical in emergency departments to guide appropriate therapy and avoid unnecessary antibiotic use (3). Traditional diagnostic methods, although reliable, are time-consuming and may delay treatment decisions (4). In this study, the AI system provided diagnostic outcomes within minutes, significantly reducing the time compared to standard laboratory testing. Similar time-saving benefits of AI-driven diagnostics have been reported in other acute care settings, supporting the integration of such tools to optimize patient flow and management (5,6).

One of the most impactful outcomes observed was the reduction in empirical antibiotic prescriptions among patients with viral infections. The AI tool contributed to a 38% decrease in inappropriate antibiotic use, reinforcing its role in promoting antibiotic stewardship. This is particularly important in countries like India, where antibiotic misuse remains a major contributor to antimicrobial resistance (AMR) (7,8). Prior research has emphasized that decision-support systems integrated with AI algorithms can effectively curb unnecessary antibiotic administration by providing evidence-based diagnostic insights (9,10).

The high sensitivity and specificity observed in this study are consistent with earlier evaluations of AI applications in infectious disease diagnostics (11). Machine learning models trained on large datasets, incorporating clinical and laboratory parameters, have been shown to accurately distinguish bacterial from viral etiologies, thereby enhancing clinician confidence in treatment decisions (12,13). Furthermore, the AI tool's ability to process complex datasets rapidly offers a scalable solution for resource-limited settings, where access to advanced diagnostics may be restricted (14).

However, despite the promising results, certain limitations must be acknowledged. The study was conducted in a single-center setting, which may limit the generalizability of the findings. Additionally, while the AI tool demonstrated high

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accuracy, its performance is dependent on the quality and completeness of input data. Integration with electronic health records and continuous model training using diverse patient populations could further improve its robustness (15).

Future research should focus on multi-center trials to validate these findings across different healthcare environments and patient demographics. Moreover, exploring AI integration with point-of-care diagnostic devices could further enhance real-time decision-making in emergency and primary care settings.

Conclusion

In conclusion, the AI-assisted diagnostic tool proved to be an effective and efficient solution for differentiating bacterial and viral respiratory infections in emergency care. Its implementation not only improved diagnostic accuracy and reduced time but also contributed significantly to rational antibiotic use, addressing a critical aspect of AMR management.

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