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ELECTRONIC STETHOSCOPES IN THE DIAGNOSIS OF HEART DISORDERS: AN INTEGRATIVE REVIEW OF THE EVIDENCE AND CLINICAL APPLICATIONS

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Abstract: Objective: This study aims to review and discuss the advances and applications of electronic stethoscopes in the diagnosis of cardiac conditions, highlighting their benefits, limitations and future potential in medical practice. **Methods:** To carry out this integrative review, a comprehensive search was conducted in the PubMed database, using combinations of specific keywords such as "electronic stethoscope," "cardiac auscultation," "heart sounds," "diagnostic accuracy," and "comparison with acoustic stethoscope." Articles in English or Portuguese that addressed the use of electronic stethoscopes in cardiac auscultation, compared their effectiveness with acoustic stethoscopes and were systematic reviews, cohort studies, case-control studies or case reports were included. After the initial selection of 45 articles, 8 were included in the final review. **Results:** The articles reviewed showed that electronic stethoscopes have significant advantages over traditional stethoscopes, such as noise reduction and improved diagnostic accuracy. The application of acoustic filters allowed electronic sounds to be perceived as acoustic, facilitating doctors' transition to the new technology. The use of artificial intelligence algorithms has improved the identification of cardiac anomalies, with an accuracy of up to 86.9% for heart sounds. **Conclusion:** Electronic stethoscopes represent a significant advancement in cardiac auscultation, offering greater sensitivity and accuracy, especially in noisy environments and for challenging populations. Integration with AI and telemedicine technologies further enhances its clinical applicability, and it is essential to harmonize its acoustic characteristics to maximize acceptance and effectiveness in medical practice.

Keywords: Electronic Stethoscope, Heart Auscultation, Heart Sounds, Diagnostic Accuracy.

INTRODUCTION

The use of a stethoscope is a fundamental pillar in medical practice, especially for lung and heart auscultation. Since its invention, the traditional stethoscope has been an essential tool for evaluating internal sounds and helping to diagnose various conditions. However, the advent of the electronic stethoscope has brought significant advances in the accuracy and effectiveness of auscultation, especially in environments with high background noise, such as air medical transport, or in situations that require greater diagnostic accuracy (SEAH et al., 2023; TOURTIER et al., 2011).

The electronic stethoscope, with its amplified and computer-assisted capabilities, offers a number of benefits compared to traditional models. Studies have shown that these devices not only reduce background noise, but also improve the quality of auscultation, making it easier to diagnose heart and lung conditions. The use of advanced denoising and sound segmentation algorithms enables a more detailed and precise analysis of auscultated sounds, making them a valuable tool for both clinicians and researchers (LENG et al., 2015).

During the COVID-19 pandemic, the relevance of electronic stethoscopes has further increased due to the need for telemedicine and the use of wearable technologies for remote patient monitoring. With the growth of 5G technology and the trend toward smart hospitals, the integration of digital stethoscopes into clinical practice is an essential consideration to improve quality of care and facilitate early diagnosis of lung and heart diseases (SEAH et al., 2023).

This article aims to review and discuss the advances and applications of electronic stethoscopes in the diagnosis of pulmonary disorders, highlighting their benefits, limitations and future potential in medical practice.

METHODOLOGY

To carry out this integrative review, a comprehensive search was conducted in the PubMed database, with the aim of identifying relevant studies on the use of electronic stethoscopes in the diagnosis of cardiac conditions.

The search strategy used combinations of keywords and specific descriptors, such as "electronic stethoscope," "cardiac auscultation," "heart sounds," "diagnostic accuracy," and "comparison with acoustic stethoscope." Articles published in English or Portuguese that addressed the use of electronic stethoscopes in cardiac auscultation, compared the effectiveness of electronic stethoscopes with acoustic stethoscopes, and were systematic reviews, cohort studies, case-control studies or case reports were included. Articles that included populations with comorbidities that could affect the results, studies carried out on animals, studies with inadequate methodology or considered pilots, and publications without access to the full text were excluded.

The initial search resulted in 45 articles. After reading the titles and abstracts, 25 articles were excluded because they did not meet the inclusion criteria. Of the remaining 20 articles, 8 were selected for final review after applying the exclusion criteria. The data extracted from the selected articles were organized in a table, facilitating the comparison and analysis of the information. Data collected included authors and year of publication, study objective, study type and methodology, main results and conclusions, and study limitations. The results of the 8 articles were synthesized and discussed regarding the advantages and disadvantages of electronic stethoscopes compared to acoustic ones, diagnostic accuracy, noise reduction and clinical applicability in different contexts. The integrative review provided a comprehensive understanding of the available evidence on the

use of electronic stethoscopes in the diagnosis of cardiac conditions, offering valuable insights for improving clinical practice and the adoption of new technologies.

RESULTS

The results table summarizes the findings of several studies investigating the use of electronic stethoscopes compared to traditional acoustic stethoscopes in diagnosing cardiac conditions.

DISCUSSION

Rennoll et al. (2021) address one of the main challenges of electronic stethoscopes: the discrepancy in sound characteristics compared to acoustic stethoscopes. The study proposes a filtering method that adjusts sounds captured by electronic stethoscopes so that they sound like those from an acoustic stethoscope. This filtering technique proved effective as medical professionals were unable to distinguish between filtered and acoustic sounds, suggesting that this method may facilitate the acceptance of electronic stethoscopes in clinical practice while maintaining the sound familiarity essential for accurate diagnoses.

Wu et al. (2022) develop an electronic stethoscope integrated with an artificial intelligence (AI)-based classification algorithm for cardiopulmonary sounds. This study highlights how AI technology can improve the accuracy and consistency of diagnoses, overcoming limitations associated with variations in doctors' hearing ability and professional training. With an accuracy of 86.9% for heart sounds, this approach demonstrates that the combination of electronic stethoscopes and AI can significantly improve the identification of cardiac anomalies.

Nowak & Nowak (2018) explore differences in acoustic parameters transmitted by various electronic and acoustic stethoscopes. The findings indicate that these differences can impact diagnostic quality, underscoring the importance of standardizing and improving application guidelines for electronic stethoscopes. This study reinforces the need for methods such as the one proposed by Rennoll et al. (2021) to harmonize the listening experience across devices.

Studies such as that by Huang et al. (2017) and Luo et al. (2022) show the incorporation of advanced technologies into electronic stethoscopes, such as condenser microphones, Bluetooth and intelligent analysis software. These innovations not only improve the quality and analysis of heart sounds, but also facilitate telemedicine and remote teaching, expanding the reach and efficiency of medical care.

Kalinauskienė et al. (2019) and Vörös et al. (2012) compare the sensitivity and specificity of electronic and acoustic stethoscopes. The results indicate a greater sensitivity of electronic devices in detecting regurgitation and heart murmurs, especially in challenging populations such as obese patients and dogs with heart murmurs. These findings reinforce the potential of electronic stethoscopes to improve diagnostic accuracy in complex conditions.

Kamran et al. (2013) demonstrate the feasibility of using electronic stethoscopes to determine heart rate variability (HRV), a critical measure of cardiac autonomic function. The strong correlation found between HRV measurements obtained by electronic stethoscopes and single-lead ECGs suggests that electronics may be a practical and cost-effective tool for cardiac monitoring in clinical and outpatient settings.

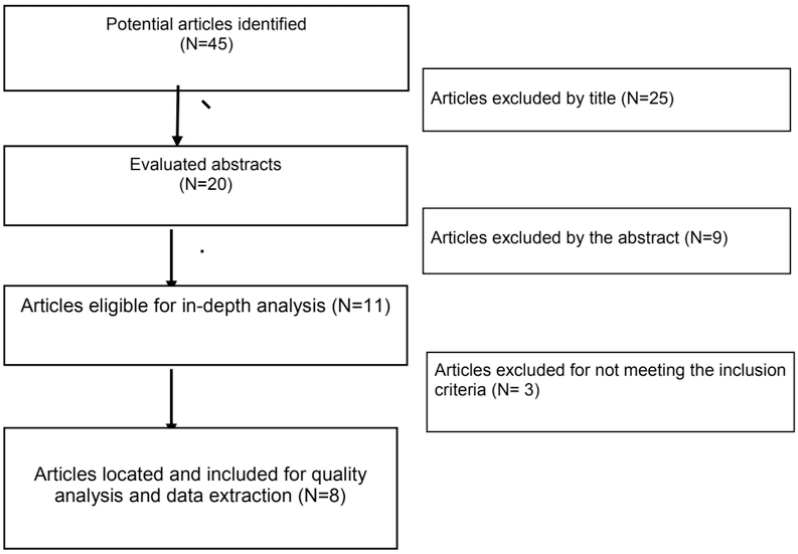

Figure 1.0: Flowchart of the distribution of articles found and selected.

Source: Chagas LJ et al. (2024)

Study	Electronic Stethoscope	Main results
Rennoll et al., 2021	Frequency Response Filter	The proposed filtering method caused electronic sounds to be perceived as acoustic, encouraging the adoption of electronics.
Wu et al., 2022	Condenser microphone and AI	Better accuracy for heart sounds (86.9%) and lung sounds (73.3%); use of segmentation and machine learning.
Nowak & Nowak, 2018	Four models tested	Significant differences in acoustic characteristics between stethoscopes, impacting diagnostic quality.
Huang et al., 2017	Condenser microphone and Bluetooth	Integrated system with Bluetooth and real-time analysis, promoting hospital use and teaching.
Luo et al., 2022	Smartphone (iPhone)	80% of users achieved good quality recordings; Age can affect quality, hardware does not.
Kalinauskienė et al., 2019	3M Littmann 3200	Greater electronic sensitivity for regurgitation (60.1% vs. 45.7%); high specificity for both.
Vörös et al., 2012	Welch Allyn Meditron	Better electronic sensitivity in detecting heart murmurs in dogs; high agreement between observers.
Kamran et al., 2013	Electronic stethoscope	HRV measurements correlated strongly (ICC 0.73-1.0) between methods; promising electronic device for HRV in hospital.

Table 1.0: Studies used in the integrative review on the use of the stethoscope in the clinical diagnosis of pediatric conditions

Source: Chagas LJ et al. (2024)

FINAL CONSIDERATIONS

The studies reviewed highlight the significant advantages of electronic stethoscopes in diagnosing cardiac conditions, including improved sensitivity, noise reduction, and integration with advanced AI and telemedicine technologies. However, the transition to these devices requires approaches that harmonize acoustic characteristics and maximize clinical acceptance. The combination of technological advances with robust methodologies can transform the practice of cardiac auscultation, improving patient outcomes and diagnostic efficiency.

REFERENCES

HUANG, M.; LIU, H.; PI, X.; AO, Y.; WANG, Z. Zhongguo yi liao qi xie za zhi. **Zhongguo Yi Liao Qi Xie Za Zhi**, v. 41, n. 3, p. 161-165, 2017.

KALINAUSKIENĖ, E.; RAZVADAUSKAS, H.; MORSE, D. J.; MAXEY, G. E.; NAUDŽIŪNAS, A. Uma comparação de estetoscópios eletrônicos e tradicionais na auscultação cardíaca de pacientes obesos. **Medicina (Kaunas)**, v. 55, n. 4, p. 94, 2019.

LENG, S.; TAN, R. S.; CHAI, K. T.; WANG, C.; GHISTA, D.; ZHONG, L. The electronic stethoscope. **Biomed Eng Online**, v. 14, p. 66, 2015.

LUO, H.; LAMATA, P.; BAZIN, S.; et al. Smartphone como estetoscópio eletrônico: fatores que influenciam a qualidade do som do coração. **Eur Heart J Digit Health**, v. 3, n. 3, p. 473-480, 2022.

NOWAK, L. J.; NOWAK, K. M. Sound differences between electronic and acoustic stethoscopes. **Biomed Eng Online**, v. 17, n. 1, p. 104, 2018.

RENNOLL, V.; MCLANE, I.; EMMANOUILIDOU, D.; WEST, J.; ELHILALI, M. Electronic stethoscope filtering mimics the perceived sound characteristics of acoustic stethoscope. **IEEE J Biomed Health Inform**, v. 25, n. 5, p. 1542-1549, 2021.

SEAH, J. J.; ZHAO, J.; WANG, Y.; LEE, H. P. Review on the advancements of stethoscope types in chest auscultation. **Diagnostics (Basel)**, v. 13, n. 9, p. 1545, 2023.

TOURTIER, J. P.; FONTAINE, E.; COSTE, S.; et al. In flight auscultation: comparison of electronic and conventional stethoscopes. **Am J Emerg Med**, v. 29, n. 8, p. 932-935, 2011.

VÖRÖS, K.; BONNEVIE, A.; REICZIGEL, J. Comparison of conventional and sensor-based electronic stethoscopes in detecting cardiac murmurs of dogs. **Tierarztl Prax Ausg K Kleintiere Heimtiere**, v. 40, n. 2, p. 103-111, 2012.

WU, Y. C.; HAN, C. C.; CHANG, C. S.; et al. Development of an electronic stethoscope and a classification algorithm for cardiopulmonary sounds. **Sensors (Basel)**, v. 22, n. 11, p. 4263, 2022.

KAMRAN, H.; NAGGAR, I.; ONIYUKE, F.; et al. Determinação da variabilidade da frequência cardíaca com um estetoscópio eletrônico. **Clin Auton Res**, v. 23, n. 1, p. 41-47, 2013.