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**EDITORIAL**

# Can artificial intelligence-assisted auscultation become the Heimdallr for diagnosing congenital heart disease?

**Yanqiu Ou***

Department of Epidemiology, Guangdong Cardiovascular Institute, Guangdong Provincial Key Laboratory of South China Structural Heart Disease, Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences, #96 Dongchuan Road, Guangzhou 510080, China

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**This editorial refers to 'Artificial intelligence-assisted auscultation in detecting congenital heart disease', by J.J. Lv *et al.*, on page 119.**

Timely detection is crucial for the survival and prognosis of congenital heart disease (CHD) patients. Without timely diagnosis and treatment, approximately one-third of children with CHD would die within the first year after birth.[1] With the development and wide use of foetal echocardiography and echocardiography examination in neonates, more and more CHD, especially the complex and critical CHD are detected prenatally or in very early life.[2] However, these technologies cannot be used as a screening tool in the general population due to the high medical cost and time consumption. This is especially challenging in the undeveloped regions or geographic remote areas, which is a lack of medical resources and specialized personnel.

A combination of cardiac auscultation and oxygen saturation has been reported as an essential and effective procedure for CHD screening in neonates in China.[3] Therefore, we need 'Heimdallr' (the patron saint of Rainbow Bridge in Norse mythology, who could hear the grass growing in the meadows and wool growing on sheep) in our clinical practice and large-scale screening for CHD. A traditional cardiac auscultation is highly relied on the skilled 'ears' and clinical expertise on cardiac pathology. It usually requires extensive training for some primary care physicians to identify a heart murmur accurately. The training process is also time-consuming and involves a lot of effort and resources,[4] which therefore undermines the utility and proficiency of traditional auscultation in the low-resource settings with a shortage of trained cardiologists.[5] Previous study found that the missed diagnosis rate of severe CHD before discharged from birth hospital was 71% in the maternal hospitals in Eastern China.[6]

With the development of artificial intelligence (AI) technology, its application in the medical field is becoming more and more extensive. The electronic stethoscope combined with AI technology has realized the digital acquisition of heart sounds and intelligent identification of pathologic murmur, which makes early detection and screening of CHD possible. Artificial intelligence-assisted auscultation (AI-AA) is hopefully to become the 'Heimdallr' for CHD patients.

Lv *et al.*[7] presented the 'AI-AA platform', with the aim of evaluating the accuracy of auscultations of abnormal heart sounds of an AI-AA platform they created in Shanghai Children's Medical Center. The authors initially enrolled 1397 operative patients with CHD and finally included 1362 patients in the analysis. The author's approach proceeded in three steps. First, the samples of the operative patients' heart sounds were recorded and uploaded to the platform using a digital stethoscope. Secondly, both remote auscultation by a team of experienced cardiologists from Shanghai Children's Medical Center and automatic auscultation of the heart sound samples were conducted by the platform. Thirdly, the results of remote auscultation and AI-AA were compared to experts' face-to-face auscultation. The sensitivity, specificity, and accuracy were calculated, as well as the Kappa coefficients were measured. The authors found that compared to face-to-face auscultation, AI-AA demonstrated 97% sensitivity, 89% specificity, 96% accuracy, and kappa coefficient 0.84.

This work represents a feasible way to screen CHD with AI-AA in a large-scale clinical practice and the general population in a cost-effective way. Despite the emerging interest in using AI for automated interpretation of echocardiograms, the complex anatomic variation present in CHD will prove a more challenging target for image-based AI interpretation, at least in the short term.[5] Therefore, echocardiography seems to be less attractive for large-scale population screening compared to acoustic-based strategies currently.[5]

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* Corresponding author. Email: ouyanqiu@gdph.org.cn

Moreover, the proficiency of AI-AA is supposed to improve and surpass the performance of experts or physicians, if they can be fed with enough validated dataset of heart sound recording, considering the bias that the experts or physicians has already known the clinical features of the patient before the auscultation in the study. Last but not least, the AI-AA is also beneficial for educating and training primary care physicians to grasp the auscultation skills by repeatable practice with the same case and condition, which could not be realized through the unrepeatable face-to-face auscultation.

However, to become the Heimdallr for diagnosing CHD, there are still some problems to be overcome for AI-AA. First, to acquire a high diagnostic accuracy of CHD, the improvement of AI algorithms is crucial. There are many kinds of noise interference in the clinical heart sound signal collection process, especially the crying of infants and young children, which poses challenges to the segmentation and classification algorithms, and ultimately affects the recognition accuracy of the algorithm. Despite that researchers have proposed a series of denoising algorithms for the environmental noise, such as using band-pass filter or wavelet denoising,[4,8,9] algorithm should be improved to filter out the noise and detect abnormal heart sounds with high accuracy. Secondly, the development and testing of AI-AA algorithms are hindered due to the lack of a validated dataset of heart sound recordings, especially those are in high-quality, standardized, and accompanied with detailed clinical and echocardiographic information for each case. Therefore, it is recommended to organize experts to form a consensus, establish a standardized and authoritative heart sound dataset, standardize the heart sound collection process, clarify the data distribution of the heart sound dataset, and unify the diagnostic criteria for CHD based on heart sound characteristics. Thirdly, the previous studies were limited to a small sample size[5,6] and has not been validated in the population. Further validation of large-scale clinical applications and general population screening, especially in neonates screening before discharge, are essential.

Overall, Lv *et al.* are to be congratulated for taking an important step towards CHD screening. It is promising that AI-AA will become the Heimdallr to detect CHD in clinical practice and a large-scale general population in a cost-effective and reliable way. However, AI-AA to screen for CHD is likely to be most effective as a decision support tool and should be used in combination with other clinical features.

**Conflict of interest**: none declared.

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