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Data for AI in Congenital Heart Defects: Systematic Review

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Abstract. Congenital heart disease (CHD) represents a significant challenge in prenatal care due to low prenatal detection rates. Artificial Intelligence (AI) offers promising avenues for precise CHD prediction. In this study we conducted a systematic review according to the PRISMA guidelines, investigating the landscape of AI applications in prenatal CHD detection. Through searches on PubMed, Embase, and Web of Science, 621 articles were screened, yielding 28 relevant studies for analysis. Deep Learning (DL) emerged as the predominant AI approach. Data types were limited to ultrasound and MRI sequences mainly. This comprehensive analysis provides valuable insights for future research and clinical practice in CHD detection using AI applications.

Keywords. Congenital Heart Disease, Prenatal Care, Artificial Intelligence, Deep Learning, Machine Learning, Standards, Interoperability

1. Introduction

Congenital heart diseases (CHD) are one of the most common organ specific birth defects [1]. Early and accurate prenatal detection is crucial for peri- and postnatal outcomes, as well as appropriate counselling for the expecting parents. Artificial Intelligence (AI), along with its subsets Machine Learning (ML) and Deep Learning (DL), has the potential to improve prediction of CHDs. This systematic review aims to investigate the current state of prenatal AI applications in CHD detection and the underlying data, with the ultimate goal of improving prenatal detection rates.

2. Methods

We performed a systematic review in line with the PRISMA [2] Guidelines. The literature search was executed in PubMed, Embase and Web of Science using keywords answering our research questions according to the PICO format [3]. Only original English articles focusing on AI for CHD detection were included. Information was

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collected on the accuracy of each algorithm as well as data source, standards, and bias protection mechanisms. Rayyan was employed for data management purposes.

3. Results

After removing 222 duplicates, 399 articles were screened by abstract/title, leaving 79 for full-text screening. In total, 28 articles were included in our analysis.

Most studies used DL (79%, n=22) while the rest employed ML (18%, n=5), or both (3%, n=1). Among the papers, the majority used Convolutional Neural Networks (CNNs) (25%, n=7) to detect CHDs, which followed by Residual Networks (ResNET) (14%, n= 4). The third most used algorithm was Yolo (11%, n=3). The majority of data came from one center only (75%, n=21). Ultrasound images (54%, n=15) were the most common, followed by Ultrasound video images (18%, n=5) and MRI images (11%, n=3). Less than half of the studies (43%, n=12) mentioned any standards, with DICOM being the most frequent one.

4. Discussion

Our analysis highlights the prominence of DL in prenatal CHD detection. Which can be explained by the continuous development of DL as a decision-making tool, able to outperform humans. Ultrasound images are frequently used in prenatal care and because image data is useful for training AI models, this creates a dependency on these images and therefore their quality and quantity [4]. The widespread utilization of data from a single center may generate bias and small samples, highlighting the necessity of multi-center cooperation. In order to guarantee data consistency and model generalizability, more standardized procedures are required, as evidenced by the low adherence to standards like DICOM. By addressing these problems, AI models for prenatal CHD detection may become more robust and clinically applicable.

5. Conclusion

Currently, AI applications derive from imaging data from a single center, leaving out clinical data, which plays a pivotal role in accurate prenatal CHD prediction. Therefore, this study shows a necessity for collaborative standardized datasets for AI in this field.

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