

# Identification of abdominal ECG lead location over fetal development for non-invasive single channel W-NETR fetal ECG extractor

## I. INTRODUCTION

To enhance real-time usability, significant efforts have been made to develop algorithms enabling fECG extraction from a single non-invasive abdominal ECG lead [1]. Despite the accuracy achieved by these single-lead extraction models, their performance is heavily influenced by the precise location of the abdominal lead, impacting the quality of the input signal and its practical implementation. Our recent study [1] employed transformer-based deep learning techniques to extract fECG from a single maternal abdominal input. While this method demonstrated high extraction accuracy on well-known datasets like ADFECGDB and PCDB, it performed poorly with specific abdominal leads, such as channel 3 in most instances of the PCDB dataset.

This discrepancy raises a critical question: What is the optimal abdominal ECG lead placement for achieving the most accurate fECG extraction in single-channel extraction systems? And could this placement depend on fetal development?

## II. METHOD OVERVIEW

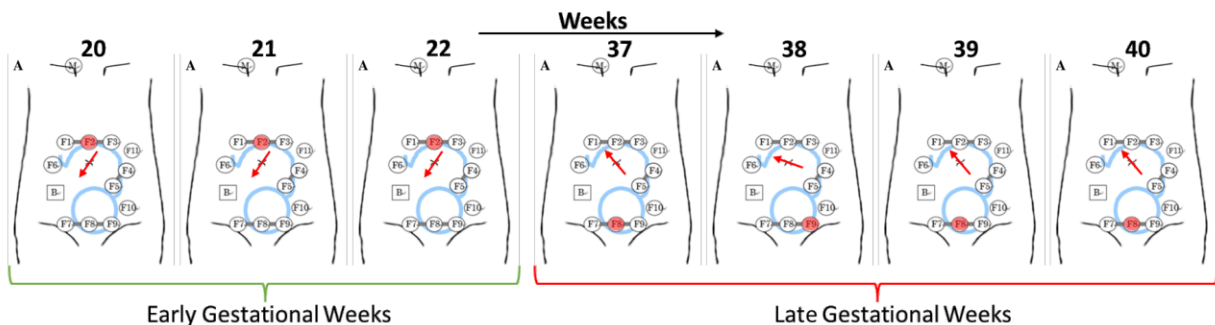
To address this query, we utilized real data extracted from the 11 abdominal ECG lead device presented by Doshi et al. covering gestational periods between 20-22 and 37-40 weeks. This exploration marks the first attempt to investigate the ideal abdominal ECG lead location for accurate fECG extraction across fetal development in utero. Leveraging our W-NETR pipeline proposed in our previous work [1], we extracted the fECG signal from each of the 11 abdominal signals in the dataset and compared them against the provided ground truth fECG signal over early and late gestational weeks. The structural similarity index (SSIM) [2], [3] was utilized to gauge the similarity between the extracted signal and the ground truth, aiding in identifying the prime lead location for optimal fECG extraction over fetal development using fast and user-friendly single-lead extraction systems.

## III. RESULTS

The final findings are visually represented in Figure 1, which illustrates the best abdominal ECG lead location for accurate fECG extraction throughout the chosen gestational weeks. Additionally, it reveals the generally superior two-dimensional vector direction for improved extraction, considering that the reference lead (annotated as "B") is positioned on the mother's back. These results underscore that during the early stage of gestational weeks (between 20-22), the optimal lead location is situated in the upper part of the mother's abdomen. Conversely, in the later stages of pregnancy, the optimal lead location shifts to the lower part.

## REFERENCES

- [1] Murad Almadani, Leontios Hadjileontiadis, and Ahsan Khandoker. One-dimensional w-netr for non-invasive single channel fetal ecg extraction. *IEEE Journal of Biomedical and Health Informatics*, 2023.
- [2] Alan C Bovik, Hamid Rahim Sheikh, Eero P Simoncelli, and Z Wang. Image quality assessment: From error visibility to structural similarity. *IEEE Transactions on Image Processing*, 13(4):600–612, 2004.
- [3] Dominique Brunet, Edward R Vrscaj, and Zhou Wang. On the mathematical properties of the structural similarity index. *IEEE Transactions on Image Processing*, 21(4):1488–1499, 2011.



**Fig. 1:** Visualization of the optimal abdominal ECG lead location for precise fECG extraction across the selected gestational weeks. The red arrow represents the two-dimensional vector direction aimed at enhancing extraction, taking into account that the reference lead (marked as "B") is situated on the mother's back.