Fetal arrhythmia detection in non-invasive heart rate recordings: a case report

G.J.J. Warmerdam, R. Vullings, S.G. Oei, P.F.F. Wijn
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   - Non-invasive fetal electrocardiogram
   - Extract fetal heart rate
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Fetal Arrhythmias
- Occurs in 2% of all pregnancies
- Account for up to 20% of the referrals to fetal cardiologists
- Irregular heart rhythms, tachycardia (>180BPM), bradycardia (<100BMP)

Premature atrial contraction (PAC)
- Contraction that originates in the atria, but not at the sinoatrial-node
- Isolated PACs are not associated with fetal distress (no treatment required)
Fetal arrhythmias

Arrhythmia monitoring
- Doppler ultrasound (M-mode imaging, pulsed-wave Doppler, tissue-Doppler)
- Uns suited for long-term continuous monitoring:
  - Manually performed
  - Fetal orientation
  - Susceptible to movement
  - Transmits energy into the body

Additional information: non-invasive fetal ECG
- Continuous monitoring
- Beat-to-beat heart rate
- ECG-waveform morphology

Goal
Show the potential of non-invasive fetal ECG for prolonged recording of arrhythmias
Non-invasive fetal ECG

Schematic electrode configuration

Maternal ECG

Fetal ECG

Fetal HR?
Extract fetal heart rate

1. Raw signal

2. Fetal ECG

3. Enhanced fetal ECG

4. Beat-to-beat heart rate
Heart rate based PAC detection

PAC classification
1. Instantaneous RR ($RR_i$) < 85% of average RR
2. Next RR ($RR_{i+1}$) >115% of $RR_i$

Example PAC

RR = time between R-peaks, not BPM!
Results case study

Case:
Recording 45 minutes, gestational age: 24+1

Annotation:
• # 6376 ECG complexes
• # 371 PACs

Performance algorithm

Sensitivity (Se):

\[ Se = \frac{TP}{TP + FN} \times 100\% \]

TP = # True-Positives
FN = # False-Negatives
FP = # False-Positives

Positive-Predictive-Value (PPV):

\[ PPV = \frac{TP}{TP + FP} \times 100\% \]
Results

• **Sensitivity: 91%**
  - Most PACs are detected

• **Positive-Predictive-Value: 92%**
  - Only a few ECG complexes are misclassified as a PAC
Discussion & conclusions

Case study
- The non-invasive fetal ECG can be used for detection of fetal arrhythmia
- Reduced performance near artifacts

To do
- Further validation of PAC detection
- Extent to different types of arrhythmias
- Use ECG-waveform information
Contact: g.j.j.warmerdam@tue.nl