

Automated detection of premature atrial contractions in non-invasive fetal heart rate recordings : a case report

Citation for published version (APA):

Warmerdam, G. J. J., Vullings, R., Oei, S. G., & Wijn, P. F. F. (2014). Automated detection of premature atrial contractions in non-invasive fetal heart rate recordings : a case report. In *Proceedings of the 3rd International Congress on Cardiac Problems in Pregnancy, February 20-23, 2014, Venice, Italy*

Document status and date:

Published: 01/01/2014

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

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

TU / **e**

Technische Universiteit
Eindhoven
University of Technology

Where innovation starts

Contents

1. Fetal arrhythmias

2. Methodology:

- Non-invasive fetal electrocardiogram
- Extract fetal heart rate
- Heart rate based detection of premature atrial contractions

3. Results

4. Discussion & conclusions

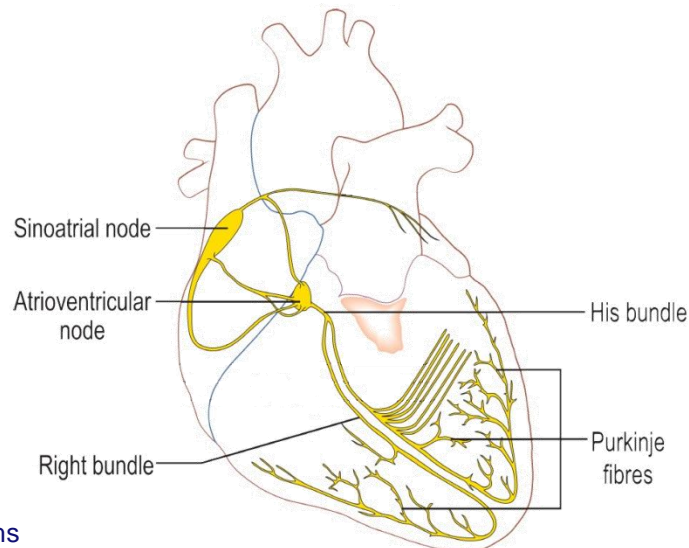
Fetal arrhythmias

Fetal Arrhythmias

- Occurs in 2% of all pregnancies
- Account for up to 20% of the referrals to fetal cardiologists
- Irregular heart rhythms, tachycardia ($>180\text{BPM}$), bradycardia ($<100\text{BPM}$)

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)
- Unsited for long-term continuous monitoring:
 - Manually performed
 - Fetal orientation
 - Susceptible to movement
 - Transmits energy into the body

Additional information: non-invasive fetal ECG

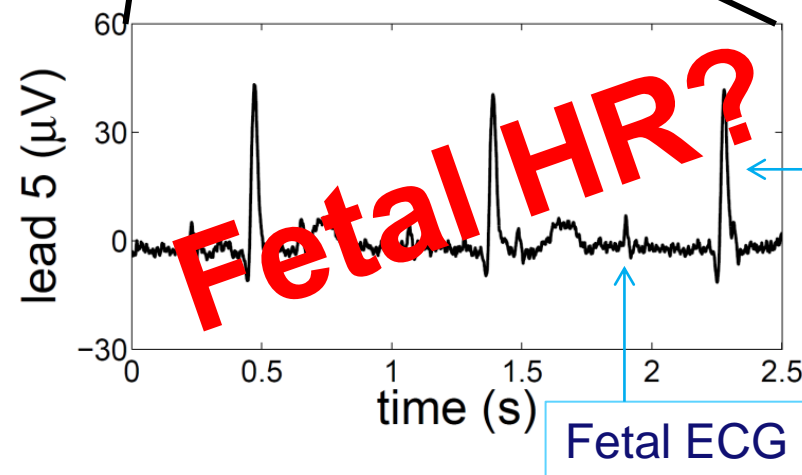
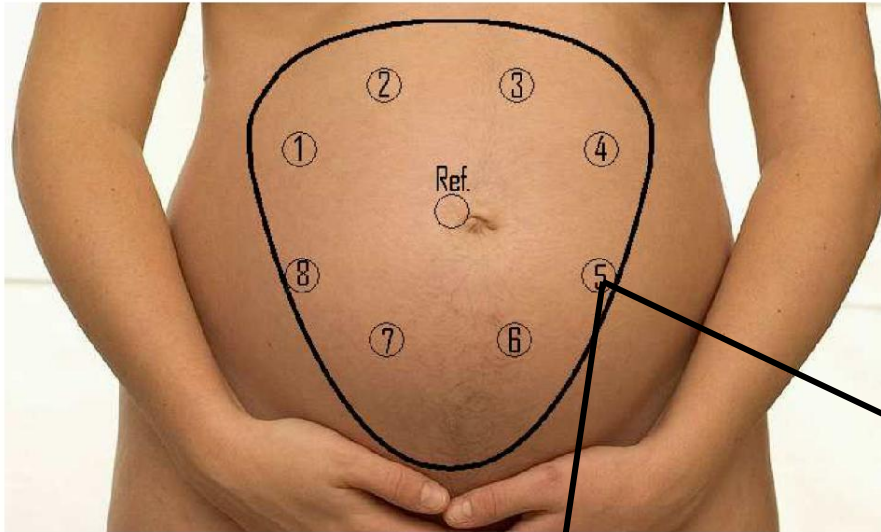
- Continuous monitoring
- Beat-to-beat heart rate
- ECG-waveform morphology

Goal

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

Non-invasive fetal ECG

Schematic electrode configuration

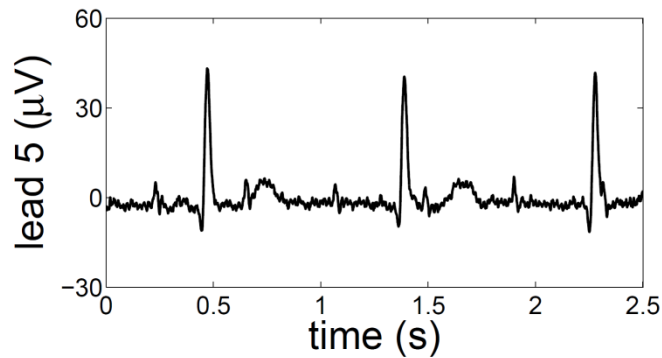


Maternal ECG

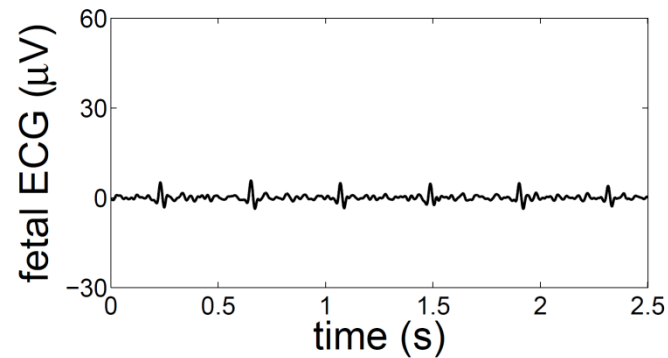
Fetal ECG

Extract fetal heart rate

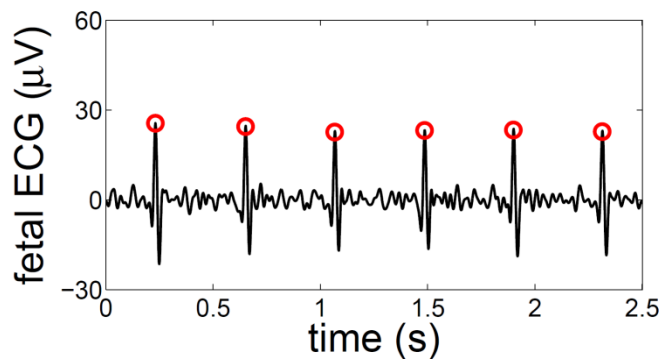
1. Raw signal



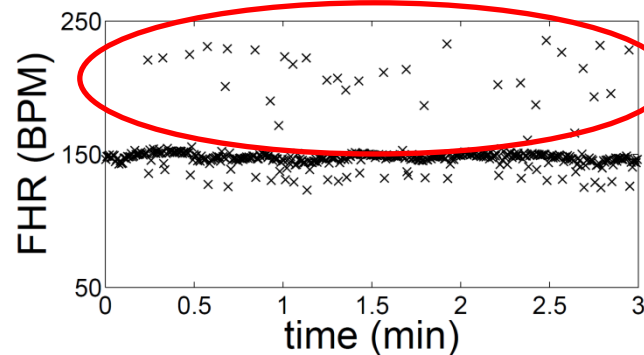
2. Fetal ECG



3. Enhanced fetal ECG



4. Beat-to-beat heart rate



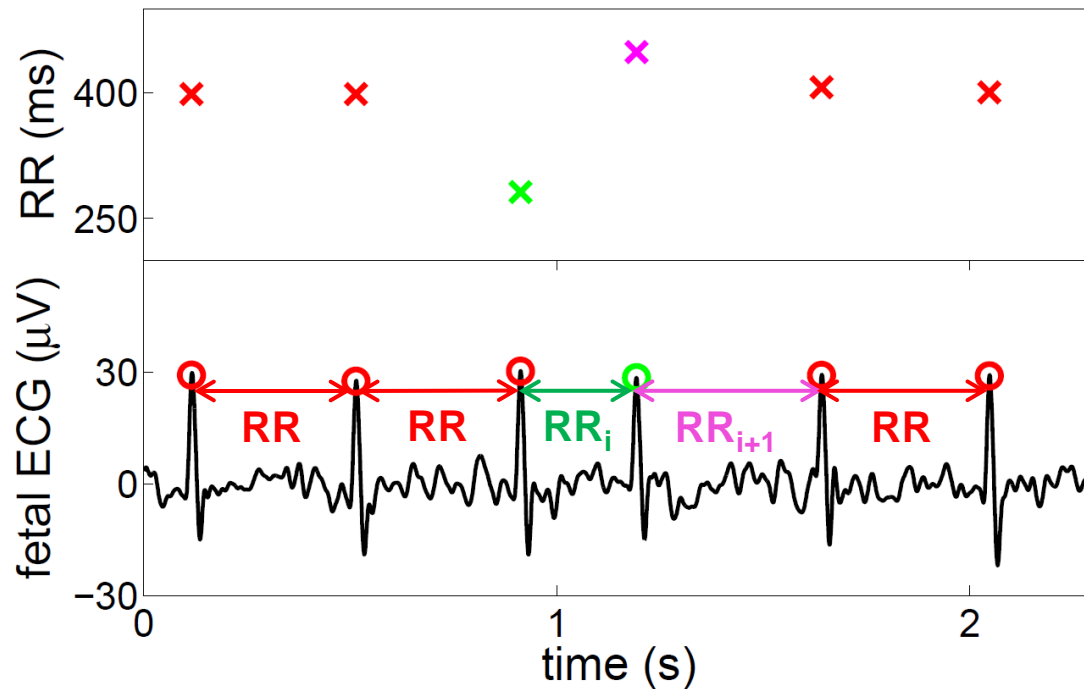
PACs

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):

$$Se = \frac{TP}{TP + FN} 100\%$$

TP = # True-Positives

FN = # False-Negatives

FP = # False-Positives

Positive-Predictive-Value (PPV):

$$PPV = \frac{TP}{TP + FP} 100\%$$

Results

- Sensitivity: **91%**
 - Most PACs are detected
- Positive-Predictive-Value: **92%**
 - Only a few ECG complexes are misclassified as a PAC

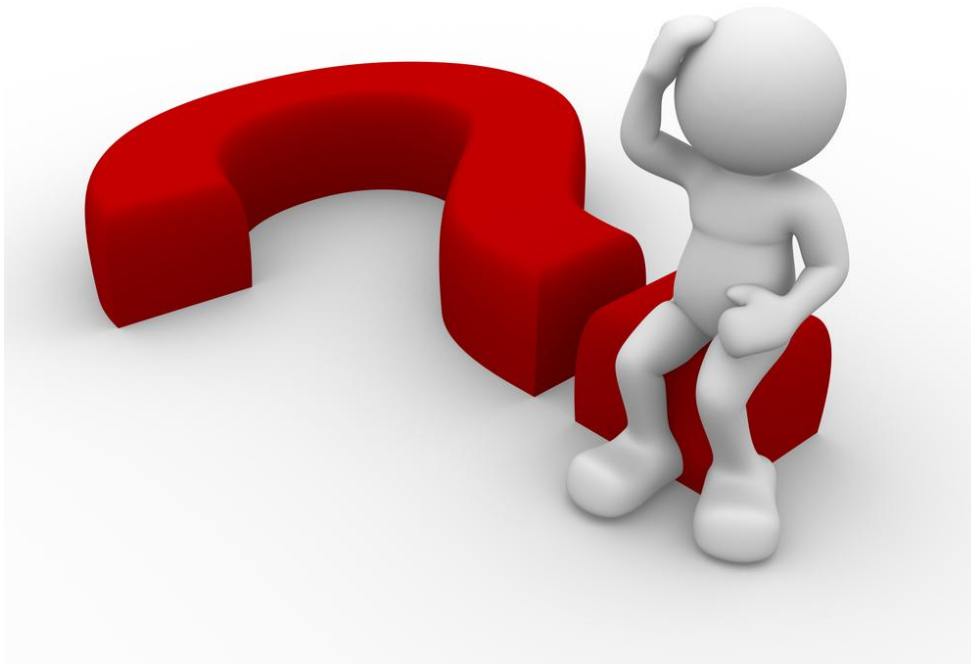
Discussion & conclusions

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