Do Maternal Emotional Reactions Influence the Fetus in Real-Time?

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Introduction

There is convincing evidence that maternal stress, depression and anxiety have negative programming effects on fetal neurodevelopment and birth outcomes but the mechanisms are not well defined. The autonomic nervous system (ANS) regulates maternal physiologic reactions to unpleasant conditions or perceived threat or by altering sympathetic and parasympathetic input but there is limited evidence that the fetus responds to maternal emotional or autonomic state in real-time.

Specific Aim: To determine if maternal autonomic reactivity induces a similar response in the fetus. If confirmed, the results would support a model of *in utero* programming, suggest underlying mechanisms by which maternal stress affects child outcomes, and support early assessment and interventions for maternal mental health.

Methodology

Figure 1: Left; Subject enrollment and study procedures. Middle; Fetal biomagnetometer. Right; Raw data before (A.) and after (B.) ICA decomposition to extract maternal and fetal signals.

When women were between 30-32 weeks gestation, simultaneous maternal-fetal magnetocardiograms (MCG) were recorded while women viewed a series of photos with validated emotional valence that ranged from neutral, pleasant, unpleasant and threatening. See Figure 2 for examples and design of the 30 minute test.

Simultaneous maternal-fetal biomagnetometry was recorded and subjected to independent component analysis (ICA) to extract and separate maternal and fetal MCGs and other fetal signals, e.g., breathing movements, Figure 1, right.

The MCGs were processed in Kubios software to calculate metrics of heart rate (HR), and variability (HRV) in time, frequency, and nonlinear domains. Time-frequency plots were used to assess maternal and fetal autonomic reactivity.

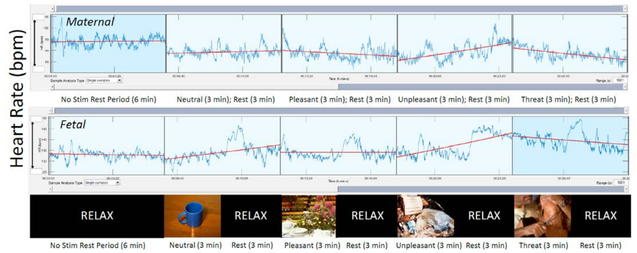

Figure 2: The test protocol is explained in the bottom panel, pictures are single examples representing each category. Upper panel; maternal and fetal HR during baseline and viewing. Red lines represent HR trend during each viewing period.

Results

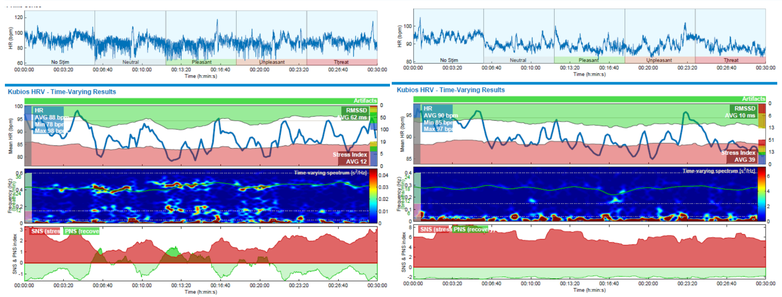

Figure 3a. Typical maternal ANS response with increased vagal input during neutral and pleasant pictures and increased sympathetic input during unpleasant and threatening pictures. (Subject A)

Figure 3b. Atypical maternal ANS response with chronic hyper-sympathetic response, low ANS reactivity, high stress index, and reduced sympatho-vagal interaction. (Subject B)

Examples of Maternal-Fetal HR Change from Baseline While Viewing

To calculate the change induced by viewing the stimuli, the mean maternal and fetal HR of each picture category was subtracted from mean baseline HR. (Fig. 4) If the fetus reacts to maternal ANS response, we expect to see similar patterns in HR and HRV between mother and child as the mother views the pictures.

We do not expect to see the type of parasympathetic-sympathetic interaction in the fetus as we see in the mother. The parasympathetic system begins to exert influence on fetal HR and HRV at the gestational age tested (30-32 weeks). However, the ANS in the fetus, infant and child is dominated by the sympathetic system.

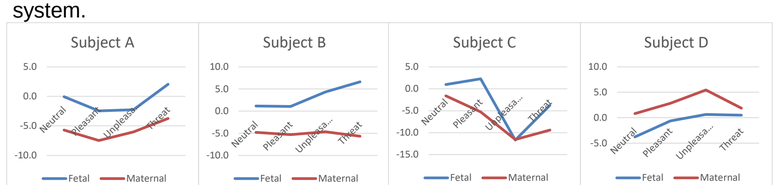

Figure 4. Difference between stimulus HR and baseline HR in women and their fetus while women are viewing pictures.

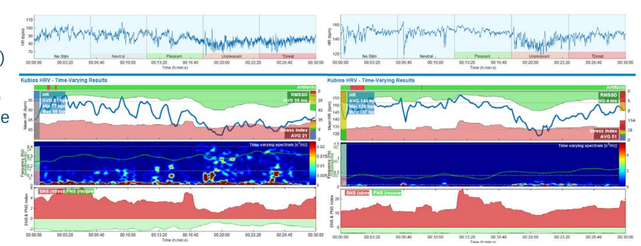

Figure 5. Maternal (left) and fetal (right) showing increased vagal input (arrows) to unpleasant picture viewing. Note fetal response mirrors maternal response. (Subject C)

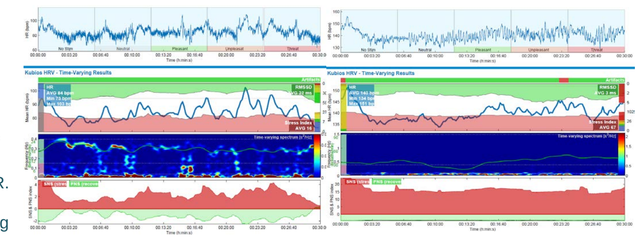

Figure 6. Maternal (left) and fetal (right). Maternal HR and sympathetic drive increases with negative valence of pictures. Fetal HR mirrors maternal HR. Fetal breathing movements resulting in increased vagal drive occur at initiation of unpleasant pictures, note lower HR during threatening pictures. (Subject D)

Conclusion

These data establish a link between maternal and fetal ANS reactivity that occurs while women view pictures designed to evoke emotional responses. These data support our hypothesis and suggest that maternal emotion and physiologic reactions related to stress, depression, anxiety and threat may have a direct effect on the autonomic reactivity and neurodevelopment of the fetus.

Simultaneous maternal-fetal biomagnetometry and use of metrics to characterize autonomic reactivity and fetal neurobehaviors may identify at-risk patients and could lead to a better understanding of underlying physiologic mechanisms that lead to poor fetal and infant outcomes. Multidisciplinary research is needed to understand biological, psychological and social risk factors. Interventions should begin early in gestation and include long-term follow up in order to benefit women and the next generation.

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