The Right Study – A Pilot Study to Evaluate Right Heart Function During Pregnancy

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Abstract: During pregnancy the maternal heart undergoes significant physiological change. Technological advancements in echocardiography (echo) have improved our ability to assess the right heart in detail and yet there is little research into adaptation during pregnancy. In this pilot study, we considered how three measures of right heart function changed in normal women from the 1st trimester through to the post-partum period. We observed a significant increase in tricuspid annulus planar systolic excursion (TAPSE) and right ventricular systolic velocity (RV S') from the 1st to the 2nd trimester; both measures of longitudinal right ventricular function. There was no significant difference in right ventricular systolic area change, which is more difficult to accurately measure, and reflects radial function. TAPSE and RV S' are easy to accurately measure with modern echo technology. This pilot study suggests that any reduction in these values from the 1st to the 2nd trimester should prompt more detailed assessment, and correlation with clinical symptoms. It would be valuable to undertake a comprehensive study to define normal ranges for common measures of right ventricular function, using echo, during pregnancy. The ability to assess the right heart, with an understanding of expected normal values, has the potential to significantly improve our understanding and management of maternal cardiovascular disease.

Keywords: Pregnancy, Right heart, Cardiovascular, Echocardiography, TAPSE.

INTRODUCTION

Pregnancy demands major changes in the maternal cardiovascular system, which starts with systemic vasodilation as early as 5 weeks gestation, before the uteroplacental circulation is complete [1, 2]. The increase in maternal cardiac output is most apparent in the first trimester and continues to increase until the second trimester when it plateaus and is maintained into the third trimester. Echocardiography has most frequently been used to document the increase in cardiac output by imaging the left heart. In contrast, how the right ventricle adapts to pregnancy has not been systematically investigated. This paucity of data relates to historical difficulties in objectively evaluating right ventricular function that have largely been abolished by advances in image quality and imaging techniques. Understanding changes in echo parameters in normal women is important when using these to assess women with cardiac decompensation in pregnancy, as cardiac disease remains a leading cause of maternal death in western countries [3, 4]. The aim of this study was to assess serial change in the right ventricle with echocardiography as pregnancy advanced, using three parameters of right ventricular function.

METHODS

The study protocol was approved by the local ethics committee. Twenty-four women, with no prior cardiac history and a singleton pregnancy, were recruited from the antenatal clinic at the Royal Sussex County Hospital in Brighton over an 18-month period. All women were able to give written, informed consent and were recruited by a research nurse. Routine data were recorded including: age, smoking status, past medical history and obstetric history. Echocardiograms were undertaken at 12 weeks gestation (1st trimester), 24 weeks (2nd trimester), 36 weeks (3rd trimester) and 3 months post-partum. Data were entered onto a dedicated database.

Echo Protocol

All studies were undertaken by a senior, British Society of Echocardiography (BSE) accredited, sonographer using a Philips IE33 ultrasound machine. Studies were performed in the left lateral decubitus position, after a rest period. The initial 1st trimester

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echocardiogram was performed according to BSE minimum dataset [5] and included 3D assessment of the left ventricle. Figure **1** demonstrates one of the common views, from which detailed left and right heart assessments can then be made. Right ventricular function was evaluated using M-mode to assess tricuspid annulus planar systolic excursion (TAPSE) from which an ejection fraction was calculated (TAPSE x 3.2) [6], tissue Doppler imaging to assess tricuspid lateral annulus peak systolic velocity (RV S' wave) [7] and 2D imaging to measure right ventricular systolic area change by assessing diastolic and systolic areas.

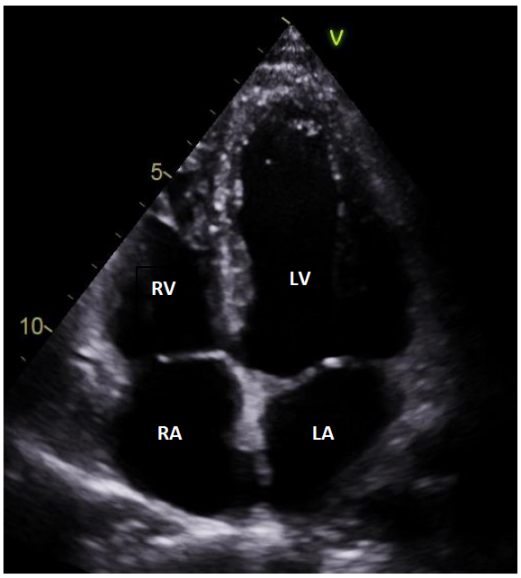

Figure 1: Apical 4 chamber view.
RV = right ventricle; RA = right atrium; LV = left ventricle; LA = left atrium.

Transthoracic echocardiography was repeated at 24 weeks (2nd trimester), 36 weeks (3rd trimester) and 3 months post-partum to reassess the measurements of right ventricular function. Consistent with other pregnancy studies, post-partum measurements were used as surrogate markers for pre-pregnancy values.

Statistical Analysis

The strategy used for analysis was to sequentially compare right ventricular measurements between non-pregnant (post-partum) and paired 1st trimester subjects, followed by first trimester with paired 2nd trimester subjects, followed finally by 2nd trimester with paired 3rd trimester subjects. Paired T tests were used to analyse the data, assuming normally distributed data.

RESULTS

Of the 24 pregnant women who enrolled into the study during their 1st trimester, 17 re-attended for the 2nd trimester echocardiogram and 9 patients returned for the post-partum echocardiogram. The age of participants ranged from 18 to 38 years, with a mean of 28 years. Baseline characteristics are summarised in Table **1**. Table **2** outlines echo measurements taken at each time interval.

There was no significant difference in right ventricular TAPSE derived ejection fraction (p = 0.76), right ventricular S' wave (p = 0.14) and right ventricular

Table 1: Baseline Characteristics

Characteristic	
Mean age in years *(range)*	28 (18-38)
Past medical history *Number (%)*	Asthma: 2 (8) Nil: 22 (92)
Smoking status	Current smoker: 5 (21) Non-smoker: 19 (79)
Number of pregnancies including current	1: 8 (33) 2: 6 (25) 3: 1 (4) 4: 4 (17) 5: 1 (4) 6: 2 (8) Unknown: 2 (8)
History of obstetric complications	Recurrent miscarriage: 3 (13) Anaemia in pregnancy: 1 (4) Nil: 20 (83)

Table 2: Echo Measurements

	1st Trimester	2nd Trimester	3rd Trimester	Post-partum
LVIDd (cm)	4.4 +/- 0.4	4.54 +/- 0.4	4.64 +/- 0.36	4.5 +/- 0.4
3D LVEF (%)	66.6 +/- 5.5	67.5 +/- 4.1	63.4 +/- 7.2	65.5 +/- 6.2
LVED mass (g)	103 +/- 31	109 +/- 18.7	121 +/- 19.9	109 +/- 30
LVEF Biplane Simpsons (%)	67.8 +/- 4.3	67.6 +/-4.5	65.7 +/- 4.0	66.9 +/- 5.3
RV TAPSE EF (%)	63.8 +/- 11.5	70.8 +/- 8.5	75.7 +/- 11.4	59.4 +/- 7.8
RV S' velocity (cm/s)	13.7 +/- 1.9	16.3 +/- 2.5	16.9 +/- 1.9	11.9 +/- 1.5
RV fractional area change (%)	53.0 +/- 8.0	51.7 +/- 7.1	52.1 +/- 5.2	50.8 +/- 6.7

LVIDd = left ventricular internal diameter in diastole; LVEF = left ventricular ejection fraction; LVED = left ventricular end diastolic; RV = right ventricular; TAPSE = tricuspid annular plane systolic excursion; RV S' velocity = right ventricular lateral tricuspid annulus peak systolic velocity

area change (p = 0.60) between subjects during the non-pregnant (post-partum) period compared with the 1st trimester (Figure **2**).

The TAPSE derived ejection fraction of subjects in the second trimester was significantly higher than during the first trimester (p=0.02). Right ventricular S' velocity was also significantly higher in subjects during the second trimester compared with the first trimester (p=0.002). There was no observed difference between the right ventricular fractional area change between the first and second trimester (p=0.67) (Figure **3**).

There was no significant difference between TAPSE ejection fraction (p = 0.20), right ventricular S' wave (p

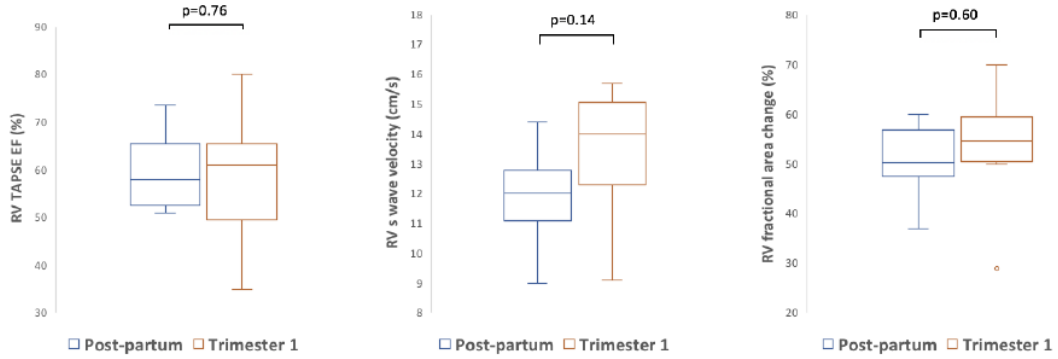

Figure 2: Echo measurements 1st trimester versus non-pregnant period.

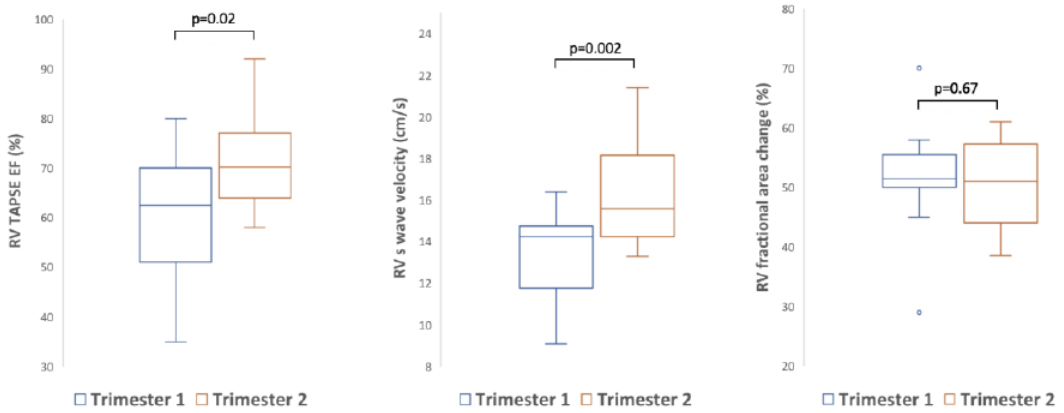

Figure 3: Echo measurements 2nd trimester versus 1st trimester.

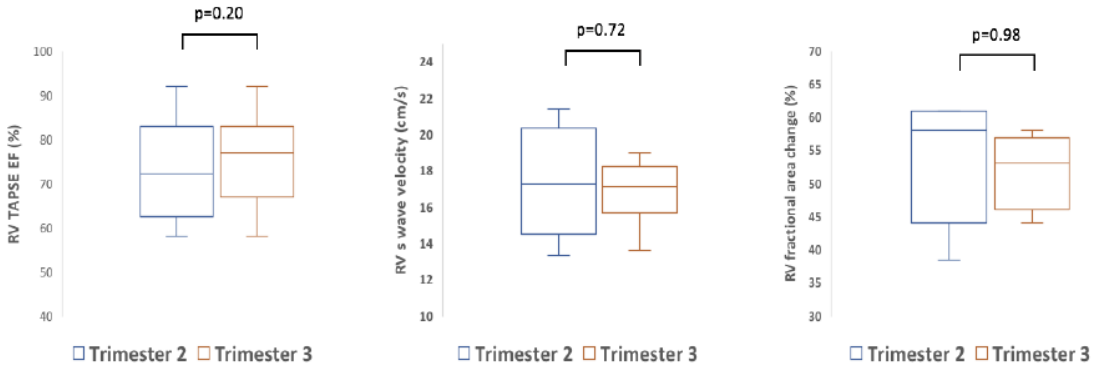

Figure 4: Echo measurements 3rd trimester versus 2nd trimester.

= 0.72) and area change (p = 0.98) between 2nd trimester and 3rd trimester subjects (Figure **4**).

DISCUSSION

With normal maternal adaptation to pregnancy there is an increase in cardiac output, accompanied by a fall in peripheral vascular resistance and reduction in blood pressure in early pregnancy. The circulating blood volume expands and in the second half of pregnancy, as the mean arterial pressure rises, the heart functions under conditions of increased afterload and preload. These cardiovascular changes cause physiological hypertrophy of the maternal heart and are magnified in cases of multiple pregnancy [8]. Due to the large capacitance of the pulmonary vasculature there is no accompanying increase in pulmonary vascular resistance in pregnancy [1]. The increase in cardiac output in normal pregnancy peaks in the 2nd trimester (weeks 22-24) and is largely maintained until delivery.

Although there are a number of different echo modalities to assess right ventricular function, the most widespread in clinical practice are tissue Doppler derived tricuspid annular peak systolic velocity (RV S'), TAPSE and fractional area change [5]. Both imaging modalities are easily obtainable in most individuals and have been shown to be reliable and reproducible parameters of right ventricular function outside of pregnancy [9, 10]. Although both assess the longitudinal function of the right ventricle, they have shown good correlation with radio nucleotide techniques or cardiac magnetic imaging for assessing global systolic right ventricle function [6, 11]. TAPSE <16mm and tissue Doppler derived RV S' <10cm/s are consistent with right ventricular impairment. Assessing right ventricular function using fractional area change provides an estimate of global ventricular function and has shown good correlation with assessment of right ventricular systolic function on MRI [12]. It is obtained using 2D imaging by tracing the endocardium of the right ventricle. A value <35% is consistent with impairment [13].

The results of this small pilot study demonstrate a significant increase in TAPSE and hence derived right ventricular ejection fraction between the 1st and 2nd trimester. There was also an increase in tricuspid annular systolic velocities, assessed by tissue Doppler, in the 2nd trimester. We were unable to demonstrate a significant increase in right ventricular systolic area change between these two periods.

Assessment of right ventricular function by echocardiography can be limited by its proximity to the transducer, limiting the near field 2D resolution in the parasternal views, and the shape of the chamber. 3D evaluation of right ventricular ejection fraction is possible but is not widespread in routine practice. In comparison the use of M-mode to assess TAPSE and tissue Doppler to assess systolic velocities from the tricuspid annulus are widely used. The parameters are reproducible and can be calculated even when the 2D image quality is less than ideal. However, both of these parameters reflect longitudinal function rather than radial function which is better assessed by right ventricular systolic area change. The reason for the absence of an increase in this measure of right ventricular function in the second trimester is not clear. It may reflect the fact that the parameter is more an assessment of radial function. This may be of relevance given that the muscle fibre arrangement of the right ventricle differs from the left in that the circumferential layer of the right ventricle is poorly developed and most fibres are arranged longitudinally [14]. Right ventricular contraction is mainly determined by longitudinal shortening.

The influence of pregnancy on different, commonly used, parameters of right ventricular function requires further investigation. However, the findings demonstrate that when evaluating any pregnant woman with echocardiography it should be appreciated that a normal TAPSE value for 2nd trimester is significantly higher than the non-pregnant state and any reduction in the obtained value should trigger an in depth assessment, particularly if the woman is symptomatic.

CONCLUSIONS

Accepting the limitations of small numbers due to difficulties in recruitment and follow up, we have demonstrated a significant increase in TAPSE and tissue Doppler derived tricuspid annular velocities by the 2nd trimester of pregnancy. This pilot study should be followed by a comprehensive study to define normal ranges for common echo-derived parameters of right ventricular function during pregnancy.

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