Relationship Between Fetal Heart Rate, Cardiac Index and Maternal Blood Pressure in SecondTrimester of PregnancyBetween 14 to 20 Weeks of Gestationin Yobe State Specialist Hospital Damaturu.

ABSTRACT

Aims: The aim of this study is to assess the relationship between fetal heart rate, fetal cardiac index and maternal blood pressure at 14-20 weeks of gestation among antenatal clients attending Yobe state specialist hospital, Damaturu.
Study design: The study is a cross-sectional study.
Place and Duration of Study: The study was conducted in Yobe State specialist hospital Damaturu between June 2021 and November 2021.
Methodology: The samples were selected using a purposive sampling method where 150 pregnant women were selected, and group into three categories (hypertensive, hypotensive and normotensive). Subjects undergo ultrasound scan imaging.The data was analyzed using software program SPSS statistical package (IBM Corp. IBM SPSS Statistics for Macintosh, Version 25.0. Armonk, NY, USA).
Results:A statistically significant relationship was observed between maternal blood pressure and fetal heart rate (p=0.000), but no significant relationship observed between maternal blood pressure and fetal cardiac index (p=0.476), and also between maternal age and the fetal heart rate (p=0.533) or between maternal age and fetal cardiac index (p=0.528).
Conclusion: Fetal heart rate has shown a significant correlation with maternal blood pressure. Thus maternal blood pressure changes can serve as a highly valuable parameter in providing vital information on fetal condition during pregnancy.

Key words: Fetal heart rate, Cardiac Index, Maternal blood pressure, maternal age, obstetrics ultrasound scan, Hypertensive, Hypotensive, Normotensive.

1. INTRODUCTION

Nigeria has the second highest rate of stillbirth in the world (WHO 2015). While the global rate of stillbirth was estimated in 2015 to be 18.4 per 1000 births, with a nearly 25.5% decline between 2009 and 2015. Nigeria experienced a stillbirth rate of 41.67 per 1000 in 2009, with no appreciable improvement in 2015 (Blencowe *et al.,* 2015). In 2015, Nigeria's estimated 317,700 stillbirths accounted for 12.2% of the 2.6 million estimated global stillbirths (Lawn *et al.,* 2016). This suggests that Nigeria still makes substantial contribution to the global burden of stillbirths.

The major causes of stillbirths in a hospital study in Nigeria included hypertensive disorders of pregnancy, antepartum hemorrhage and uterine rupture (Suleiman *et al.,* 2015). Gestational hypertension is the leading causes of maternal morbidity and adverse birth outcomes (Duley. 2009) and it occurs in approximately 5%–6% of all pregnancies (Lain *et a.,l*2002). According to

the American Heart Association (AHA), a healthy pregnant woman should have a blood pressure reading of less than 120/80 millimeters of mercury (mmHg). A systolic blood pressure of 140 mm Hg or higher and/or a diastolic blood pressure of 90 mm Hg or higher is considered to be gestational hypertension. Low blood pressure, or hypotension, occurs when the systolic blood pressure drops below 90mmHg, and diastolic blood pressure below 60mmHg (Jenna 2020). The maternal respiratory system is the only source of oxygen for the fetus. If the maternal oxygen supply or oxygen-carrying capacity is diminished at any level of pregnancy, fetal oxygenation is certain to decrease at some point. This can occur in conjunction with any maternal respiratory, circulatory, hemolytic, or cardiac condition that affects maternal oxygenation. Examples of these include, hypertension, hypotension, and various forms of cardiac decompensation or insufficiency. To maintain optimal or even sufficient fetal oxygenation, maternal oxygenation must be adequately maintained and supported (Zezo 2016).

Recording the fetal heart rate using ultrasonography is an important part of routine antepatum and intrapatum care (Moawia *et al.*, 2015). Globally, approximately 140 million births occur every year (UNICEF, 2016). The majority of these are vaginal births among pregnant women with no identified risk factors for complications, either for themselves or their babies, at the onset of labour (Danilack, 2015). Approximately half of all stillbirths and a quarter of neonatal deaths result from complications during labour and childbirth (Lawn, 2016). The burden of maternal and perinatal deaths is disproportionately higher in low- and middle-income countries (LMICs) compared to high-income countries (HICs) (Lawn, 2016). Therefore, improving the quality of care in pregnancy, especially in LMICs, has been identified as the most impactful strategy for reducing stillbirths, maternal and newborn deaths. (Bhutta, 2014). Maternal hypertension is considered one of the main influences on fetal heart rate (Moawia *et al*., 2015). Hypertension is attributed at least in part to autonomic deregulation (i.e. digressed parasympathetic and increased sympathetic cardiac modulation), which results in an increase in maternal heart rate and enhanced vasomotor sympathetic modulation, which causes vasoconstriction (Dabrowaki 1996).

Most of the diagnosis of fetal heart rate abnormalities are made late in Nigeria (Ajah *et al*., 2016). The majority of stillbirths occurred in developing countries and Nigeria still makes substantial contribution to the global burden of stillbirths with an estimate of 317,700 cases that accounted for 12.2% of the 2.6 million estimated global still birth (WHO, 2015). Most of the times pregnant women present to hospital when they only noticed decrease or absence fetal movement (Moawia*et al*., 2015). Fetal distress has the potential to lead to serious complications, including, permanent injuries, disabilities, intrautrine growth restriction or death (Paul *et al.,* 2018).

Fetal heart rate (FHR) is a vital predictor of fetal outcome. Factors that influence baseline fetal heart rate are not well documented (Moawia *et al*., 2015). There is an association between maternal autonomic modulation of heart rate and FHR, such that the maternal autonomic system influences fetal cardiac function in pregnancies complicated by hypertension (Brown, 2008).

Most studies considered fetal heart rate in third trimester and during parturition (Moawia. *et al* 2015) this study would therefore give additional information to maternal blood pressure in relation to fetal heart rate and fetal cardiac index in second trimester between 14 to 20-week gestation.

Early diagnosis of abnormal fetal heart rate and cardiac index would lead to prompt correction of maternal hemodynamic changes and restore fetal heart rate back to normal, finding and relating maternal cardiovascular indices to these fetal parameters is of research importance.

The study will provide vital information about maternal blood pressure in relation to fetal heart rate and cardiac index. It will reduce the rate of intrauterine fetal death by providing information about fetal outcome early in pregnancy. This study will also help in early noninvasive anticipation of fetal condition due to maternal blood pressure variation by addressing the maternal blood pressure changes.

2. MATERIAL AND METHODS

2.1 **Study Design and Sampling**

The samples were randomly selected using a systematic sampling technique where 150 pregnant women in their second trimester between 14 to 20 weeks of gestation were selected, and group into three categories. Hypertensive, hypotensive and normotensive with 50 subject in each group.

2.1.1 Sampling Criteria

Inclusion criteria

- Pregnant women in second trimester (between 14 to 20 weeks of gestation)
- Participants had to between age 18 to 42 years

Exclusion criteria

- Pregnant women with multiple gestation
- Pregnant women with fetal anomaly (e.g. hydrocephalus, omphalocele and anencephale)
- Pregnant women with premature rupture of membrane (PROM)

2.1.2 Data Collection

2.1.2.1 Instrument of Data Collection

- Data was collected on a Data Capturing form which include

- Biodata of the mother (Name, Age, Tribe, family income, educational and Marital Status)
- Maternal blood pressure using a standard mercury sphygmomanometer.
- Fetal parameters (fetal heart rate, cardiac index, gestational age).

2.1.3 Fetal Heart Rate Measurement

Subjects undergo ultrasound scan imaging using a 3.5 MHz probe, according to the obstetric scanning protocol (Salomon, 2013) and in accordance with the 2008 Helsinki declaration. fetal heart activity was observed using the 4-chamber view and M mode was applied to measure fetal heart rate (Moawia*et al.,* 2015).

2.1.4 Fetal Cardiac Index Measurement

Fetal stroke volume was measured using Doppler machine (Chison Q5) where the ventricular outflow tract is obtained and multiply by the velocity time interval obtained from the pulse wave Doppler function (Mercado et al., 2017). Stroke volume (SV) and heart rate (HR) is use to obtained cardiac output (CO) by multiplying SV×HR (Merck, 2009). Fetal body surface area (BSA) was obtained using Dubois method where BSA = 0.007184*Height $^{0.725}$ * Weight $^{0.425}$(Dubois *et al.*,1916). Cardiac index(CI) was calculated using CI=CO÷BSA (Merck, 2009).

2.2 Statistical Analysis

Data was collated and filtered using Microsoft exel, the maternal blood pressure were graded as 1 for low blood pressure, 2 for normal blood pressure and 3 for high blood pressure with one outlier in each category. The data was subjected to test of normality using Kolmogorov-Smirnov test which shows majority of the data are normally distributed. The data was analyzed using software program SPSS statistical package (IBM Corp. IBM SPSS Statistics for Macintosh, Version 25.0. Armonk, NY, USA). One-way ANOVA was used to compare for difference in means of the fetal variables among the maternal blood pressure groups and Games-Howell post-hoc test was used to compare the means of the fetal variables between the maternal blood pressure groups. Pearson correlation coefficient was used to make inference about the associations between the fetal heart rate, cardiac index and maternal blood pressure. Frequency table was use to present the distribution of the demographic and health variables of the respondents. Descriptive statistic of mean± standard error of mean was used to summarize the basic features of the variables. P values < 0.05 was considered statistically significant.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Socio-demographic characteristics of the participants.

Table 1 displayed the socio-demographic information of the participants of the study. Majority of the participants speaks Hausa (56.1%) as shown in the table. Most of the participants have primary/high school education (53.9%). The majority of the participants reside in the urban area (83.5%), and most of the participant have income of N 31,000 and more (57.9). Majority of the participants falls between the age of 15 to 25 years (61.7%).

TABLE 1. Socio-demographic characteristcs of the participants

VARIABLE	PERCENT %
AGE	
15-25	61.7
26-35	36.3
36-45	2
EDUCATION	
Primary	53.9
Secondary	25.7
Tertiary	8.2
None-formal	12.2
FAMILY INCOME	
Less than N 12,251	16.5
N 12,251 to N 30,000	25.6
N 31,000 and more	57.9
LANGUAGE SPOKEN	
Kanuri	25.6
Fulani	16.7
Hausa	9.8
Others	47.9
AREA OF RESIDENCE	
Urban	83.5
Rural	16.5

3.1.2 Descriptive Statistic of the Participants

Table 2 displayed the descriptive statistics of the participants, which shows the mean age of the participants among different blood pressure group with those with high blood pressure having the highest mean age of 29 ± 2.23 when compared to those with normal and low blood pressure.

TABLE 2. Descriptive statistics of the participants

Variable	**Normal Blood Pressure**	**Low Blood Pressure**	**High Blood Pressure**
Age	21 ± 1.82	25 ± 2.10	29 ± 2.23
SBP	96 ± 0.24	84 ± 0.22	142 ± 0.66
DBP	62 ± 0.18	50 ± 0.12	94 ± 0.24
MAP	83 ± 0.21	53 ± 0.13	110 ± 0.26

Values are expressed as mean ± SEM. SBP= Systolic blood pressure, DBP= Diastolic blood pressure, MAP= Mean arterial pressure, FGA= Fetal gestational age.

3.1.3 Fetal characteristics among mothers with different blood pressure group

Table 3 displayed the fetal characteristics among mothers with different blood pressure group, which shows a significant increase in fetal heart rate among mothers with low (158.92±1.64) and high blood pressure (171.24±1.19) when compared to those with normal blood pressure, but the fetal cardiac index tends to be significantly lower in mothers with low blood pressure(698.54±22.7).

TABLE 3. Fetal characteristics among mothers with different blood pressure group

Characteristics	**Normal Blood Pressure**	**Low Blood Pressure**	**High Blood Pressure**	**P Value**
CO	17.59 ± 1.53	12.94 ± 1.01[a]	13.53 ± 1.23	0.021*
SV	0.123 ± 0.01	0.08 ± 0.007[a]	0.08 ± 0.007[a]	0.000*
FW	0.157 ± 0.12	0.132 ± 0.01	0.125 ± 0.01	0.104
CHL	12.71 ± 0.37	12.14 ± 0.34	11.14 ± 0.38[a]	0.010*
BSA	0.020 ± 0.001	0.018 ± 0.001	0.018 ± 0.001	0.373
CI	858.48 ± 41.7	698.54 ± 22.7[a]	744.24 ± 28.1	0.002*
HR	136.76 ± 0.64	158.92 ± 1.64[ab]	171.24 ± 1.19[ab]	0.000*

Values are expressed as mean ± SEM; (n=50); *= P≤ 0.05
When compound with normal blood pressure group.
Key: CHL = Fetal Crown Heel Length, FW = Fetal Weight, BSA = Fetal Body Surface Area, HR = Fetal Heart Rate, SV = Fetal Stroke Volume, CO = Fetal Cardiac Output, CI = Fetal Cardiac Index, a=normal blood pressure group, b= low blood pressure group, c= high blood pressure group.

3.1.4 The relationship between maternal blood pressure and fetal variables

Table 4 displayed the relationship between maternal blood pressure and fetal variables, which shows a significant negative correlation between fetal heart rate and maternal systolic blood pressure among mothers with low blood pressure (p=0.020, r= -0.331), but a significant positive correlation in mothers with high blood pressure (p=0.007, r=0.381).

TABLE 4. The relationship between maternal blood pressure and fetal variables

Variables/Groups		SBP		
		NBP	LBP	HBP
FHR	r	0.125	-0.331*	0.381**
	p	0.392	0.020	0.007
FCI	r	0.231	-0.181	0.234
	p	0.110	0.214	0.106
FCHL	r	0.110	0.175	-0.053
	p	0.452	0.228	0.717
FBSA	r	0.066	0.080	-0.006
	p	0.651	0.583	0.969
FW	r	0.070	0.159	-0.129
	p	0.631	0.274	0.375

*Correlation is significant at the 0.05 level (2. Tailed), **Correlation is significant at the 0.01 level (2. Tailed). Key: FCHL = Fetal Crown Heel Length, FBSA = Fetal Body Surface Area, FHR = Fetal Heart Rate, FSV = Fetal Stroke Volume, FCO = Fetal Cardiac Output, FCI = Fetal Cardiac Index, NBP= Normal Blood Pressure, LBP= Low Blood Pressure, HBP= High Blood Pressure.

3.1.5 The relationship between maternal mean arterial pressure and fetal variables

Table 5 displayed the relationship between maternal mean arterial pressure and fetal variables, which shows a significant positive correlation between the fetal heart rate and maternal mean arterial blood pressure among mothers with high blood pressure (p=0.047, r =0.285).

TABLE 5. The relationship between maternal mean arterial pressure and fetal variables

Variables/Groups		**MAP**		
		NBP	LBP	HBP
FHR	r	-0.035	-0.251	0.285*
	p	0.810	0.082	0.047
FCI	r	0.205	-0.076	0.057
	p	0.157	0.605	0.695
FBSA	r	0.096	-0.048	0.100
	p	0.511	0.741	0.492

*Correlation is significant at the 0.05 level (2. Tailed), **Correlation is significant at the 0.01 level (2. Tailed). FBSA = Fetal Body Surface Area, FHR = Fetal Heart Rate, FCI = Fetal Cardiac Index, NBP= Normal Blood Pressure, LBP= Low Blood Pressure, HBP= High Blood Pressure.

3.1.6 The relationship between fetal cardiac index and fetal variables among mothers with different blood pressure group.

Table 6 displayed the relationship between fetal cardiac index and fetal variables among mothers with different blood pressure group, which shows a significant negative correlation between fetal heart rate and fetal cardiac index in mothers of low blood pressure (p=0.001, r=-0.461) and high blood pressure (p=0.041, r=-0.293). Fetal cardiac output shows a significant negative correlation with fetal cardiac index in mothers with low blood pressure (p=0.000, r=-0.833), and also a significant negative correlation between fetal stroke volume and fetal cardiac index among mothers with low blood pressure (p=0.000, r=-0.830). Fetal body surface area shows a significant negative correlation with fetal cardiac index among mothers with normal blood pressure (p=0.019, r=-0.334) and low blood pressure (p=0.000, r=-0.863), with similar findings between fetal weight and fetal cardiac index in mothers with normal blood pressure (p=0.022, r=-0.327) and those with low blood pressure (p=0.000, r=-0.829), but for the fetal crown heel length shows a significant negative correlation with fetal cardiac index in both the three blood pressure groups, normal (p=0.002, r=-0.433), low (p=0.000, r=-0.954), and high blood pressure (p=0.001, r=-0.463).

TABLE 6. The relationship between fetal cardiac index and fetal variables among mothers with different blood pressure group

Variables/Groups		**FCI**		
		NBP	LBP	HBP
FHR	r	-0.091	-0.461**	-0.293*
	p	0.532	0.001	0.041
FCO	r	0.228	-0.833**	0.244
	p	0.115	0.000	0.091
FSV	r	0.236	-0.830**	0.250
	p	0.102	0.000	0.083
FBSA	r	-0.334*	-0.863**	-0.140
	p	0.019	0.000	0.337
FCHL	r	-0.433**	-0.954**	-0.463**
	p	0.002	0.000	0.001
FW	r	-0.327*	-0.829**	0.044
	p	0.022	0.000	0.765

*Correlation is significant at the 0.05 level (2. Tailed), **Correlation is significant at the 0.01 level (2. Tailed). Key: FCHL = Fetal Crown Heel Length, FBSA = Fetal Body Surface Area, FHR = Fetal Heart Rate, FSV = Fetal Stroke Volume, FCO = Fetal Cardiac Output, FCI = Fetal Cardiac Index, FW= Fetal weight NBP= Normal Blood Pressure, LBP= Low Blood Pressure, HBP= High Blood Pressure.

4.2 Discussion

In this study, the relationship between maternal blood pressure, fetal heart rate and fetal cardiac index was assessed among pregnant women in second trimester of pregnancy between 14 to 20 weeks' gestation attending antenatal clinic in Yobe state specialist hospital Damaturu. The study comprised of three groups, Normotensive, hypertensive and hypotensive pregnant women. A total of 150 participants that satisfies the inclusion criteria were recruited for the study with each of the three groups having 50 participants. Socio-demographic information of the participants was recorded. Majority of the participants speaks Hausa (56.1%). Most of the participants have primary school education (53.9%). The majority of the participants reside in the urban area (83.5%), and most of the participant have income of N 31,000 and more (57.9). Majority of the participants falls between the age of 15 to 25 years (61.7%).

The mean age of mothers with high blood pressure was found to be 29±2.23 which is higher to that of normal blood pressure group of 21±1.82 and low blood pressure group of 25±2.01. Anna et al., (2015) reported the risk of gestational hypertension in mothers between the age of 35 to 39 years and less in

mothers between 25 to 29 years, which in this study we found that the risk can be as early as in 29±2.23 years even earlier than expected.

The mean systolic blood pressure was found to be 96±0.24 , 84±0.22 and 142±0.66 among the normotensive, hypotensive and hypertensive mothers respectively which is within the range of the current recommendation of the American College of Obstetrics and Gynecology on maternal blood pressure changes in pregnancy.

Fetal Cardiac output and stroke volume is significantly lower in women with low blood pressure compared to those with normal blood pressure, while Fetal heart rate is found to be significantly higher in women with low blood pressure and high blood pressure compared to those with normal blood pressure, this findings agrees with the findings of Kenny et al., (1987) who reported a spontaneous increase in fetal heart rate result in decrease in stroke volume and cardiac output due to the fact that the fetal heart is incompletely developed compared with that of adults. Swansburg*et al.,* (2005) also reported that the fetal heart rate tends to increase with increase in maternal blood pressure. Fetal crown heel length is significantly lower in women with high blood pressure compared to those with normal blood pressure, which agrees with the findings of Bakkar et al., (2011) who reported a decrease in fetal growth in pregnancy complicated with high blood pressure. Fetal cardiac index is significantly lower in women with low blood pressure compared to those with normal blood pressure.

When the relationship between the maternal variable and the fetal variable are explored, Significant relationship was observed between fetal heart rate and maternal blood pressure among mothers with low and high blood pressure, which shows a negative correlation in mothers with low blood pressure ($p<0.05$, $r = 0.02$) and a positive correlation in mothers with high blood pressure ($p<0.05$, $r =0.381$). This means the lower the maternal blood pressure the lower the fetal heart rate and the higher the maternal blood pressure the higher the fetal heart rate, this finding agrees with the findings of Howard *et al (1963)* who reported fetal bradycardia with maternal hypotention and Moawia*et al* (2015) who reported that maternal hypertension increases fetal heart rate. And also another report by Brown *et al* (2008) reported that maternal hypertension influences fetal heart rate by increasing the fetal heart rate. No significance relationship was observed between the fetal cardiac index and maternal blood pressure, but the direction of the relationship between the fetal cardiac index tends to be negative among mothers with low blood pressure though not significance but implies with low blood pressure the cardiac index tends to show negative relationship. This needs further exploration with probably increasing the number of subject for the study. When the relationship between the fetal variable and fetal cardiac index among mothers with different blood pressure, significance relationship was observed between fetal heart rate and fetal cardiac index among mothers with low and high blood pressure, it shows any increase in the heart rate of fetuses of such mothers tends to show decrease in their cardiac index.

4. CONCLUSION

Fetal heart rate has shown a significant correlation with maternal blood pressure in 14 to 20 weeks' gestation but no significant correlation between maternal blood pressure and fetal cardiac index observed. Thus maternal blood pressure changes can serve as a highly valuable parameter in providing vital information on fetal condition during pregnancy.

CONSENT (WHERE EVER APPLICABLE)

Informed consent was obtained from all subjects involved in the study.

ETHICAL APPROVAL (WHERE EVER APPLICABLE)

Ethical approval was obtained for the study.

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