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Ultrasound and Biological Characteristics of the Liver in Newborns of Diabetic or Hypertensive Mothers at CHUZ-SL (Cotonou II and III), Benin

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Abstract

Gestational diabetes and pregnancy-induced hypertension are common conditions associated with neonatal complications, including growth abnormalities and metabolic disorders. However, their impact on neonatal liver morphology remains poorly documented in Africa. This study aims to analyze the factors associated with morphological changes in the liver among newborns born to diabetic or hypertensive mothers in Cotonou. This was a descriptive and analytical cross-sectional study conducted at CHUZ-SL (Cotonou II and III) in Benin. The study included newborns aged 0 to 21 days born to diabetic, hypertensive, or healthy mothers, selected consecutively. Maternal diabetes was classified according to WHO criteria, and hypertension was defined as BP ≥ 140/90 mmHg. The hepatic liver span was systematically measured by ultrasound. A multivariate linear regression analysis was performed with a significance level set at $p < 0.05$. 241 newborns (78 controls, 82 from diabetic mothers, and 81 from mothers with hypertension) were included. Newborns of diabetic mothers had a significantly higher birth weight (4190.85 g) than those of healthy mothers (2827.21 g; $p < 0.000$), as well as an increased hepatic diameter (73.88 mm vs. 55.08 mm), indicating hepatomegaly. In mothers with hypertension, the increase was moderate (62.69 mm). A significant positive correlation was observed between birth weight and liver size ($p = 0.001$). Multivariate analysis identified maternal profile, age ≥ 5 days, fetal weight, and birth weight as associated factors, while maternal weight was negatively asso-

ciated. Maternal diabetes has a greater impact on neonatal liver growth than hypertension. Birth weight appears to be a key determinant of liver size, underscoring the importance of rigorous prenatal monitoring.

Keywords

Gestational Diabetes, Hypertensive Disorders of Pregnancy, Newborn, Hepatomegaly, Cotonou-Benin

1. Introduction

Maternal conditions such as gestational diabetes and hypertension are major risk factors for maternal and fetal morbidity, particularly in resource-limited countries. Maternal diabetes is known to cause chronic hyperglycemia, which leads to fetal hyperinsulinemia, promoting excessive fetal growth (macrosomia) and neonatal metabolic abnormalities [1] [2]. Conversely, gestational hypertension is often associated with placental insufficiency, which can lead to intrauterine growth restriction (IUGR) [3]. Although the effects of these conditions on birth weight are well documented, their impact on organ morphology—particularly that of the liver—remains understudied, especially in sub-Saharan Africa. However, early liver changes may be associated with long-term metabolic disorders. This study aims to investigate the factors associated with morphological changes in the livers of newborns born to mothers with diabetes or hypertension in the Cotonou II and III health zones.

2. Study Framework and Study Method

This study was carried out at the Suru Léré Zone University Hospital (Cotonou II and III) in the medical imaging department for the performance of liver ultrasounds. The biological samples taken were analyzed in several laboratories.

Study Design and Study Population

This was a descriptive and analytical cross-sectional study conducted from January 2 to June 15, 2024. The study targeted newborns aged 0 to 21 days (the maximum age represented in the cohort) born to mothers classified into three distinct, consecutively enrolled groups: diabetic, hypertensive, or healthy (controls).

Maternal Group Definitions and Diagnostic Criteria

- Diabetic Mothers: Defined according to WHO guidelines. Gestational diabetes mellitus (GDM) was diagnosed during pregnancy based on an oral glucose tolerance test (OGTT) with a 75 g glucose load (fasting plasma glucose ≥ 0.92 g/L, 1-hour ≥ 1.80 g/L, or 2-hour ≥ 1.53 g/L), or pre-existing type 1/2 diabetes. Out of the 82 diabetic mothers, 74 had gestational diabetes and 8 had pre-existing diabetes.
- Hypertensive Mothers: Defined by a persistent systolic blood pressure ≥ 140

mmHg and/or diastolic blood pressure ≥ 90 mmHg measured on at least two occasions after 20 weeks of gestation (pregnancy-induced hypertension or preeclampsia).

- Healthy Mothers (Controls): Normotensive pregnant women with normal glucose tolerance, without any history of chronic systemic disease.

Selection and Exclusion Criteria

Inclusion Criteria

All newborns born to the three designated maternal groups during the study period were consecutively recruited to prevent selection bias.

Exclusion Criteria

Newborns with severe congenital malformations, chromosomal abnormalities, clinical signs of neonatal infection, major neonatal distress requiring intensive resuscitation, or those with clinically apparent hepatic tumors or infectious hepatitis were excluded from the study. Newborns without clinical hepatomegaly were eligible for liver measurements.

Clinical, Biological, and Ultrasound Assessments

Maternal and neonatal demographic and clinical data were collected during interviews and from medical records. Weight measurements were taken using a standardized automatic neonatal scale.

Biological Measurements

Venous blood samples were collected from newborns to determine serum transaminase levels (AST and ALT) by spectrophotometry. Blood glucose levels were also measured immediately after birth using a glucose oxidase method (spectrophotometry) to evaluate early metabolic profiles.

Ultrasound Protocol

A hepatic ultrasound was performed in the supine position by an experienced radiologist using an ultrasound machine with a 3.5 MHz convex probe. The hepatic liver span (formerly referred to interchangeably as "hepatic deflection", "liver length", or "diameter") was measured on the mid-clavicular line from the uppermost diaphragmatic dome to the lower liver border at the end of quiet inspiration.

Statistical Analysis

The data were analyzed using SPSS 25 and STATA 17 software, with calculation of statistical parameters and analysis of correlations. A multivariate linear regression analysis was performed to identify factors independently associated with hepatic liver span. Statistical significance was defined as a p-value < 0.05. Actual p-values are reported, with very low values expressed as $p < 0.001$.

3. Results

The study involved 241 recruited newborns. Of these, 82 (34%) were born to diabetic mothers, 81 (33%) to hypertensive mothers, and 78 (32.4%) to healthy mothers. Table 1 shows the sex distribution of newborns according to their mothers' profiles.

Table 1. Sex distribution of newborns according to the profile of mothers.

		Gender				Total	
		Female		Men's			
Profile of the mother	Witness	39	16.2%	39	16.2%	78	32.4%
	Diabetic	42	17.4%	40	16.6%	82	34.0%
	Hypertensive	40	16.6%	41	17.0%	81	33.6%
Total		121	50.2%	120	49.8%	241	100.0%

As shown in Table 1, the population comprised 120 boys and 121 girls, for a male-to-female ratio of 1. The newborns ranged in age from birth to 8 days, with the exception of one 21-day-old infant. We also assessed the mean birth weight of the newborn in grams (g) according to the maternal profile, and the data are summarized in Table 2.

Table 2. Average birth weight of the newborn in grams (g) by maternal profile.

Gender	Witness	Diabetic	Hypertensive	Total
Female	2796.85 ± 235.55	4184.5 ± 622.25	2789.45 ± 407.95	3276.07 ± 803.69
Male	2857.56 ± 212.17	4197.53 ± 570.94	2882.41 ± 389.85	3312.71 ± 753.09
Total	2827.21 ± 223.25	4190.85 ± 594.12	2836.51 ± 399.14	3294.31 ± 777.50

From the analysis of this table, a newborn born to a diabetic mother has an average birth weight 1.5 times greater than that of the other two categories.

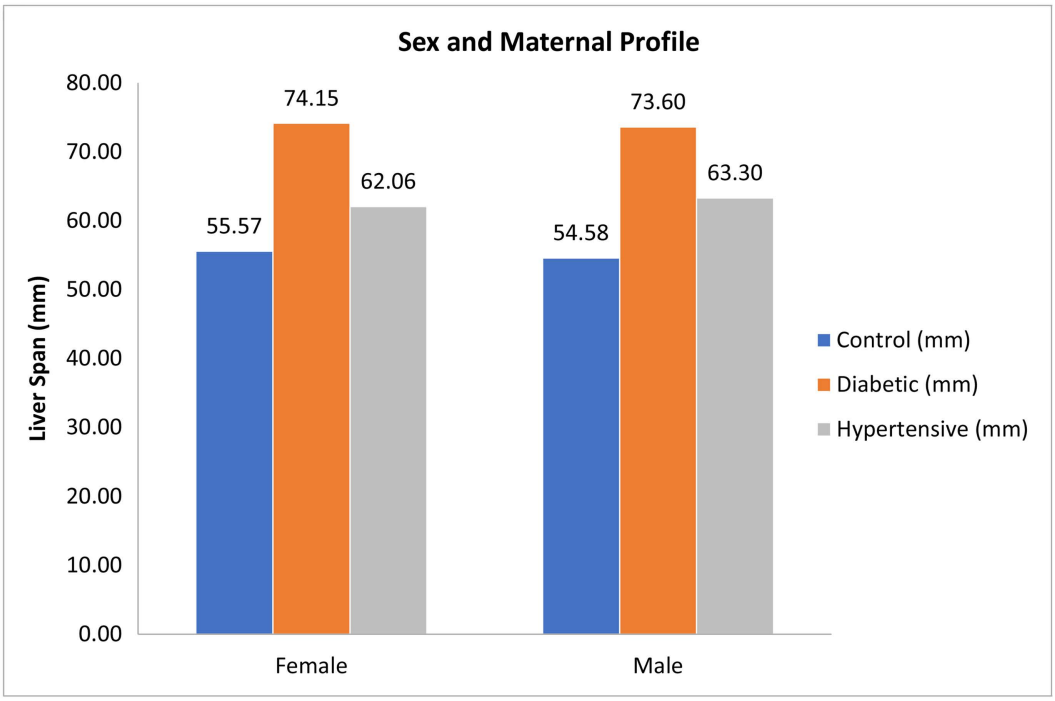

Figure 1. Hepatic deflection (mm) of the newborn by sex and profile of the mother.

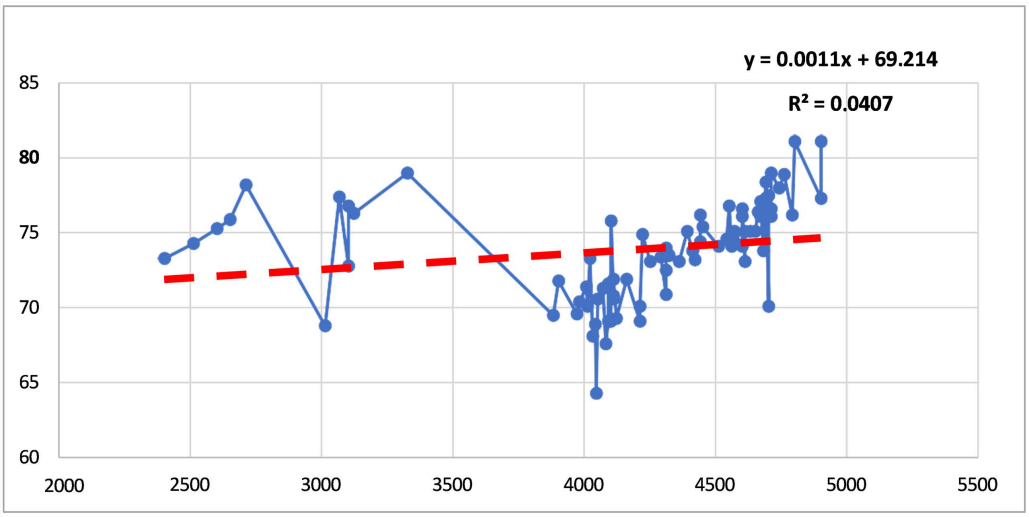

Figure 2. Hepatic arrow in newborns of diabetic mothers.

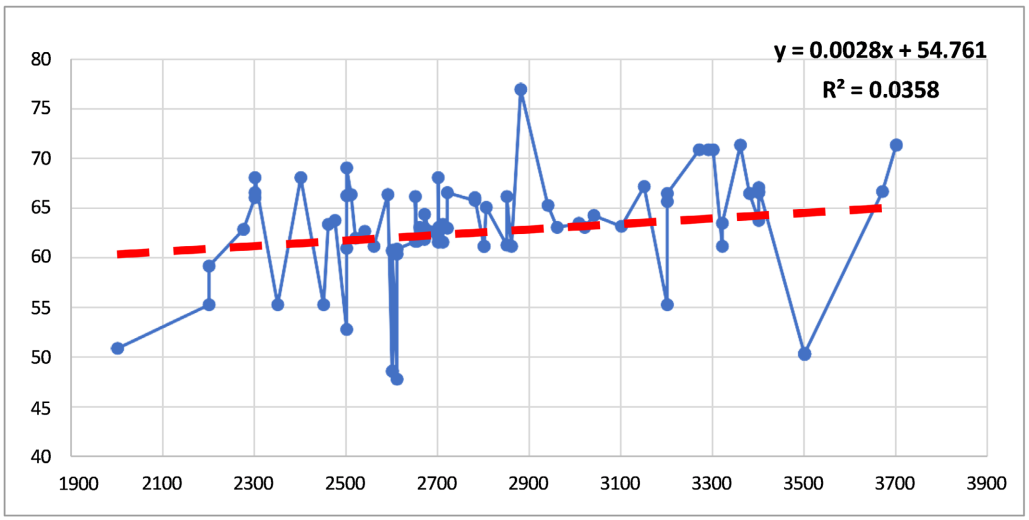

Figure 3. Hepatic arrow in newborns of hypertensive mothers.

The analyses in Figures 1-3 show that there is a significant increase in hepatic arrow depending on the number of diabetic, hypertensive or healthy mothers with $p < 0.000$ and a Fisher statistic equal to 472.791.

The analysis in Figure 4 showed that, regardless of sex, newborns born to diabetic mothers had significantly higher liver arrow and birth weight on average than those born to hypertensive or healthy mothers. Differences in hepatic deflection were estimated to be between 10 and 12 mm between the diabetic and hypertensive groups, and between 18 and 19 mm between the diabetic and control groups. In addition, the birth weight of newborns of diabetic mothers was on average 1315 to 1395 g higher than that of children of hypertensive mothers and 1340 to 1388 g higher than controls.

The study had been analysed, by regression, the factors related to morphological changes in the liver in newborns born to diabetic, hypertensive or healthy mothers.

It had thus made it possible to identify the main determinants of these changes. The results of the multivariate linear regression are presented in Table 3.

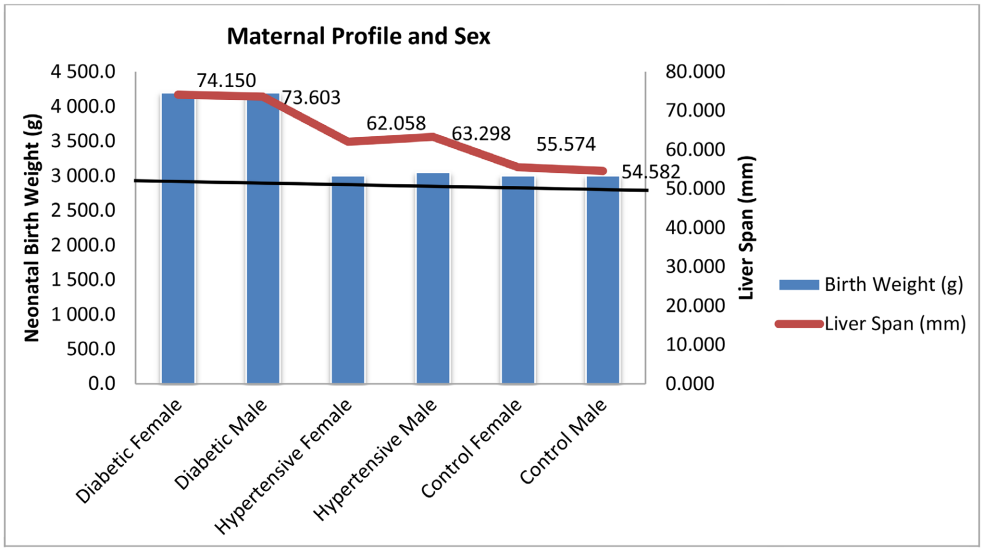

Figure 4. Evolution of birth weights in grams (g) and hepatic arrow (mm) of the newborn according to maternal profile.

Table 3. Results of multivariate linear regression of the hepatic arrow of the newborn of the diabetic, hypertensive and healthy mother compared to the statistically significant study variables.

Hepatic arrow regression		Coefficients Cient	Variance type	t	p > t	[95% conf. interval]	
Profile of mothers of newborns	Diabetic	17.88	1.201	14.89	0.000	15.52	20.25
	Hypertensive	0.000	0.000	0.000	0.000	3.07	9.22
Age range	Older newborns 3 to 4 days	0.19	0.774	0.24	0.808	−1.34	1.71
	Newborns 5 days of age and older	6.11	1.316	4.64	0.000	3.52	8.70
Measured hypertension		0.004	0.260	0.02	0.987	−0.51	0.52
Fetal weight in grams		0.0002	0.0001	4.87	0.000	0.0002	0.0004
Weight of the pregnant mother in Kg		−0.096	0.039	−2.47	0.014	−0.17	−0.02
Newborn birth weight in grams		0.003	0.001	3.22	0.001	0.00	0.00
Constant		53.52	4.103	13.05	0.000	45.44	61.61

The multivariate linear regression model showed that several factors were significantly associated with morphological changes in the liver in newborns of diabetic or hypertensive mothers. These include maternal profile (diabetic or hypertensive), a neonatal age greater than or equal to 5 days, fetal weight and birth weight, all positively related to these changes. In contrast, maternal weight during pregnancy has a negative association. All of these relationships are statistically significant at the 5% level.

Maternal diabetes had a greater impact on the newborn's liver development than hypertension, highlighting the need for rigorous monitoring of high-risk pregnancies. The analysis of biological data on structural changes in the liver of newborns of diabetic, hypertensive or healthy mothers has been summarized in Table 4 and Table 5.

Table 4. Variation in biochemical parameters in hypertensive patients.

Settings	Witness	Hypertensive	p-value	Statistical Significance
ASAT (UI/I)	42.8 ± 15.92	80.25 ± 54.39	0.0009	Very significant
TOOLS (UI/I)	11.6 ± 3.50	24.00 ± 25.18	0.0066	Very significant
Blood glucose (g/L)	0.85 ± 0.21	0.85 ± 0.21	$p > 0.05$	Not significant

Statistical analysis of the biochemical parameters of the controls and hypertensive subjects showed that the levels of AST and ALT showed statistically significant differences, while the blood glucose level showed no significant variation.

Table 5. Variation in biochemical parameters in diabetics.

Settings	Witness	Diabetic	p-value	Statistical Significance
ASAT (UI/I)	42.8 ± 15.92	36 ± 1.40	0.0377	Significant
TOOLS (UI/I)	11.6 ± 3.5	10 ± 0.01	0.1150	Not significant
Blood glucose (g/L)	0.85 ± 0.21	1.59 ± 0.1	0.0030	Significant

Statistical analysis of the biochemical parameters of controls and diabetic subjects showed that AST and blood glucose levels showed statistically significant differences, while ALT levels showed no significant variation.

4. Discussion

The results of this study highlighted the significant influence of maternal diabetes and hypertension on the liver morphology of newborns in the Cotonou II and III health zones.

In our series, the population was gender-balanced (120 boys and 121 girls, sex ratio = 1) (Table 1, Table 2). This homogeneous distribution suggests the absence of gender-related selection bias and reinforces the internal validity of the results. However, the literature reported that male sex was often associated with a slightly higher birth weight and an increased risk of macrosomia [4]. The age of the newborns, the majority were between 0 and 8 days. This distribution corresponded to the early neonatal period, characterized by rapid metabolic adaptations, particularly in newborns born from diabetic pregnancies [5].

The increase in birth weight in newborns of diabetic mothers (4190.85 g) compared to those of healthy mothers (2827.21 g; $p < 0.0001$) confirmed the central role of maternal hyperglycemia in the occurrence of fetal macrosomia (Figure 1, Figure 2). From a pathophysiological point of view, this macrosomia could be

explained by fetal hyperinsulinism induced by excess maternal glucose. In accordance with the pathophysiology of fetal hyperinsulinism [1] [2], an increase in fetal weight would be observed [1] [2]. Our results are consistent with those reported in sub-Saharan Africa, notably by Opara *et al.* in Nigeria [6] and Adam *et al.* in South Africa [7], where newborns of diabetic mothers also had high birth weights, often above 4000 g, with an increased risk of complications such as neonatal hypoglycemia and shoulder dystocia (**Figure 2**, **Figure 3**).

Our study showed a significant increase in hepatic arrow in newborns of diabetic mothers (73.88 mm compared to 55.08 mm in controls), indicating hepatomegaly (**Figure 4**). This observation suggested that the effects of maternal diabetes are not limited to weight growth, but also concern organ development. The observed hepatomegaly could be explained by fetal hyperinsulinism, which would promote lipid storage and liver tissue growth [8]. These results are consistent with those of Friel *et al.* [9], who showed that excessive fetal growth is associated with an increase in the size of organs, including the liver.

On the other hand, in newborns of hypertensive mothers, the increase in hepatic arrow is more moderate (62.69 mm), which reflects different pathophysiological mechanisms. Gestational hypertension is usually associated with impaired placental blood flow, leading to reduced oxygen and nutrient supplies to the fetus [3]. Unlike diabetes, it does not promote excessive growth, but rather intrauterine growth restriction (IUGR) or moderate growth. Noubiap *et al.* in South Africa [10], in a meta-analysis of Africa, confirmed this trend, showing that hypertensive disorders of pregnancy are more associated with prematurity and low birth weight than with macrosomia.

Analysis of the positive correlation between birth weight and liver arrow showed that the higher the birth weight, the more the liver size increased, regardless of maternal profile (**Table 3**, **Table 4**). This relationship is confirmed by multivariate linear regression, with a significant positive coefficient ($p = 0.001$). These results corroborate those of Friel *et al.* and Graham *et al.*, who identified fetal growth as a key determinant of organic development [9] [11].

In addition, multivariate analysis identified maternal profile (diabetic or hypertensive), fetal weight and birth weight as the main determinants of hepatic morphological changes (**Table 3**, **Table 4**). On the other hand, maternal weight appears to be a negatively associated factor ($p = 0.014$), suggesting a complex relationship between maternal nutritional status and fetal growth. This observation could reflect multifactorial interactions involving maternal metabolism, placental function, and fetal adaptation mechanisms [11].

From a clinical point of view, these results underline the importance of rigorous management of high-risk pregnancies (**Table 5**). Glycemic control in diabetic women appears to be essential to prevent macrosomia and its complications, including neonatal metabolic disorders. Similarly, follow-up of hypertensive women should be strengthened in order to prevent complications related to IUGR and prematurity. Strengthening early detection strategies for gestational diabetes and

hypertension, as well as improving antenatal follow-up, could help reduce neonatal morbidity [6] [10].

However, there are some limitations that need to be taken into account. The cross-sectional nature of the study does not allow a causal relationship to be established between the factors studied and the observed changes. In addition, the lack of longitudinal follow-up limits the assessment of the long-term consequences of neonatal hepatomegaly. Prospective studies would be needed to better understand the evolution of these abnormalities and their impact on the future health of children.

5. Conclusion

Maternal diabetes and hypertension significantly influence the liver morphology of newborns. Children of diabetic mothers have a higher birth weight and liver arrow than those of hypertensive or healthy mothers ($p < 0.05$). There is a positive correlation between birth weight and liver size. Gestational diabetes appears to be the main factor in hepatic hypertrophy, while maternal weight is negatively associated. These results underscore the importance of rigorous prenatal follow-up to prevent neonatal complications.

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Author Contributions

Alphonse Sako AVOCEFOHOUN: conceptualization, methodology, data collection and analysis, interpretation of results, revision; Raimatou Lewemon Omonlola AKPONA, Nadège Nina BOKO and Francis T. M. HOUNSOU: methodology, data collection and analysis, interpretation of results, writing, revision; Worou Nicodème CHABI: data analysis, revision; Alassane ABDOU KARIM YOUSSAO: supervision; Papin Sourou MONTCHO: methodology, interpretation of results, revision, supervision.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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