MORPHOLOGICAL AND HISTOLOGICAL ALTERATIONS OF THE PLACENTA IN PREGNANCIES COMPLICATED BY DIABETES MELLITUS

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Annotation

This study investigates the profound morphological and histological alterations in the human placenta associated with maternal diabetes mellitus, encompassing both gestational (GDM) and pre-gestational diabetes. As the critical interface between mother and fetus, the placenta undergoes significant structural adaptations in response to the hyperglycemic and hypoxic environment characteristic of diabetic pregnancies. Through macroscopic, histological, and morphometric analyses of placentas obtained post-delivery, we compared the pathological changes in diabetic groups against healthy controls. The findings highlight severe structural anomalies, including placentomegaly, villous immaturity, chorangiosis, thickening of the trophoblastic basement membrane, and increased fibrinoid necrosis. This study underscores the direct correlation between maternal glycemic control and placental structural integrity, emphasizing how these morphological shifts contribute to adverse fetal outcomes such as macrosomia and chronic fetal hypoxia.

Key Words: diabetes mellitus, placenta, morphological changes, chorangiosis, villous immaturity, maternal-fetal interface, hypoxia, trophoblastic basement membrane.

Introduction

Diabetes mellitus during pregnancy, whether pre-existing (Type 1 or Type 2) or gestational, presents a complex metabolic challenge that significantly impacts both maternal and fetal health. The placenta, a highly dynamic and responsive organ, acts as the primary mediator of this environment. In a diabetic pregnancy, maternal hyperglycemia leads to fetal hyperglycemia, subsequently triggering fetal hyperinsulinemia. This metabolic cascade drastically alters the intrauterine environment, inducing oxidative stress and relative fetal hypoxia.

To maintain adequate nutrient and gas exchange under these adverse conditions, the placenta undergoes various compensatory, though often pathological, structural modifications. Understanding the precise microscopic and macroscopic morphological changes in the diabetic placenta is vital for deciphering the pathogenesis of pregnancy complications such as fetal macrosomia, stillbirth, and preeclampsia. This study aims to systematically evaluate the morphological deviations in diabetic placentas compared to normal term placentas, providing structural evidence of diabetes-induced placental dysfunction.

Material and Methods

1. Study Population A comparative observational study was conducted utilizing placental tissues collected immediately following delivery. The study included placentas from 60 pregnant women, categorized into two main groups:

- **Group 1 (Control):** Placentas from 30 healthy women with uncomplicated, normoglycemic, full-term pregnancies.
- **Group 2 (Diabetic):** Placentas from 30 women diagnosed with diabetes mellitus (comprising both GDM and poorly controlled pre-gestational diabetes) delivering at term.

2. Tissue Collection and Macroscopic Examination Immediately after expulsion, the placentas were weighed, measured (diameter and thickness), and examined for macroscopic abnormalities such as infarcts, calcifications, and abnormal cord insertions. The placental weight-to-birth weight ratio was calculated.

3. Histological Preparation Full-thickness tissue biopsies were obtained from the central, paracentral, and peripheral regions of the placental disc, avoiding areas of gross infarction. The samples were fixed in 10% neutral buffered formalin for 48 hours, processed routinely, and embedded in paraffin wax. Sections of 4–5 µm thickness were stained using:

- **Hematoxylin and Eosin (H&E):** For routine histological evaluation of villous architecture.
- **Masson's Trichrome:** To evaluate collagen deposition and fibrosis within the villous stroma.
- **Periodic Acid-Schiff (PAS):** To assess the thickening of the trophoblastic basement membrane.

4. Morphometric Analysis Microscopic evaluation focused on terminal villi structure. Parameters assessed included the degree of villous maturation, the presence of syncytial knots, the frequency of chorangiosis (defined as the presence of 10 or more

capillaries in at least 10 terminal villi in several fields), and the extent of fibrinoid necrosis.

Results and Discussion

Macroscopic Findings The placentas from the diabetic group exhibited significant macroscopic alterations compared to the control group. Placentomegaly was a prominent feature; the mean placental weight and volume were significantly higher in Group 2. Consequently, the placental weight-to-fetal weight ratio was elevated, indicating placental hypertrophy. Furthermore, the diabetic placentas frequently presented with a plethoric (congested) appearance, increased lobulation, and a higher incidence of marginal hematomas and focal calcifications.

Microscopic and Morphological Alterations Histological analysis revealed profound structural remodeling in the placentas of diabetic mothers:

- **Villous Immaturity:** The most consistent finding was delayed villous maturation (distal villous hypoplasia). The terminal villi were abnormally large, edematous, and featured a continuous, thick layer of syncytiotrophoblast, contrasting with the small, highly vascularized terminal villi typical of a healthy term placenta.
- **Vascular Abnormalities (Chorangiosis):** A highly significant increase in the capillary bed within the terminal villi was observed. This compensatory hypervascularization (chorangiosis) is a direct morphological response to chronic pre-placental hypoxia driven by increased fetal metabolic demand.
- **Basement Membrane Thickening:** PAS staining demonstrated a marked, uniform thickening of the trophoblastic basement membrane and the basal lamina of fetal capillaries. This thickening acts as a physical barrier, significantly increasing the diffusion distance for oxygen and nutrients.
- **Fibrinoid Necrosis and Syncytial Knots:** The diabetic group showed extensive perivillous fibrinoid deposition and an increased formation of syncytial knots, indicating accelerated placental aging and focal syncytiotrophoblast degeneration.

Discussion The morphological variations documented in this study reflect a classic maladaptive response to the altered metabolic milieu of diabetes. The combination of maternal hyperglycemia and resulting fetal hyperinsulinemia upregulates angiogenic factors (such as VEGF), driving the abnormal proliferation of fetal capillaries (chorangiosis) and increasing overall placental mass. However, the concurrent thickening of the basement membrane and delayed villous maturation functionally negate this increased vascularity by creating a thicker, less efficient diffusion barrier. This architectural paradox—increased vascular mass with decreased

functional efficiency—creates a vicious cycle of chronic fetal hypoxia, ultimately threatening fetal well-being and contributing to the high rates of perinatal morbidity associated with diabetic pregnancies.

Conclusion and Recommendation

Conclusion Maternal diabetes mellitus induces distinct and severe morphological alterations in the placenta, characterized macroscopically by placentomegaly and microscopically by delayed villous maturation, chorangiosis, basement membrane thickening, and increased fibrinoid necrosis. These structural changes represent a failed compensatory mechanism to overcome chronic intra-amniotic hypoxia and metabolic stress, directly impairing the placenta's functional capacity for gas and nutrient exchange.

Recommendation Given the severe impact of maternal dysglycemia on placental microarchitecture, strict glycemic control throughout the entirety of gestation is paramount to prevent these maladaptive morphological changes. Furthermore, clinical protocols should incorporate enhanced, high-resolution Doppler ultrasound monitoring during the third trimester to actively assess uteroplacental hemodynamics and early signs of placental hypertrophy, thereby allowing for timely clinical interventions to prevent adverse fetal outcomes.

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