HISTOMORPHOLOGY OF TERMINAL VILLI OF HUMAN PLACENTA AT LOW AND HIGH ALTITUDE WITH EMPHASIS ON BLOOD CAPILLARIES

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ABSTRACT

Objective: This cross sectional study is designed to compare the histomorphological characteristics of human placenta at high altitude (HA) i.e. Skardu (8500 ft) with those at low altitude (LA) i.e. Rawalpindi (1800 ft).

Study Design: Cross sectional comparative study

Place and duration of study: The study was conducted in the anatomy department of Army Medical College Rawalpindi, from October 2002 to April 2003.

Materials and methods: Eighty placentae, 40 each from normal cases at LA and HA, were included. Three full depth samples of placental tissue were taken. Histological study was done in Haematoxylin and eosin (H&E) and Periodic acid Schiff (PAS) stained sections. Detailed morphology of terminal villi was studied and number of capillaries was counted.

Results: The core of terminal villus in LA group contained few capillaries with considerable amount of stroma while in HA group it contained abundant dilated capillaries with very little stroma. Mean number of capillaries in LA and HA groups were 201.45 ± 2.692 and 216.97 ± 2.828 respectively.

Conclusion: The capillaries in terminal villi were dilated and there number was significantly more in high altitude group probably showing adaptive changes in response to hypoxia.

Keywords: High Altitude, terminal villi, angiogenesis.

INTRODUCTION

The placenta is essential for maintaining pregnancy and promoting normal fetal development. This fetomaternal organ comprises of a fetal portion "the chorionic plate" and a maternal portion "the decidual plate" separated by a lacunar space "the intervillous space [1]. A large number of finger like projections, "the villi" project into this lacunar space. These villi are comprised of a highly cellular core of mesenchyme invested by the trophoblast. The trophoblast in turn is composed of outer syncytiotrophoblast and inner cytotrophoblast. The syncytiotrophoblast forms the primary barrier between mother and fetus [2].

The villi arising from the chorionic plate are the stem villi. Repeated branching of these stem villi into the intervillous space (IVS) results in formation of branching villi. The branching villi further give rise to free or terminal villi, which are completely surrounded by maternal blood. These are the site of fetomaternal exchange.

The structure of a terminal villus modifies with advancement of pregnancy. Villi of first trimester are lined by a thick layer of syncytiotrophoblast and cytotrophoblast, and contain capillary loops. Later they contain dilated fetal capillaries lying close to or even bulging the surface of syncytiotrophoblast in thin regions. Consequently the diffusion distance between maternal blood in the intervillous space and fetal blood in placental capillaries is greatly reduced in the later placenta facilitating oxygenation of fetal blood [3].

In a normal individual living at high altitude, hypoxic hypoxia is a problem. The composition of the air stays the same but the total barometric pressure falls with increasing altitude. Therefore the PO2 also falls. At 3000 meter above sea level (approximately 10,000

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ft) the alveolar PO2 is about 60 mm Hg and there is enough stimulation of the chemoreceptors to definitely increase ventilation [4].

Development of villi is dependent upon many factors; the exposure to reduced partial pressure of oxygen at high altitude is one of those. The effects of hypoxia may complicate pregnancies that occur at high altitude. There are many maternal and placental mechanisms that are brought to brunt the effects of hypoxia in the fetus. Altitude differences in specific gravity of placenta raise the possibility of underlying alterations in placental composition [5]. The placental samples from high altitude also showed altered branching pattern of the villous tree [6] but the quantitative analysis is lacking.

In view of this background knowledge the current study has been designed to compare the histomorphological characteristics of human placenta at high altitude ith those close to sea level with special reference to the number of capillaries in terminal villi.

MATERIALS AND METHODS

A total of 80 placentae from normal full term pregnancies were collected randomly. 40 High altitude (HA) samples were collected from Obstetric Department of District Headquarters Hospital Skardu, while 40 low altitude (LA) samples were collected from department of Gynecology and Obstetrics of Military Hospital Rawalpindi. Placenta from those pregnant women were included who remained at the same altitude (either low or high) throughout the gestational period. Secondly placenta of normal healthy neonates having birth weight 2500 gm or more were included.

Immediately following delivery, membranes were trimmed and placenta was placed in 10% Formol saline solution for 24 - 48 hours. It was then divided into two halves. The half of placenta containing insertion of umbilical cord was taken and a slice of about 1cm thickness was cut. Three full depth samples of placental tissue, were cut from this slice i.e. one from close to umbilical cord insertion (A), one from periphery (C) and one midway between A and C (B).

Specimens were further processes for paraffin sectioning and 4-5 μm thick sections were made and stained with H&E and PAS. Microscopic examination was carried out on terminal villi. They were recognized as smallest villi containing capillary loops and completely surrounded by blood. Complete circular cross sections were selected. The number of capillaries was counted randomly in five high power fields per slide using 40X objective.

The data was fed in computer program SPSS.10 for Windows. The statistical significance of difference between the number of capillaries in two groups was evaluated by using "Student's t-test". The difference was regarded significant if p value was less than 0.05.

RESULTS

The histological appearance of the placenta in LA and HA groups was similar. It was composed of two layered structures, chorionic plate and decidual plate, with an intervening intervillous space. Chorionic plate was a layer of connective tissue containing blood vessels and lined by squamous cells. The decidual layer was composed of large polyhedral decidual cells with eosinophilic cytoplasm and large vesicular nuclei. From this layer a large number of decidual septae were extending towards the intervening space. The IVS contained RBCs and cross sections of various villi. The smallest terminal villi were seen lying free in the IVS (fig.1).

The terminal villi were lined by the syncytiotrophoblast and cytotrophoblast. The core of the villus contained highly cellular stroma which was loosely arranged. A large number of capillaries were present within the stroma. These capillaries were at places situated close to the periphery of the villi. They were lined by flat endothelial cells and contained numerous RBCs. The IVS also contained a large number of RBCs (fig-2).

The distinguishing features between two groups were; firstly the core of terminal villus

in LA group contained few capillaries with considerable amount of stroma (fig-3) while in HA group it contained abundant capillaries with very little stroma (fig-4). Secondly in HA group these capillaries were lined by more widely spaced endothelial cells and were more dilated thus stretching the villous membrane (fig-4).

Number of capillaries was counted in five different high power fields per slide from all three regions i.e. A, B and C. In LA group mean number of capillaries in these regions was 82.55 + 1.376, 65.12 ± 1.227 and 52.87 ± 0.980 respectively (table-1). Mean number of capillaries in HA group in A, B and C regions was 88.10 ± 1.379, 71.00 ± 1.025 and 59.52 ± 1.212 respectively (fig-5). The quantitative difference between number of capillaries in A, B and C regions in LA and HA group was statistically significant (table-1).

On pooling the data from three regions the mean number of capillaries in LA and HA groups was 201.45 ± 2.692 and 216.97 ± 2.828 respectively. The quantitative difference between total number of capillaries in LA and HA groups was statistically significant (table-2).

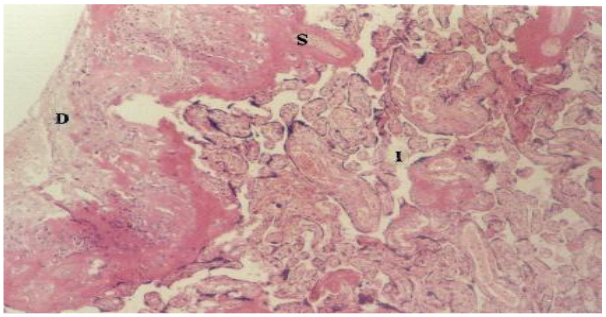

Fig-1: Section of human placental tissue showing decidual plate (d), decidual septae (s) and intervillous space (i). Case no 22 - la. H&e stain. Photomicrograph Approx 240x

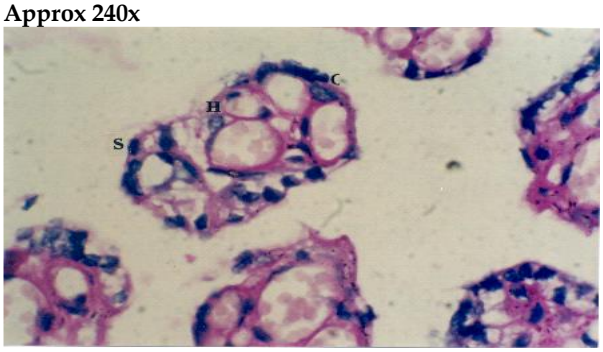

Fig- 2: Photomicrograph showing terminal villus with syncytial cells (S), cytotrophoblast (C), Hofbauer cell (H). Case no 25-LA PAS stain Approx 2400X

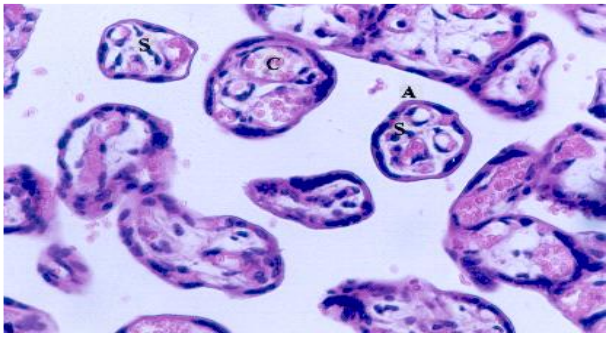

Fig.3: Section of human placental tissue showing terminal villi (A) with capillaries (C) and stroma (S). Case no 20-LA.PAS stain. Photomicrograph Approx 1200X

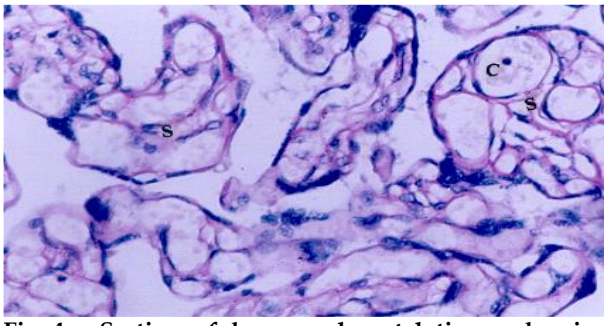

Fig -4: Section of human placental tissue showing terminal villi with capillaries (C) and stroma (S). Case no 5-HA. PAS stain. Photomicrograph Approx. 1200X

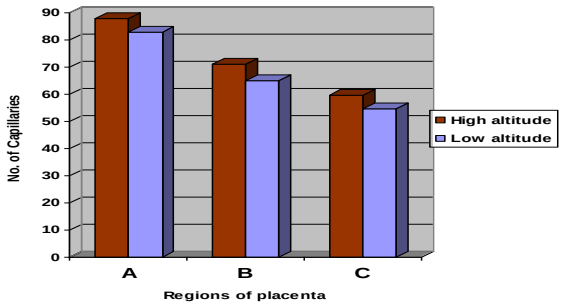

Fig 5: Mean number of capillaries in different regions of placenta in LA and HA groups

DISCUSSION

It is estimated that throughout the world a large population (30 million people) permanently live at altitudes i.e. about 2500 meters above sea level [7]. The pregnancies that occur at high altitude are bedeviled by many complications particularly those due to atmospheric pressure disturbances.

Human high-altitude fetus is subjected to the double insult of hypoxia; firstly due to lowered maternal arterial PO2 and secondly due to decreased uterine blood flow [8]. Observations on placental circulation by Chabes et al [9]. Suggested that fetus is shielded from the hypoxic environment. It

Table-1: Mean Number of Capillaries in La and Ha Groups

Parameters	Regions of Placenta	LA Group Mean ± S.E. n = 40	HA Group Mean ± S.E. N = 40	Statistical significance between LA and HA groups
Number of capillaries	A	82.55 ± 1.376	88.10 ± 1.379	P<0.05
	B	65.12 ± 1.227	71.00 ± 1.025	P<0.05
	C	52.87 ± 0.980	59.52 ± 1.212	P<0.05

Table –2: On Pooling the Data of all the three Regions Mean Number of Syncytial Knots in La and Ha Groups

Parameters	LA Group Mean ± S.E. n = 40	HA Group Mean + S.E.n = 40	Statistical Significance of difference between LA and HA groups
Number of capillaries	201.45 ± 2.692	216.97 ± 2.828	P<0.05

means that the rate, at which oxygen is delivered to the fetus, is regulated through certain placental mechanism which we tried to reveal in our study.

In our study the histological picture of placental tissue exhibited chorionic plate and decidual plate with intervening IVS. The appearance of chorionic plate and decidual plate was similar in both groups. Histological appearance of IVS revealed some differences in two groups. Capillaries within the terminal villi were found to be more dilated in HA group. They were not of uniform caliber but displayed highly dilated segments. Similar findings have been reported and these segments have been referred to as "sinusoids" which occur on the outer wall of a tight capillary bend where the wall tension is highest [10]. Our results are also supported by Mayhew [11] and according to him these segments lead to thinning of diffusion pathway as an adaptive reaction in response to fetal hypoxia. Kingdom et al [12] observed that type IV collagen in the surrounding basement membrane, potentially encircle capillaries and resist dilatation, but they are absent in the vicinity of the sinusoids.

Our study showed that number of capillaries was significantly more at HA. This is to some extent supported by most of the previous studies. Burton [13] reported increase in volume of capillaries accompanied by reduction in volume of stromal tissue at HA. Ali [14] documented increased branching and reduced coiling of fetal capillaries in HA placenta leading to shorter capillary loops which probably helps in rapid saturation of fetal hemoglobin by preventing travel along longer capillary loops.

The most consistent observation about HA placenta was increased vasculogenesis and angiogenesis, which may compensate to some extent for the hypoxia [15].

Excessive peripheral villous capillarization has been reported in pregnancies at HA, smoking and anemia. These are probably due to impaired oxygen delivery to placenta. Results of our study quantitatively proved these qualitative observations. This is in accordance with the concept of "placental hypoxia" which stated that it is the placenta not the fetus that is initially affected by failure of transformation of uteroplacental circulation.

CONCLUSION

Our study showed some qualitative as well as quantitative differences in placental samples from low and high altitude groups.

In LA group the core of terminal villi contained few capillaries with considerable amount of stroma while in HA group they contained abundant dilated capillaries with very little stroma. These capillaries were lined by more widely spaced endothelial cells. The number of capillaries in different regions of placenta in HA groups was significantly more.

Thus our study indicates some of the adaptive changes which placenta has to adopt to overcome the brunt of reduced oxygen supply thus leading to birth of normal healthy baby at high altitude.

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