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Placental Index, Placental Characteristics, Birth Weight, and Neonatal Outcome in Pregnancies

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Abstract

BACKGROUND: Recent studies have highlighted the clinical importance of placental weight, as predictors of maternal and neonatal morbidity and mortality. The placental index is the ratio between placental weight and fetal weight. Placental index is considered as a placental efficiency indicator.

AIM: This study aimed to describe and determine correlation of placental index with pregnancy and neonatal outcome.

METHODS: This study used a cross-sectional design using primary data obtained from Mitra Sejati, Herna, and Methodist Sussana-Wesley Hospital in Medan, Indonesia, for all women with singleton term pregnancy from January to August 2020 and 200 pregnancies were included in this study.

RESULTS: Mean birthweight was 3197.47 ± 512.26 g. Mean placental weight was 583.85 ± 96.71 g. Mean placental index was 0.18 ± 0.02. There were no significant mean placental index difference in gravida, parity, neonatal gender, and umbilical cord insertion group. There was a significant positive correlation between birth weight and placental weight (r = 0.52) and a significant and progressive placental index decrease in birth weight group. There was no significant correlation between placental index and Apgar score at 1 and 5 min.

CONCLUSION: Placental index was not associated to maternal age, maternal BMI, maternal gravida and parity level, neonates gender, umbilical cord insertion, and Apgar score at 1 and 5 min. There was a significant positive moderate correlation between birth weight and placental weight, meaning an increase in birth weight will be followed by increased placental weight.

Introduction

Placental anatomy, physiology, and molecular structure remain some of the most intriguing and understudied topics in obstetrics. The placenta translates how the fetus experiences the maternal environment, thus placental characteristics is clinically important as a neonatal and maternal morbidity and mortality predictor [1].

At term, the typical placenta weights 470 g, is round to oval, with a 22 cm diameter and has a central thickness of 2.5 cm. Routine placental pathological examination is not mandatory, unless there are specific indications, including preterm or post-term delivery (maternal indications), birth weight ≤10th or ≥95th percentile, fetal or neonatal compromise (fetal indications), and marginal or velamentous cord insertion and markedly abnormal placenta shape or size (placental indications) [2], [3].

Placental index is defined as the ratio between the placental weight and the fetal weight [4]. Placental index is an important marker used as an index of placental nutrient transport efficiency and found to be associated to adult onset of coronary artery disease, diabetes, and stroke [5], [6], [7]. Placental index has also been suggested to be useful in studying impaired fetal growth [8].

The relationship between placental weight and infant size at birth has been studied for over a century. The previous studies have shown that placental weight is associated with pregnancy outcomes. High placental weight was associated with poor perinatal outcomes, decreased Apgar scores, respiratory distress syndrome, and perinatal mortality. On the other hand, low placental weight was associated with maternal medical complications. Barker *et al*. reported that changes in placental growth have been reported to be predictors of maternal conditions such as cardiovascular disease, hypertension, and diabetes. Other factors such as race and socioeconomic status also affect placental weight [9].

During pregnancy, oxygen is transferred from the mother's circulation through the placenta to the fetus, and impaired placental function can lead to suboptimal oxygen levels in the fetus and lower Apgar scores. Higher placental weight compared to birth weight has been reported to result in the lower Apgar scores [10].

Appropriate fetal growth depends on the proper movement of nutrients through the placenta.

The placental index is often used as a substitute for placental efficiency. The increase in placental index of a properly grown fetus (small placenta) is thought to be due to upregulation of the placenta's ability to move nutrients. In fetal growth retardation (FGR), placental index often decrease when the fetus is genetically below its prescribed growth capacity. This may indicate that the placenta does not regulate nutrient transfer capacity to accommodate its small size. Evidence showing that changes in placental index were matched with similar alterations in placental nutrient transfer may help to identify those placentas adapting, or failing to adapt, their placental nutrient transfer according to fetal demand. This is important because, taking the example of FGR, a reduced placental index may be indicative of inadequate placental nutrient transfer [11].

Placental weight is associated with many common pregnancy complications. Low placental weight found in pregnancies complicated by pre-eclampsia, preterm delivery, stillbirth, and low birth weight while high placental weight is more likely in pregnancies with post-term delivery and high birth weight [1]. Placental index is also related to placental anatomy characteristics. Abnormal umbilical cord insertion (non-central) is associated to lower placental index, whereas small and thin placentas are associated to high placental index [12]. Placental index is also found higher in male fetuses than female fetuses and correlates to gestational week [4].

A study conducted in Italy by Londero [4] found high placental index among pregnancies characterized by poor outcomes and conceived by *in vitro* fertilization or intracytoplasmic sperm injection. Until recently, research and study describing correlation of placental index with pregnancy and neonatal outcome placental index in Indonesia remains largely unknown. The objective of this study was to describe and determine correlation of placental index with pregnancies (maternal age, maternal body mass index, placental weight, parity level, and umbilical cord insertion) and neonatal outcome (birth weight and Apgar score).

Materials and Methods

This study used a cross-sectional design using primary data obtained from January to August 2020 at Mitra Sejati, Herna, and Methodist Sussana Wesley Hospital in Medan, Indonesia. This study included all women delivering singleton term pregnancy (37 – 42 weeks of gestation), a total of 200 pregnancies are recruited. Exclusion criteria were pregnancy with fetal anomalies, multiple gestation, intrauterine fetal death, and incomplete medical record.

Maternal characteristics were recorded at enrollment. Maternal age at delivery in years, maternal weight in kilogram, maternal height in meters, the pregnancy history, and parity level. The newborn was weighed soon after delivery on electronic scales. Placentas also were weighed shortly after delivery with membranes and umbilical cord attached after removal of the blood and the clot by an absorbable cotton pad. Placental index was calculated by dividing placental weight by birth weight, both in grams.

Umbilical cord insertion was determined by obstetrician on-site. The type of umbilical cord insertion were categorized as central, lateral, marginal, and velamentous. Central insertion defined as umbilical cord insertion near the center of the placenta (i.e., less than 3 cm from the center). Lateral insertion was defined as umbilical cord insertion more than 3 cm from the center and more than 2 cm from the nearest margin. Marginal insertion was defined as umbilical cord insertion within 2 cm of the disc's edge, whereas velamentous insertion represents an umbilical cord insertion directly into the membranes [13].

Data were analyzed using Spearman correlation test, Mann–Whitney and Kruskal–Wallis test to determine the mean placental index difference between groups. Statistical analysis was performed using SPSS version 22 and considered p value < 0.05 statistically significant.

Results

The characteristics of subjects are shown in Table 1. In our study, mean maternal age at delivery was 29.5 ± 5.30 years (range 17-43 years). Mean newborn weight was 3197.47 ± 512.26 gram (range 1170-4500 gram), 57.5% of infants were male and 42.4% were female. Mean placental weight was 583.85 ± 96.71 gram (range 300-900 gram). Mean placental index was 0.18 ± 0.02 (range 0.13-0.30).

Table 1: Characteristics of subjects

Characteristics	N (%)
Total	200 (100)
Placental index (Mean ± SD)	0.18 ± 0.02
Maternal age (Mean ± SD)	29.5 ± 5.30
Maternal weight (kg) (Mean ± SD)	70.87 ± 11.00
Maternal BMI (kg/m^2) (Mean ± SD)	29.48 ± 5.04
Gravida	
Primigravida	60 (30)
Multigravida	140 (70)
Parity	
Nulliparity	62 (31)
Primiparity	68 (34)
Multiparity	70 (35)
Umbilical cord insertion	
Central	91 (45.5)
Lateral (paracentral)	93 (46.5)
Marginal	15 (7.5)
Velamentous	1 (0.5)
Neonatal gender	
Male	115 (57.5)
Female	85 (42.5)
Neonatal Weight (gram) (Mean ± SD)	3197.47 ± 512.26
< 2500	14 (7)
2500–4000	180 (90)
> 4000	6 (3)
Apgar 1 min (Mean ± SD)	7.22 ± 0.78
Apgar 5 min (Mean ± SD)	8.10 ± 0.42

Using Mann–Whitney test, there were no significant mean placental index difference between male (0.183 ± 0.02) and female (0.188 ± 0.03) neonates and primigravida (0.183 ± 0.02) and multigravida (0.185 ± 0.03). There was also no significant mean placental index difference based on parity level and umbilical cord insertion group using Kruskal–Wallis test ($p > 0.05$). There was a significant and progressive placental index mean difference in birth weight group: from 0.22 ± 0.04 in neonates weighing <2500 g to 0.17 ± 0.02 in neonates weighing >4000 g ($p < 0.05$). Using Spearman correlation test, there was also a significant negative moderate correlation between placental index and birth weight group ($r = -0.39$; $p < 0.05$), described in Table 2. Meaning a decrease in placental index will be followed by increased birth weight.

Table 2: Placental index based on characteristics

Characteristics	N (%)	Placental Index (Mean ± SD)	p value
Gravida			0.72[a]
Primigravida	60 (30)	0.183 ± 0.02	
Multigravida	140 (70)	0.185 ± 0.03	
Parity			0.10[b]
Nulliparity	62 (31)	0.183 ± 0.02	
Primiparity	68 (34)	0.180 ± 0.02	
Multiparity	70 (35)	0.190 ± 0.03	
Umbilical Cord Insertion			0.47[b]
Central	91 (45.5)	0.18 ± 0.02	
Lateral (paracentral)	93 (46.5)	0.19 ± 0.03	
Marginal	15 (7.5)	0.17 ± 0.02	
Velamentous	1 (0.5)	0.17 ± 0.00	
Neonatal Gender			0.43[a]
Male	115 (57.5)	0.183 ± 0.02	
Female	85 (42.5)	0.188 ± 0.03	
Neonatal Weight (gram)			<0.05[b]
< 2500	14 (7)	0.22 ± 0.04	
2500 – 4000	180 (90)	0.18 ± 0.02*	
> 4000	6 (3)	0.17 ± 0.02*	
Apgar score at 1 min			0.38[a]
< 7	3 (1.5)	0.21 ± 0.06	
≥ 7	197 (98.5)	0.18 ± 0.02	

[a]Mann–Whitney test, [b]Kruskal–Wallis test. *$p < 0.05$ as compared to Neonatal Weight< 2500 g group, with $R = -0.39$ ($p < 0.05$).

There was no significant correlation between placental index and Apgar score at 1 and 5 min, but there was a significant positive moderate correlation between birth weight and placental weight, meaning an increase in birth weight will be followed by increased placental weight ($r = 0.52$; $p < 0.05$).

Discussion

There were 200 pregnancies recruited in this study, shows there was no mean placental index difference in neonates gender, parity, and umbilical cord insertion group, no significant correlation between placental index and Apgar score at 1 and 5 min. There was a significant and progressive placental index mean difference in birth weight group and a significant negative moderate correlation between placental index and birth weight group, meaning a decrease in placental index will be followed by increased birth weight. There was a significant positive moderate correlation between birth weight and placental weight, meaning an increase in birth weight will be followed by increased placental weight.

Earlier study conducted by Lurie *et al*. [14] found the mean fetal-placental weight ratio (this study used placental-fetal weight ratio) in normal singleton near term pregnancies is 5.6 ± 0.96, with a wide range 2.9–10.6. Our study shows similar results with mean fetal placental weight ratio was 5.5 ± 0.80, ranging from 3.3 to 7.8.

Recently Londero *et al*. [4] found that high placental index was associated to high maternal age, parity and prevalence of male infants. In this study, there were no significant correlation between placental index and maternal age, parity, and neonates gender. Our study was also found there were no significant mean placental index difference on both parity and neonates gender group. Mean placental index was slightly higher in female (0.188 ± 0.03) than male neonates (0.183 ± 0.02). At 40 weeks gestation, the fetal to placental weight ratio was higher in male compared with female deliveries but the median difference was very small and equivalent to that reported previously [15]. Male neonates had larger placentas at birth than females, whereas their placentas were smaller than those of females when related to the weight of the baby. This is suggesting that male's placentas are more efficient than female's placentas, but may have less reserve capacity [16]. Irrespective, the mean placental index difference on neonates gender group was very small and unlikely explain the differences in developmental programming in males compared to females.

Londero *et al*. [4] also found that placental index was higher in newborn with Apgar score at 1 min <6 points with adjusted OR 3.58. In our study, we confirmed that the placental index was higher in neonates with Apgar score at 1 min <7 thus needed neonatal resuscitation than neonates with Apgar score ≥7, despite was not statistically significant.

There was a significant and progressive placental index mean difference in birth weight group and a significant negative moderate correlation between placental index and birth weight group, meaning an decrease in placental index will be followed by increased birth weight. These results might be showing the fetus growth disproportionate to placental growth.

Placental index is affected by many factors, such as maternal nutritional status, maternal metabolism, and hypertensive disorders in pregnancy. Poor maternal nutritional status and metabolism, and concurrent hypertensive disorder in pregnancy could lower the placental weight, thus lower the placental index, despite the neonates gender.

The strength of this study is to the best of our knowledge this is one of the few study in Indonesia to describe and determine placental index and placental characteristics correlation to maternal age, weight, BMI, parity level, neonates gender, birth weight, umbilical cord insertion, and neonatal outcome (Apgar score).

Limitations in this study include weighing the untrimmed placenta (with the membrane and umbilical cord attached) that is arguably more prone to error than weighing without membrane and umbilical cord. However, until today, this guideline is still unclear.

Nevertheless, we believe that these data and results may be useful to encourage further research to define and help us to better understand the relationship between placental index and characteristics and its influence on maternal outcome and neonatal outcome.

Conclusion

Placental index was not associated to maternal age, maternal BMI, maternal gravida and parity level, neonates gender, umbilical cord insertion, and Apgar score at 1 and 5 min. There was a significant positive moderate correlation between birth weight and placental weight, meaning an increase in birth weight will be followed by increased placental weight. We believe the information provided in this article is useful to both clinicians and researchers for further studies.

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