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Placental weight, birth weight and fetal:placental weight ratio in dichorionic and monochorionic twin gestations in function of gestational age, cord insertion type and placental partition

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ABSTRACT

Introduction: We established reference values for placental weight, birth weight, and fetal:placental weight ratio (FPR) (a possible index of placental functional efficiency) in monochorionic and dichorionic twin gestations.
Methods: Placental weight, birth weight, and FPR in function of gestational age, cord insertion type and placental sharing were determined in 151 dye-injected diamniotic-monochorionic and 198 double-disc diamniotic-dichorionic twin placentas (25–39 weeks' gestation).
Results: As expected, FPR values increased with gestational age in both groups. Birth weights and placental weights of monochorionic twins >28 weeks' gestation were significantly lower than those of age-matched dichorionic twins. When stratified per placental weight, the birth weights and FPR values of monochorionic twins were overall lower than those of dichorionic twins within the same placental weight category. However, in the subset of monochorionic twins with small share in unevenly partitioned placentas, birth weights and FPR values per placental weight were similar to those of dichorionic twins, and significantly higher than those of monochorionic twins with larger share or even placental sharing. Cord insertion type did not correlate with birth weight or FPR values per placental weight in either twin type.
Discussion: Reference values were generated for placental weight, birth weight and FPR in monochorionic and double-disc dichorionic twins. The generally lower FPR per placental weight in monochorionic twins compared with dichorionic twins is suggestive of inherently lower placental functional efficiency in monochorionic gestations. The mechanisms and clinical implications of the apparent differential modulation of FPR/efficiency in monochorionic twins according to placental partitioning remain to be determined.

1. Introduction

Recent studies have highlighted the clinical importance of placental weight, and of the relationship between placental weight and birth weight, as predictors of maternal disease, obstetrical outcome, perinatal or neonatal morbidity and mortality, and childhood development [1–4]. Furthermore, placental weight and/or fetal:placental weight ratio (FPR, grams of fetus sustained per gram of placenta), which is often considered a proxy of placental functional efficiency, have been linked to adult onset of coronary artery disease, hypertension in childhood or adulthood, diabetes and stroke [4–10]. More recently, associations have been reported between placental size and risk for colorectal cancer [11], sudden cardiac death [12] and even lifespan [13].

This heightened interest in placental weight and its relationship with birth weight as potential determinants of lifelong health has increased the clinical and investigational relevance of reference values for normal placental and birth weights, preferably reflecting

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a contemporary patient population. Whereas numerous reference charts for placental weight, birth weight, and corresponding FPR values in singletons have been published [14–19], surprisingly few studies have addressed the relationship between placental weight and birth weight in twins. To our knowledge, only two previous twin studies have included fetal:placental or placental:fetal weight ratios; these studies involved either dichorionic twins [20] or monochorionic twins [21].

In singleton placentas, FPR has been reported to be influenced by placental anatomic characteristics. Specifically, abnormal (non-central) cord insertion has been linked to a reduction of FPR in singletons [22,23], whereas FPR values tend to be higher in small and thin placentas [18,24–26]. The correlation between these placental characteristics and FPR values in twin gestations remains largely undetermined, but is highly pertinent in view of the high prevalence of abnormal cord insertion and aberrations of placental size and shape (uneven partitioning) in twins. The aims of this study were: 1) to establish age-specific reference values for placental weight, birth weight, and FPR in large cohorts of diamniotic-monochorionic and diamniotic-dichorionic twin gestations; and 2) to determine birth weight and FPR values in monochorionic and dichorionic twins in function of placental weight, cord insertion type and placental partition. Studies of twin pregnancies, and in particular monochorionic twin pregnancies, may contribute to a deeper understanding of the mechanisms and clinical implications of placental and birth weight, as well as their interrelationship (FPR), as determinants of perinatal and lifelong outcome.

2. Materials and methods

2.1. Patient populations

A prospective cohort of 227 consecutive monochorionic placentas was examined at the Department of Pathology at Women and Infants Hospital between 2009 and 2013. Placentas from higher order multiple births (9), monochorionic-monoamniotic placentas (8), placentas with remote (>48 h prior to delivery) fetal demise of one twin (5), placentas from twins with congenital or chromosomal anomalies (2), placentas from pregnancies with twin–twin transfusion syndrome (TTTS) (24) and placentas from previable infants (<23 weeks gestation) (2) were excluded. In addition, we excluded 26 placentas in which injection could not be performed, either due to marked disruption of the chorionic plate (12), or inadvertent prior fixation (2), or for logistical reasons (12). The remaining 151 diamniotic-monochorionic twin placentas (i.e. 302 individual twins) (77% of total) constituted the monochorionic cohort in this study.

Data obtained in monochorionic twin placentas were compared with diamniotic-dichorionic twin placentas, retrospectively retrieved from the archives of Women and Infants Hospital. Between 2010 and 2013, 619 dichorionic placentas were examined. Of these 619 placentas, 299 were fused (single-disc), 72 had no clear orientation of twins, 22 were associated with fetal demise of at least one twin, 10 had no reliable recording of birth weight, and 18 were excluded for miscellaneous reasons (such as higher order multiple gestation and congenital anomalies). The present study involved the remaining 198 double-disc dichorionic twin placentas (32% of total), which had appropriately labeled twin cords, available birth weights, and no history of fetal demise or anomalies. Fused-disc dichorionic twin placentas were excluded because their relative partition had been roughly estimated by gross examination of the position of the intertwin membrane; the size estimates of the individual discs thus obtained were deemed insufficiently accurate to allow inclusion in the current study. For all pregnancies, the accompanying patient charts were reviewed to determine the gestational age, birth weights of both twins, presence/absence of TTTS (for monochorionic twins), and presence/absence of congenital or chromosomal anomalies.

2.2. Analysis of type of cord insertion

Gross examination of the placenta was performed as previously described in detail [27,28]. The placentas were examined in fresh state at time intervals ranging between 2 and 48 h after delivery, depending on the timing of delivery with respect to the workweek. The type of cord insertion was categorized as paracentral, marginal, or velamentous (the latter two combined under the term “peripheral” cord insertion in this study). Paracentral (PC) cord insertion was defined as cord insertion on the placental disc proper, and is used as an umbrella term for central, paracentral and eccentric (non-marginal) types of cord insertion. Velamentous cord insertion was defined as cord insertion into the fetal membranes rather than onto the placental disc; marginal cord insertion was defined as cord insertion at the edge of the placental disc. The (total) fresh placental weight was determined following trimming of membranes and cords. Chorionicity was confirmed by microscopic examination of the dividing membrane in all cases.

2.3. Analysis of choriovascular distribution, surface area and (estimated) weight of each individual twin territory in monochorionic twin placentas

Monochorionic twin placentas were subjected to color-coded injection of the chorionic plate arteries and veins, as previously described [27]. The injected placentas were photographed. Determination of the relative placental share of each twin was based on the distribution of the respective chorionic vasculature. The surface area of each individual twin's vascular territory was determined by image analysis of calibrated digital images of the placenta. Hereto, the peripheral extent of the vascular bed, demarcated by dye, was traced manually. The choriovascular surface area of each individual twin was expressed as a percentage of the total surface area. To determine the estimated placental weight of each individual twin, the fraction of the total placental surface area allotted to that twin, based on its choriovascular territory, was multiplied by the total placental weight. For the sake of convenience, the term ‘estimated individual placental weight’ of monochorionic twin placentas will from here on be abbreviated to ‘individual placental weight’. The fetal:placental weight ratio (FPR) was calculated by dividing the twin's birth weight by its individual placental weight. Analysis of the placenta was performed by a single perinatal pathologist (MEDP) who had no knowledge of the clinical course or birth weights of the twins.

2.4. Data analysis

Values are expressed as mean ± standard deviation (SD) or median (range). The significance of differences between groups was determined by Student *t*-test, ANOVA with post-hoc Scheffe test, Fisher's exact test, or Wilcoxon matched pairs signed rank test, where applicable. Data were analyzed and graphically represented using GraphPad Prism 5 software (GraphPad Software Inc., San Diego, CA). The significance level was set at $P < 0.05$. The study was approved by the Institutional Review Board.

3. Results

3.1. Birth weight, placental weight and fetal:placental weight ratio in monochorionic and double-disc dichorionic twin pregnancies in function of gestational age

The gestational ages of the 151 diamniotic-monochorionic and 198 double-disc diamniotic-dichorionic twin sets included in this study ranged between 25 and 39 weeks (median age: 35 and 36 weeks, respectively). Based on the small number of dichorionic twins between 25 and 27 weeks' gestation available for study (2 sets), analysis of the correlation between age and placental or birth weights was focused on twins between 28 and 39 weeks' gestation. During this time period, the average birth weights of dichorionic and monochorionic twins increased by 66% and 74%, respectively (Table 1). The corresponding placental weights showed a relatively smaller increase (45% and 58% for dichorionic and monochorionic gestations, respectively). Reflecting this non-linear relationship between fetal and placental growth during the second and third trimesters of gestation, the FPR values of both groups showed a gradual increase from 5.67 g g^{-1} to 6.56 g g^{-1} in dichorionic twins and from 5.91 g g^{-1} to 6.47 g g^{-1} in monochorionic twins (Table 1).

From 28 weeks onward, the mean birth weights of monochorionic twins were significantly lower (about 200 g) than those of age-matched dichorionic twins (Table 1). Similarly, the placental weights of monochorionic twins older than 28 weeks' gestation tended to be lower than those of dichorionic twins, reaching statistically significant lower levels between 28–30 and 34–36 weeks. The FPR values of dichorionic and monochorionic twins were equivalent at all ages (Table 1).

3.2. Birth weight and fetal:placental weight ratio in monochorionic and double-disc dichorionic twin pregnancies in function of placental weight

The correlation between birth weight/FPR and placental weight was studied in twins older than 33 weeks' gestation, thus excluding