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Research Article

Neonatal Size and Birth Canal Dimensions

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Abstract

The limitation of the fetal growth process during pregnancy is supposed to be an adaptative response to a physical or a physiological constraint: the pelvic size or the maternal ressources and metabolism. In this study 131 mother-infant dyads were recruited. We investigate correlation between maternal traits (height, BMI) pelvic variables (conjugate diameter, inter-spinous diameter, sub-pubic angle) and neonatal traits (gestational age, birthweight, head, suboccipito-brematic and abdominal girth). We found that the three neonatal variables are significantly inter-correlated. Among maternal traits, height is highly correlated with conjugate and inter-spinous diameters. Subpubic angle is correlated with inter-spinous diameter. Among neonatal and pelvimetry correlations, conjugate diameter is highly correlated with suboccipito-bregmatic girth. The pelvic size seems to be the primary constraint to the fetal growth process. This adjustement of fetus size to the birth canal dimensions limits the risk of dystocia. But the way this adjustement occurs at the end of pregnancy is unclear. We assume that the uterus expansion limitation may be an intermediate mechanism explaining the high correlation between pelvic and neonatal traits.

Introduction

The physiology of birth process, timing of the pregnancy or the mechanism of fetal growth process remain unclear in many aspects. Among these mechanisms, the relationship between pelvic size, birthweight, and pregnancy length has been the source of many discussions. Some authors suggest that the pelvic size is a critical factor that adjusts the birthweight to limit the risk of fetal-pelvic disproportion [1, 4]. For others, the pelvic size plays a minor role and the mean cause of the fetal growth adjustement is due to metabolic limitations [5]. Morevover, low birthweight is correlated with a higher risk of neonatal mortality [6], and dystocia i.e. difficulties during labor, clearly represents a situation of high risk for the mother (ruptured uterus, fistula, maternal death) [7]. The size of the pelvis and fetus act in two opposite ways, explaining for some authors different aspects of the biology of human birth [8, 9]. In this context, from a recent work analyzing the correlation between body size, pelvic and neonatal traits [4], suggest that pelvic dimensions are better predictors of neonatal size rather than nutritional status. However, this work suffers from two mean limitations: the consideration of head girth which is not a variable related to obstetrical risk, and the use of clinic pelvimetry, i.e. external pelvimetric measurements, where variables are only proxies of the birth canal dimensions. In this work, we consider variables of the birth canal from pelvi-CTscans, and obstetrically relevant neonatal variables.

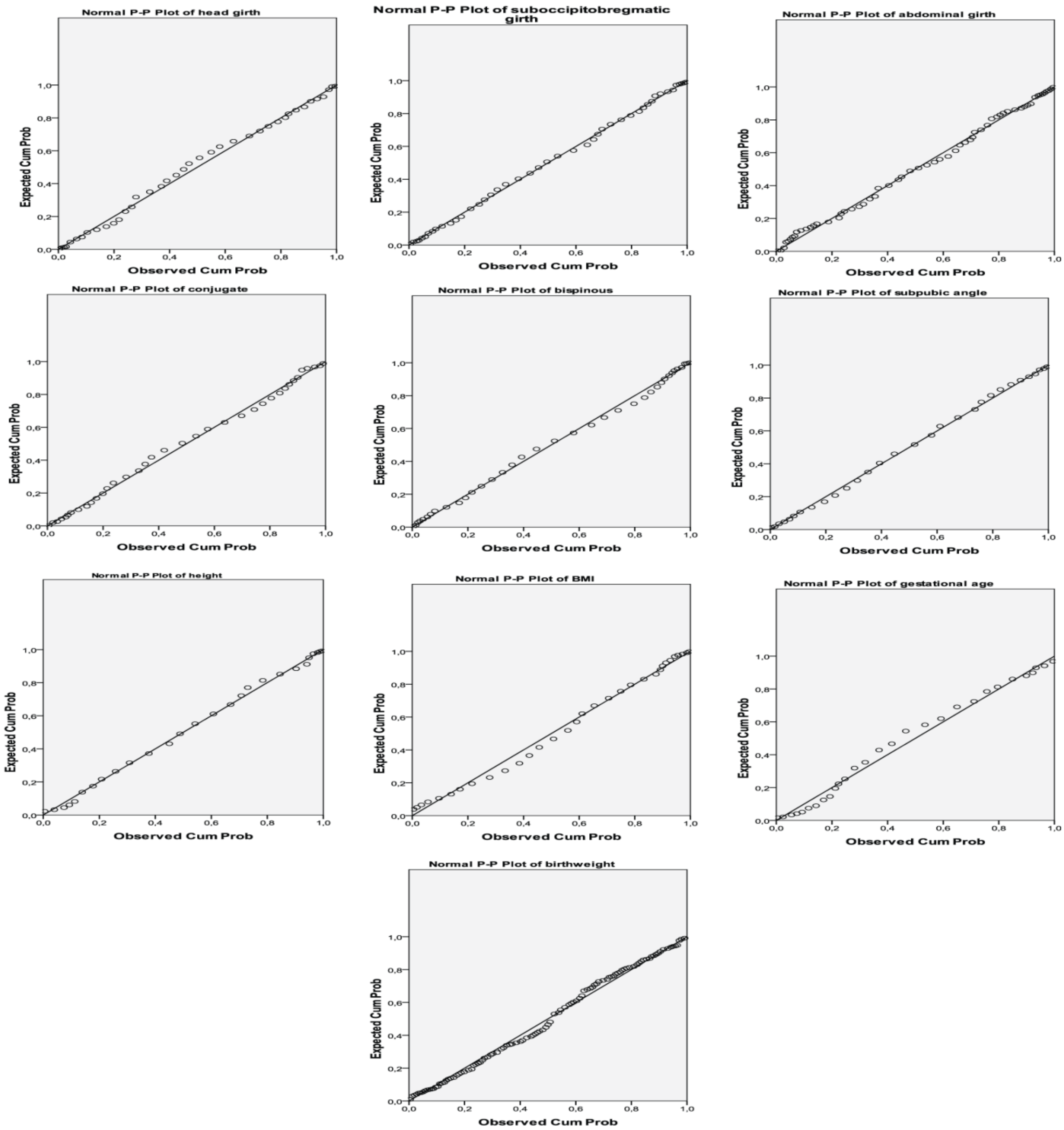
Methods

One hundred and thirty-one (131) women at Saint Joseph Hospital, March 29, 2011 to December 10, 2013 Marseille, France, were recruited in this single center study. The women were recruited from 10597 deliveries in the hospital. Among these 10597 women, only 3,7% of these had a CT scan (n=399). Among these 399 pregnant women, inclusion criterion was birth at term with a fetus in cephalic presentation. Exclusion criteria were maternal pre-eclampsia, twin pregnancies, caesarean deliveries performed in case of abnormal fetal heart rate, or before 2 hours of arrest of labor, in case of abnormal uterine contraction or iterative caesarean delivery. Newborns were also excluded if they had congenital infections, malformations or genetic syndroms. All the 131 women had both epidural anesthesia and a pelviscan before delivery. The center has three protocols for the pelvic scanning based on patient adiposity: low (100kV, 25mA); standard (100kV, 35 mA) and high adiposity (120kV, 35mA). These three protocols produce low level irradiation ranging from 15 mGy/cm to 35 mGy/cm. Indications were scar at uterus, breech presentation (during the pelviscan but cephalic presentation at the beginning of labor), suspicion or history of fetal-pelvic disproportion. CTscans were performed with a 16 Siemens Definition Flash strips scanner located in the Medical Imaging Department of our hospital. Intersection gap was 0.6-1 mm. The same operator (PF) performed the pelvic diameter measurements with Amira 5.0.0 software (FEI Visualization Sciences Group / Zuse Institute Berlin). The newborn measurements were performed during the postpartum period using anthropometric tools (cephalometric compass, tape measure, newborn scale). This study was approved by the South Mediterranean II Ethical Committee for Protection of Persons and written informed consent was obtained from all the patients. Normality of the sample was checked with the quantitative Jarque-Bera test and qualitatively with P-P plots. Correlation analyses were performed with SPSS Statistics 17.0. A correlation was significant with a p-value <0,05.

Results

The (Figure 1) shows the P-P plots of the maternal and neonatal traits: all the variables show a normal distribution. The (Table 1) shows the descriptive analysis of the sample of 131 mother-infant dyads. The mean maternal age is 31.9 years, ranging from 22 to 42 years. At the beginning of the pregnancy, the mean weight is 64.1 kg, ranging from 40 to 142 kg. At birth, the mean neonate weight is 3433 g, ranging from 2300 to 4600 g. (Table 2) shows crude correlations between maternal and neonatal traits. Among neonatal trait, the three neonatal variables are significantly inter-correlated with coefficients between 0,447 and 0,768.

Figure (1): P-P plots of the maternal and infant variables



Gestational age is correlated with all neonatal variables (birth weight, suboccipitobregmatic girth, head girth, abdominal girth) with coefficients ranging from 0,117 to 0,366. Among maternal traits, height is highly correlated with conjugate and inter-spinous diameters (r=0,424 and 0,299). Sub pubic angle is correlated with inter-spinous diameter (r=0,591). Among neonatal and pelvimetry correlations, conjugate diameter is highly correlated with suboccipito-bregmatic girth (r=0,235). Maternal stature is correlated with birth weight (r=0,220), suboccipitobregmatic girth (r=0,202), and abdominal girth (r=0,193). However, BMI is not correlated with maternal or neonatal traits

Table (1): Description of maternal and infant variables

Trait	Mean	SD	Range
Age (y)	31.9	4.5	22-42
Weight (kg)	64.1	14.1	40-142
Height (cm)	162.1	6.5	149-178
BMI (kg/m^2)	24.2	5.8	17-49
Conjugate diameter (mm)	121.1	9.2	95-142
Interspinous diameter (mm)	105.7	8.1	84-134
Subpubic angle (°)	83.7	6.9	68-100
Neonate Gestational age (wks)	39.5	1.1	37-41
Birth weight (g)	3433.3	489.9	2300-4600
Head girth (mm)	348.4	11.4	317-376
Suboccipitobregmatic girth (mm)	327.8	11.4	299-355
Abdominal girth (mm)	330.6	22.4	270-396

SD, standard deviation

Table (2): Correlations among maternal traits and neonatal size

	Maternal trait			**Neonatal trait**				
	Conjugate	Inter-spinous	Sub-pubic angle	Gestational age	Weight	Head girth	Suboccipito-bregmatic girth	Abdominal girth
Maternal trait								
Height	0,424**	0,299**	-0,047	0,068	0,220*	0 ,133	0,202*	0,193*
BMI	-0,160	0,105	-0,024	-0,004	0,132	0,148	0,113	0,010
Conjugate		0,079	-0,170	0,048	0,128	0,125	0,235**	0,132
Inter-spinous			0,591**	-0,105	0,127	0,101	0,085	0,146
Subpubic angle				-0,040	0,091	0,002	-0,004	0,058
Neonatal trait								
Gestational age					0,358**	0,366**	0,176*	0,283**
Weight						0,655**	0,645**	0,768**
Head girth							0,709**	0,449**
Suboccipito-bregmatic girth								0,447**
Abdominal girth								

*. Correlation is significant at the 0.05 level. **. Correlation is significant at the 0.01 level.

Discussion

Conjugate diameter represents the antero-posterior enlargment of the pelvic inlet. [10]the inlet is a rigid bony ring where the effect of pelvic relaxation is minimal. The inter-spinous diameter corresponds to the midplane breadth whereas the subpubic angle represents the anterior space of the outlet. Contrary to the inlet, dimensions of midplane and outlet increase during the birth process because the nutation and counternutation movements permit backward displacement of the 5th sacral vertebra. Therefore, these two last pelvic planes are not as critical during the fetal head descent as the inlet level. This different in obstetric significance should explain the close relationship between the conjugate diameter and the suboccipito-bregmatic girth. Moreover, the suboccipito-bregmatic girth represents the circumference of a cross-section of the well-flexed presentation, which is the most common presentation in eutocic deliveries, while it enters in the birth canal. It thus closely reflects the size of the presenting part at the inlet level. This may explains why correlation between conjugate diameter and head girth is absent in this work since head girth rarely represents the size of the presenting part (i.e. in case of deflexed presentation).

we did not find correlation between BMI and the rest of the variables. This nutritional status seems to be a weak predictor of neonatal trait [4]. However, we found correlations between maternal height and maternal pelvic size or neonatal trait. This is in accordance with the allometric relationship between the pelvic size and the rest of the body since the bi-iliac diameter is a proxy of the stature [11]. This relationship may explain the dystocic outcome for women less than 1, 60 m [12].

Correlation between maternal height and birthweight, but not BMI, suggest a singular physiologic tradeoff in the mother-infant dyads. The maternal height, conjugate diameter are highly correlated, as well as the sub-occipitobregmatic diameter and conjugate diameter. Our findings suggest that the inlet size may drive the fetal growth process to adjust the birthweight to the size of birth canal. This process may reduce the risk of fetal-pelvic disproportion, increases the chance of mother-infant survival rate in a non-medicalized context, and appears to be a strong selection force as suggest by [4].

However, the mechanism explaining the limitation of the fetal growth process is still unclear. [5] suggest that the limitation from the maternal metabolism is the primary constraints of fetal growth. But this hypothesis does not explain the correlation between the pelvis and the fetal size. The metabolic hypothesis could be a consequence of a physical process that induces the onset of labor; limits the gestation length and the fetal growth. An interresting trait that could be investigated in further works is the size of the uterus. As well, the uterus height is highly correlated to birthweight since it is used to assess the risk of intrauterine growth restriction in modern obstetrics practice [13]. However, the correlation between the pelvic and uterus size is still unclear. A simple variable such as the symphyseal fundal height should be considered in further investigations. The absence of this variable in this study is a limitation. Another limitation is the sample size, but the critical point is the CTscan indications since the CTscans a rare in modern obstetric, a study without indication of CTscan should be strongly limited by ethical considerations.

Conclusion

We found correlations between maternal height, conjugate diameter and neonatal traits. There is not a clear explanation of the correlation between the pelvic and neonatal traits, but we suggest that the limitation from the uterine expansion could be a physiologic constraint of fetal growth.

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