J Gynecol Obstet Hum Reprod xxx (2017) xxx–xxx

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com

Original Article

Customized and non-customized live-born birth-weight curves of single and uncomplicated pregnancies from the Burgundy perinatal network. Part I – methodology

T. Rousseau [a,*], O. Durand-Maison [b], C. Labruere-Chazal [c], F. Tabard [a], A. Jebrane [c], O. Martz [a], E. Benzenine [d], J. Cottenet [d], P. Sagot [a]

[a] *Service de gynécologie-obstétrique, médecine fœtale et reproduction humaine, CHU de Dijon, 14, rue Paul-Gaffarel, BP 77908, 21079 Dijon cedex, France*
[b] *Service de gynécologie-obstétrique, CH de Chalon-sur-Saône, 4, rue du Capitaine-Drillien, 71321 Chalon-sur-Saône, France*
[c] *UMR 5584 CNRS, institut de mathématiques de Bourgogne, université de Bourgogne Franche-Comté, BP 47870, 21078 Dijon cedex, France*
[d] *Réseau périnatal de Bourgogne, 4, boulevard Maréchal-de-Lattre-de-Tassigny, BP 77908, 21000 Dijon, France*

ARTICLE INFO

Article history:
Received 10 February 2017
Received in revised form 5 May 2017
Accepted 11 May 2017
Available online xxx

Keywords:
Birthweight
Customized charts
Intrauterine growth restriction
Perinatal network
Small for gestational age
Weight curves

ABSTRACT

Objectives. – To establish non-customized and customized birth-weight curves of single and uncomplicated pregnancies according to gestational age.
Materials and methods. – We used data for 64,173 mother–infants pairs from the Burgundy perinatal network database (France) over the period 2005–2013. A validated procedure was used to link mothers with their newborns, and maternal and fetal pathologies likely to affect birth weight were excluded. Multiple regression analysis with covariate selection was used to build a customized growth curve with maternal and fetal parameters.
Results. – Using this methodology, three different curves were generated: an unadjusted curve for birth weight, named B0, an curve adjusted for fetal gender, named B1 and a curve adjusted for fetal and maternal parameters (fetal gender, maternal height, weight and parity), named B2.
Conclusion. – We present curves showing an original distribution of birth weights for the French population in order to improve the diagnosis of small for gestational age. These curves are not based on the Gardosi in utero growth model but on actual birth weights, thus limiting bias. Nevertheless, the minimum gestational age was 25 weeks as there was an insufficient number of live-borns in small gestational ages.

Introduction

The assessment of fetal growth is a central requirement for good perinatal care. It is important to identify infants with intrauterine growth restriction (IUGR) because they have an increased risk of perinatal mortality and morbidity as well as delayed effects including cerebral palsy and adult diseases. IUGR is usually defined as failure to reach growth potential [1]. Fetal weight estimation is usually based on a composite of sonographic parameters of the fetal head, abdomen and femur length [2]. Newborns with IUGR are often, although not necessarily, small for gestational age (SGA). SGA corresponds to a weight lower than the 10th centile [3]. Hence, the choice of reference growth charts has a significant impact on the diagnosis of SGA.

According to the 2013 guidelines of the French College of Obstetricians and Gynecologists, non-customized growth charts must preferably be used as a screening tool for low-risk pregnancies and customized growth charts for pregnancies with a high-risk of IUGR [4]. Many French growth charts have been published recently [5]. These are based on two different methodologies: on the one hand, birth weight references based on neonates born at various gestational ages have been the most commonly used for nearly half a century [6]. On the other hand, the

Abbreviations: BMI, body mass index; GA, gestational age (weeks); ICD-10, International Statistical Classification of Diseases and Related Health Problems; IUGR, intrauterine growth restriction; LGA, large for gestational age; m, mean; PMSI, French hospital discharge database; SD, standard deviation; SGA, small for gestational age.

* Corresponding author.
E-mail addresses: thierry.rousseau@chu-dijon.fr (T. Rousseau), olivia.durand.maison@gmail.com (O. Durand-Maison), catherine.labruere@u-bourgogne.fr (C. Labruere-Chazal), florine.tabard@chu-dijon.fr (F. Tabard), ahmed.jebrane@u-bourgogne.fr (A. Jebrane), olivia.marcout@chu-dijon.fr (O. Martz), eric.benzenine@chu-dijon.fr (E. Benzenine), jonathan.cottenet@chu-dijon.fr (J. Cottenet), paul.sagot@chu-dijon.fr (P. Sagot).

http://dx.doi.org/10.1016/j.jogoh.2017.05.004
2468-7847/

second methodology uses ultrasound-based estimated references of fetal weight [7]. The 2013 French guidelines prioritize fetal-weight curves rather than birth-weight curves, as the latter seem to be flawed for early gestational ages. Indeed, infants born before term are more likely to be growth restricted and there are substantially fewer samples of newborns for smaller gestational ages [4].

In 2008, non-customized and fetal-gender-customized curves based on an original methodology were published [6]. The methodology consisted in minimising the bias of birth-weight curves by analyzing large amounts of population-based data. Data for over 100,000 births from 25 to 41 weeks of gestation (WG) were collected using the Burgundy perinatal network database. Thanks to mother–newborn linkage, fetal and maternal pathologies that may influence birth weight were excluded, leading to a super-normal population.

We used the same methodology in this study to obtain non-customized and customized birth-weight curves in order to meet the 2013 French guidelines.

The objective of this article was to establish a non-customized reference birth-weight curve, a curve customized according to fetal gender and another one according to fetal gender combined with maternal factors (maternal weight, height and parity) for single and uncomplicated pregnancies according to gestational age.

Material and methods

Anonymized data for a total of 155,964 consecutive mother–newborn pairs from 17 maternity units were obtained from the Burgundy perinatal network database for the period 2005–2013. We excluded 80,165 mother–newborn pairs for incomplete data (maternal age, maternal weight and height at booking, parity, fetal gender and birth weight) as well as multiple pregnancies, miscarriages, stillbirths and chromosomal abnormalities. In addition, we excluded all mother–newborn pairs corresponding to several ICD-10 codes identified in French hospital discharge database (PMSI) and linked using a previously published and validated linkage procedure [11–13]. In particular these codes were linked to hypertension, diabetes, preeclampsia and placental insufficiency.

It concerned the following ICD-10 codes: E10, E11, H360, N083, O240, O241, O242, O243, O244, O249, P700, P701, E12, E13, E14, P70.0, P70.1, O15, I10, I11, I12, I13, I15, O10, O11, O13, O140, O141, O149, O16, P000, O28.5, O35.0, O35.1, O35.2, O35.4, O35.5, O35.6, O36.2, O36.4, 030, 031, O84, Z37.30, Z37.31, Z37.40, Z37.41, Z37.60, Z37.61, Z37.70, Z37.71, P01.6, P04.3, P04.4, P95, P96.4, O95, O02, O03, O04, O05, O06, O07, Z37.10, Z37.11.

Hence, the final sample included 64,173 mother–newborn pairs.

The study was limited to births from 25 weeks to 42 WG to provide a representative statistical analysis with a minimum sample size for each week of gestation.

For non-customized and fetal-gender customized curves, means and standard deviations (SD) at each WG were directly calculated from birth weights. The normality of measurements at each WG was assessed using the Kolmogorov-Smirnov test. Centiles were calculated by multiplying coefficients of variation (SD/mean) with Z-scores for the 3rd, 10th, 90th and 97th percentiles. Finally, a smoothing technique using a polynomial cubic model was applied [14–16].

For curves customized for fetal gender and maternal parameters, multiple regression with significance levels of 0.05 for covariate selection and removal was used. Coefficients were derived using a stepwise backwards elimination approach. Covariates were fetal gender, parity, maternal age, maternal height and weight at booking (both using linear, quadratic and cubic terms). A standard ANOVA test was applied to show the significance of the model. The birth weight constant was calculated for a gestational age of 280 days in a mother with her first pregnancy, a height of 164 cm, a weight of 62 kg and giving birth to a male baby. All of the analyses were performed using free “R” software under General Public License (https://www.r-project.org/).

To make the customized curves easy to use, we created a specific calculation sheet on Microsoft Office Excel software (Microsoft, Redmond, WA) available on http://www.extranat-bourgogne.fr/.

Results

Three different models were generated:

- a non-customized growth curve of birth weight from 25 to 42 WG, named B0 (for Burgundy 0);
- a birth-weight curve customized for fetal gender from 25 to 42 WG, named B1 (for Burgundy 1);
- a birth-weight curve customized according to fetal gender, maternal height and weight at booking and parity from 28 to 42 WG, named B2 (for Burgundy 2).

Table 1 describes the characteristics of the population studied and covariates entered into the multivariate B2 model. The results for B0 are shown in Table 2 with the 3rd, 10th, 90th and 97th percentiles. Table 3 and Table 4 describe the model B1 for male and female newborns, respectively.

The covariates entered into the multivariate B2 model are listed in Table 5 with coefficients and P values. Maternal height and weight at booking, parity and fetal gender were significant variables. A standard ANOVA test yielded $P < 0.0001$, showing that the model was significant. Maternal age was a non-significant parameter and was thus removed. The overall R^2 of the model was 0.38. Fig. 1 shows an example of a customized growth chart for a mother measuring 175 cm, weighing 70 kg, parity 1 and a male infant according to the B2 model.

Table 1
Characteristics of study population.

Maternal characteristics	
Maternal age (m ± SD)	28.8 ± 5.2
Weight (kg) (m ± SD)	62.9 ± 13.3
Height (cm) (m ± SD)	163.8 ± 6.2
BMI (kg/m^2) (n (%))	
< 18.5	5.487 (8.55)
[18.5; 24.9]	41.167 (64.15)
[25; 29.9]	11.530 (17.97)
[30; 39.9]	5.449 (8.49)
≥ 40	540 (0.84)
Parity (n (%))	
0	27.975 (43.59)
1	22.070 (34.39)
2	9.435 (14.70)
3	3.020 (4.71)
≥ 4	1.673 (2.61)
Birth characteristics	
Gestational age (days) (m ± SD)	39.3 ± 1.5
Birthweight (g) (m ± SD)	3.260 ± 451.4
Fetal gender	
Female (n (%))	31.855 (49.64)
Male (n (%))	32.318 (50.36)

m: mean; SD: standard deviation; n: sample size; BMI: body mass index.