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Linear association between maternal pre-pregnancy body mass index and risk of caesarean section in term deliveries

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Objective Maternal obesity is a well-known risk factor for caesarean delivery. The aim of this study is to determine whether all the spectrum of pre-pregnancy maternal corpulence (body mass index [BMI]) is associated with the risk of caesarean delivery.

Design Observational study over 4.5 years (2001–05).

Setting Groupe Hospitalier Sud-Réunion's maternity (island of La Réunion, French overseas department, Indian Ocean).

Population All consecutive singleton live births having delivered at the maternity.

Methods Data have been analysed according to different risk factors. Maternal corpulence has been defined as the maternal pre-pregnancy weight. BMIs have been studied by multiples of 5 kg/m^2 from 10–14.9 kg/m^2 to 40–44.9 kg/m^2.

Main outcome measure Rate of caesarean section.

Results There were 17 462 singleton live births during the period, of which 16 952 (97.1% of the total) pre-pregnancy BMIs have been determined. There is a linear association (χ^2 for linear trend, $P < 0.001$) between maternal corpulence and risk of caesarean deliveries, the leanest mothers having the best rate of vaginal delivery. This linear association exists in a model controlling for diagnosis of gestational diabetes, term deliveries (≥37 weeks), very short maternal height (<1.50 m), primiparity and maternal age ≥ 35 years (adjusted χ^2, $P < 0.001$).

Conclusion There is a significant linear association between pre-pregnancy maternal corpulence and risk of caesarean deliveries in pregnancies at term. The authors discuss several interpretations including the adaptability of fetal birthweights to maternal corpulence and the concept of soft-tissue dystocia.

Keywords Body mass index, caesarean delivery, dystocia, obesity, overweight, pre-pregnancy adiposity.

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Introduction

Maternal obesity is a well-known risk factor for caesarean delivery.[1–7] It has also been reported by some authors that maternal underweight has a protective effect.[8–10] Others have emphasised the role of short stature (<1.55 m) as a high-risk factor.[11]

Although caesarean delivery is not uncommon (17% of all live births in our maternity and 15.4% in term singleton pregnancies), it does represent major surgery with documented risks.[12] These risks are overshadowed by the benefits, which probably contributes to the paucity of studies seeking to better understand the array of mechanisms that lead to the decision of delivery by caesarean section. We sought then to investigate the potential association between various pre-pregnant body mass index (BMI) categories and the incidence of caesarean deliveries in term pregnancies (≥37 weeks).

Material and methods

From 1 January 2001 to 30 June 2005, the hospital records of all women who delivered at the Groupe Hospitalier Sud in La Reunion Island were abstracted in standardised fashion. All data were entered into an epidemiological perinatal database that contained information on obstetric risk factors, description of deliveries and neonatal outcomes. As participants in the French national healthcare system, all pregnant women in Reunion Island have their prenatal visits, biological and echographical examinations and anthropological characteristics recorded in their maternity booklet. In this booklet, there is a special space for pre-pregnancy weight filled by the physician doing the visit; often this weight is close to the direct measurement made by the physician at the first prenatal visit (around 6–7 weeks amenorrhoea). Maternal pre-pregnant BMI was defined as the ratio of pre-pregnancy weight in kilograms divided by height in meters squared (kg/m^2).

There were 18 459 deliveries after 21 weeks of gestation at the Groupe Hospitalier Sud-Reunion's maternity during the period. *In utero* fetal deaths and medical termination of pregnancies after 21 weeks were excluded (n = 307) as were multiple births (n = 340 deliveries, 690 infants) and charts with missing maternal weight or height (n = 860). The study population was then 16 952 women (97.1% of total deliveries). Data came from two maternities belonging to the same obstetric department and hospital (one level 3 maternity, 3200 deliveries per year and one level 1 maternity, 950 deliveries per year) and the same protocols. It is of note that in these protocols, since 1996, pelvimetries (X-ray or scanners) have been abandoned in cephalic presentations, including in case of previous caesarean section. In this protocol, the only pelvimetric indications are in case of breech presentations. Therefore, in our experience, indications of caesarean sections specifically for cephalopelvic disproportions have been very low during the study period: 66/2866 (2.2%).

In this study, mothers with diabetes have been defined as all mothers having a history of diabetes, i.e. gestational diabetes (1289/1450, 90% of cases), type I and type II.

Epidemiological data have been recorded and analysed with the software EPI-INFO 6.4 (1997, CDC, Atlanta, World Health Organisation). Analysis consisted of the χ^2 for linear trend. Pre-pregnancy BMI was categorised by groups of 5 kg/m^2, from 15–19.9 kg/m^2 to 40–44.9 kg/m^2 (results from the 10–14.9 kg/m^2 group have also been shown in tables in spite of small numbers). We considered the following covariates as possible confounders in this analysis: maternal age ≥ 35 years, diagnosis of gestational diabetes, primiparity, term pregnancies (≥37 weeks) and very short stature (<1.50 m). We included these variables and calculated the χ^2 for trend (Mantel extension), the odds ratios (OR) for each exposure level compared with the first exposure level (i.e. the entire cohort, n = 16 952).

Results

During the study period, the overall caesarean section rate was 17.2%, with 15.4% for term (≥37 weeks) births.

Figure 1 depicts the linear association between pre-pregnancy BMI and caesarean section rate (all women and women taller than 1.49 m). The caesarean section risk was lowest in leaner women and increased linearly as BMI increased (underweight, normal, overweight, obese, severe obese and very severe obese). For all groups represented in Table 1, the χ^2 for linear trend was significant (P < 0.001). For example, even if in categories such as the very short women (<1.50 m) or women having been diagnosed with gestational diabetes, the caesarean rate is approximately doubled as compared with the general population, the linear trend still exists significantly in these groups.

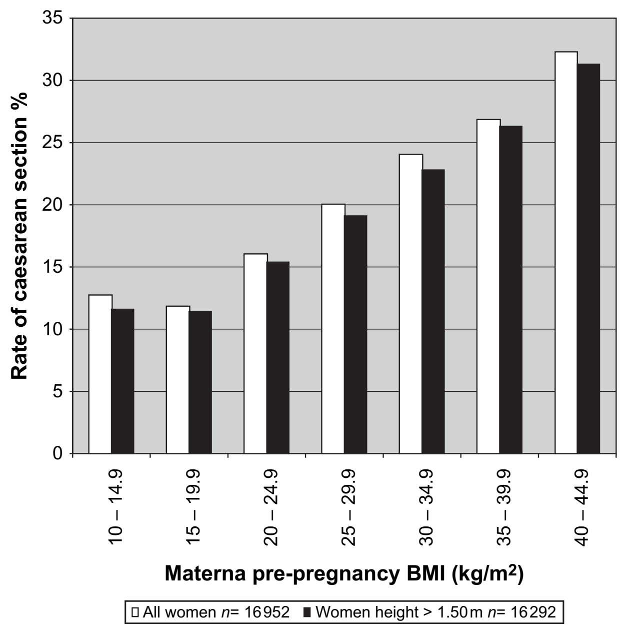

Figure 1. Caesarean section rate and pre-pregnancy maternal BMI.

Table 2 represents the overall calculation of the χ^2 for linear trend for the entire cohort (n = 16 952 women) together with the adjusted χ^2 for possible confounders (gestational diabetes, term pregnancies [≥37 weeks], very short stature [<1.50 m], primiparity and maternal age ≥ 35 years). Results of the adjusted χ^2 for these five criteria are very similar to the crude OR for trend (P < 0.001) calculated for all parturients.

Figure 2 depicts the association between the caesarean section rates and maternal heights. This risk rises sharply in our population with height below 1.50 m. It is of note that in this cohort, women shorter than 1.50 m represented only 3.9% of the overall population (mean height of women was 1.60 m). Table 3 differentiates term pregnancies (≥37 weeks) in women taller than 1.49 m. Results shown in Table 3 include more than 96% of women delivering at term.

Figure 3 depicts the mean birthweights in term pregnancies (≥37 weeks) according to the different maternal pre-pregnancy BMIs. There was a 600-g difference in birthweight between the extreme categories of maternal BMI (analysis of variance, P < 0.001).

Table 1. Pre-pregnancy maternal corpulence (BMI) and caesarean section rate (singleton live births, n = 16 952)

Maternal corpulence (BMI, kg/m^2)	All women, n = 16 952 (%)	Deliveries after 36 weeks, n =15 237 (%)	Deliveries after 33 weeks, n = 16 484 (%)	Primiparas, n = 6157 (%)	Multiparas, n = 10 795 (%)	Multiparas without previous caesarean sections, n = 9328 (%)	Women with diabetes, n = 1450 (%)	Women height < 1.50 m, n = 660 (%)	Women height ≥ 1.50 m, n =16 292 (%)
10–14.9	9/71 (12.7)	6/55 (10.9)	7/67 (10.4)	5/41 (12.2)	4/30 (13.3)	4/29 (13.8)	— (n = 2)	— (n = 2)	8/69 (11.6)
15–19.9	491/4167 (11.8)	380/3707 (10.3)	447/4056 (11.0)	253/2031 (12.5)	238/2136 (11.1)	143/1939 (7.4)	28/122 (23.0)	30/130 (23.1)	461/4037 (11.4)
20–24.9	1176/7335 (16.0)	951/6612 (14.4)	1079/7127 (15.1)	467/2702 (17.3)	709/4633 (15.3)	352/4030 (8.7)	122/442 (27.6)	84/252 (33.3)	1092/7083 (15.4)
25–29.9	665/3317 (20.0)	547/2989 (18.3)	617/3219 (19.2)	204/903 (22.6)	461/2414 (19.1)	230/2054 (11.2)	144/464 (31.0)	63/159 (39.6)	602/3158 (19.1)
30–34.9	339/1411 (24.0)	281/1276 (22.0)	313/1378 (22.7)	90/341 (26.4)	249/1070 (23.3)	125/880 (14.2)	75/254 (29.5)	35/75 (46.7)	304/1336 (22.8)
35–39.9	117/436 (26.8)	107/403 (26.6)	112/425 (26.4)	32/94 (34.0)	85/342 (24.9)	34/268 (12.7)	40/107 (37.4)	9/26 (34.6)	108/410 (26.3)
40–44.9	51/158 (32.3)	45/142 (31.7)	49/156 (31.4)	13/35 (37.1)	38/123 (30.9)	22/98 (22.4)	23/46 (50.0)	— (n = 11)	46/147 (31.3)
45–49.9	13/43 (30.2)	12/40 (30.0)	13/43 (30.2)	— (n = 6)	9/37 (24.3)	— (n = 22)	— (n = 9)	— (n = 4)	11/39 (28.2)
Over 50	— (n = 14)	— (n = 13)	— (n = 13	— (n = 10)	— (n = 10)	— (n = 8)	— (n = 4)	— (n = 1)	— (n = 13)

For all columns, χ^2 for linear trend $P < 0.001$.

Table 2. Risk of caesarean deliveries by pre-pregnancy BMI (n = 16 952)

Maternal corpulence (BMI, kg/m^2)	OR crude (95% IC)	OR adjusted* (95% IC)
15–19.9	1.00 (reference)	1.00 (reference)
20–24.9	1.43 (1.27–1.60)	1.42
25–29.9	1.88 (1.65–2.14)	1.89
30–34.9	2.37 (2.02–2.77)	2.31
35–39.9	2.75 (2.16–3.48)	2.71
40–44.9	3.57 (2.49–5.10)	3.6
P for linear trend	<0.001	<0.001

Crude and adjusted χ^2 for linear trend.

*χ^2 for linear trend adjusted for gestational diabetes (yes/no), term pregnancies (≥37 weeks, yes/no), maternal height < 1.50 m (yes/no), primiparity (yes/no) and maternal age ≥ 35 years (yes/no).

Discussion

The Groupe Hospitalier Sud-Reunion's maternity (European standards of care) is the only public hospital in the southern part of Reunion Island (Indian Ocean, French overseas department). It serves the whole population of the area, and with 4300 births per year, represents 75% of all births in the South.

Results shown in Table 1 depict a linear trend between maternal pre-pregnancy BMI and risk of caesarean section, regardless of potential confounders. Even when stratifying by major known risk factors (e.g. gestational diabetes or very short stature below 1.50 m), the incidence of caesarean section is approximately doubled as compared with the whole

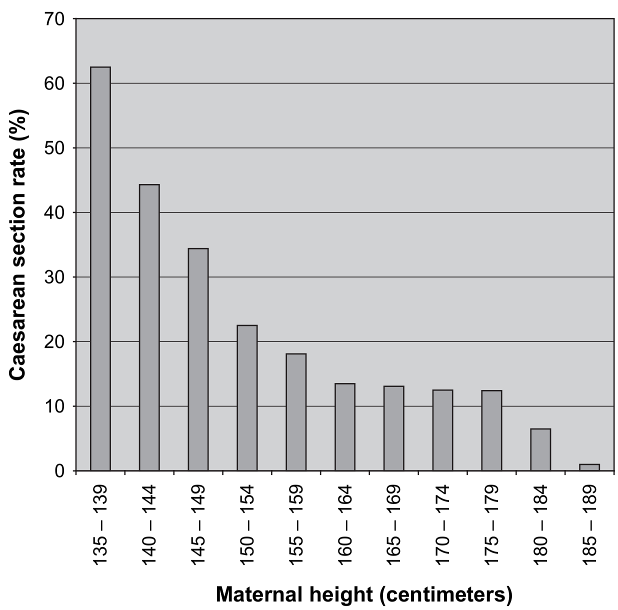

Figure 2. Maternal height and caesarean section.

Table 3. Pre-pregnancy maternal corpulence (BMI) and caesarean section rate in women taller than 1.49 m, deliveries at term (≥37 weeks) (singleton live births, n = 14 660)

Maternal corpulence (BMI, kg/m²)	All women, n = 14 660 (%)	Primiparas, n = 5352 (%)	Multiparas, n = 9308 (%)	Multiparas without previous caesarean sections, n = 8130 (%)	Women with diabetes, n = 1202 (%)
10–14.9	5/54 (9.3)	2/28 (7.1)	3/26 (11.5)	3/25 (12.0)	— (n = 2)
15–19.9	354/3591 (9.9)	191/1781 (10.7)	163/1810 (9.0)	97/1661 (5.8)	16/94 (17.0)
20–24.9	883/6399 (13.8)	369/2359 (15.6)	514/4040 (12.7)	243/3551 (6.8)	95/374 (25.4)
25–29.9	490/2842 (17.2)	155/777 (19.9)	335/2065 (16.2)	164/1783 (9.2)	110/379 (29.0)
30–34.9	252/1213 (20.8)	69/290 (23.8)	183/923 (19.8)	85/764 (11.1)	53/212 (25.0)
35–39.9	99/379 (26.1)	29/81 (35.8)	70/298 (23.5)	28/237 (11.8)	35/94 (37.2)
40–44.9	40/132 (30.3)	10/27 (37.0)	30/105 (28.6)	17/84 (20.2)	18/37 (48.6)
45–49.9	11/38 (28.9)	— (n = 6)	7/32 (21.9)	— (n = 18)	— (n = 7)
Over 50	— (n = 12)	— (n = 3)	— (n = 9)	— (n = 7)	— (n = 3)

For all columns, χ^2 for linear trend $P < 0.001$.

population and the linear association remains (χ^2 for linear trend, $P < 0.001$). This is emphasised in the control model shown in Table 2, where the step by step χ^2 values are quite similar to those of the calculations for the whole population (i.e. including premature deliveries). Considering only term pregnancies, if we look at the corresponding columns in Tables 1 and 3, results also fit a linear trend. The consistency of the linear association across results precluded the need to test kinds of indications of caesarean sections (elective, fetal distress, induction of labour, malpresentations, breeches etc.) or to look at other risk factors like weight gains during pregnancies.[10,13]

These data highlight the importance of considering both the distal ends of the BMI distribution. Although caution is warranted for the small sample sizes, very lean women (10–14.9 kg/m², n = 54, Table 3) were more likely to deliver vaginally than lean women (15–19.9) and more likely than women with normal BMI. This agrees with previous reports on underweight mothers.[7–10] Concerning obese women, these data support the need to consider additional categories. The risk for caesarean delivery changes within the different states of obesity: between obese (30–34.9 kg/m²), very obese (35–39.9) and extremely obese (40–44.9).

To our knowledge, only one team related in their discussion the concept of a global linear law between the spectrum of different BMIs and risk of caesarean section in a study of 738 nulliparous women (with a number of BMI < 24 kg/m² of 31 women and more than 34.9 kg/m² of 187 women).[4] Our data then confirm this linear trend in a larger population. Because of the well-known effect of short stature on caesarean section risk,[11] Figure 2 shows this risk in our cohort: in a population where the mean height of women was 1.60 m, there was a sharp rise of the incidence of caesarean section below 1.50 m. Table 3 depicts the risks for the great majority of parturients (96%, for those taller than 1.49 m) delivering at term.

Concerning the interpretations of this linear shape, the explanation is probably multifactorial. First, it seems that there is an adaptation between maternal corpulence and fetal weights (Figure 3), leaner women in average having lighter babies than the heavier ones, confirming the report of Sebire *et al.*[9] Other authors have clearly shown that in obese women, the birthweight curve was shifted on the right and that obesity was an independent factor for fetal macrosomia.[14,15] Second, many authors have discussed the concept of soft-tissue dystocia in maternal pelvises by the accumulation of fat tissues, narrowing the genital tract.[1–2] Although to our knowledge, there is no direct support of this concept by medical imagery studies, some indirect arguments plead for its reality: for example, for identical birthweights, there are more caesarean

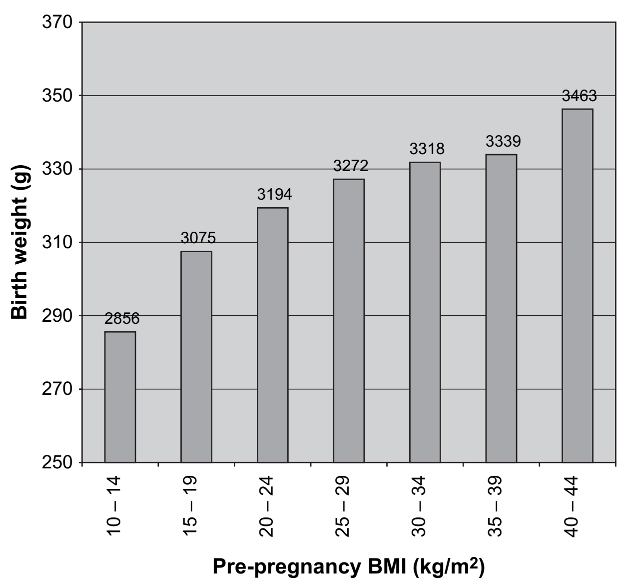

Figure 3. Infant birthweights by maternal pre-pregnancy corpulence.

sections, instrumental extractions[2] or failure to induce labour in obese women than in controls.[13] Further, for Durnwald *et al.*,[10] among women with a history of caesarean section, those having a normal BMI at the first pregnancy but an overweight at the second one presented a decreased rate of vaginal delivery as compared with those who kept a stable BMI between the two pregnancies. Maternal and fetal factors may add to result in this linear shape of caesarean section risk. Lean mothers may have at the same time lighter babies but also less fat pelvic tissues. Conversely, obese women present heavier babies with a relative narrower pelvis due to her fat pelvic tissues and therefore a higher caesarean section rate.

Conclusion

In obstetric practice, the decision to deliver by caesarean section is guided by many inputs. Knowing that maternal pre-pregnancy BMI is linearly associated with the incidence of caesarean section, practitioners may be better able to counsel, preconceptionally, with regards to weight and subsequent pregnancy outcomes. Weight gain during pregnancy may help to better define these data. ■

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