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## Smoking during pregnancy and maternal weight gain

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The effects of smoking by pregnant women on the progress of their pregnancy and the development of the fetus have been the subject of many studies [6, 10, 9, 12]. The aims of the present work are to observe the effect of smoking on the mother's gain in weight during pregnancy and to contribute towards an answer in the present-day debate on the mechanism whereby smoking affects the birthweight of the child.

### 1 Selection of the cases

The subjects of the present study were a group under study of 105 smokers and a control group of 100 non-smokers.

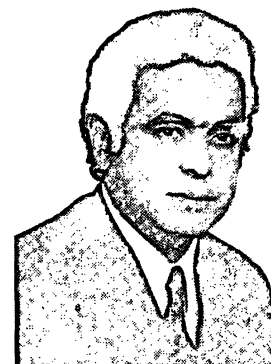
#### 1.1 The study group.

105 cases were selected from the total number of women attending the prenatal clinic regularly and the resulting births that took place at the Antoine Béclère Maternity Hospital in 1974. The women in the group smoked at least 10 cigarettes a day throughout their pregnancy. This was ascertained at the first attendance at the pre-natal clinic and was confirmed at the following attendances. Those patients who stopped smoking during pregnancy were eliminated from the study.

### Curriculum vitae

HAFEDH HAJERI was born in Tunisia in 1940. Medical degree with distinction at the University of Strasbourg (France) in 1971.

He was first assistant to Professor PAPIERNIK at the department of Gynecology and Obstetrics at the University of Paris-Sud. Since 1971 his work is dedicated to clinical research in perinatology, especially high risk pregnancy, fetal heart rate and fetal growth retardation. He is now Professeur Agrégé at the Faculty of Medicine in Sousse (Tunisia).



#### 1.2 The control group.

This consisted of 100 women who did not smoke during pregnancy and who were chosen at random from the total number of non-smokers. The twin pregnancies were eliminated.

### 2 Methodology

In the two groups under consideration information was gathered after the birth and a study by means

of a retrospective analysis was made on the relation between the following parameters:

- The birthweight and sex of the child.
- The length of gestation reckoned in weeks from the first day of the last menstruation.
- The mother's age and parity.
- The mother's height and weight at the time of conception.
- The mother's weight at the time of giving birth and the gain in weight during pregnancy.
- The weight of the placenta.
- The number of children small for dates as defined by their placing in the first decile of the Paris region birthweight distribution (LEROY and LEFORT) [7].

Maternal age, parity, weight and height of the mothers, duration of pregnancy and sex of infants were included in order to control for possible confounding due to a correlation of these factors with weight gain on the one hand and smoking on the other or with birthweight and smoking.

### 2.1 Study on the duration of gestation and the mother's age, height, parity and maternal weight at conception

The two groups were found to be comparable as to period of gestation in relation to the mother's age, height, parity and maternal weight at conception. There is no difference between the two groups in so far as these variables are concerned, as is shown in Tab. I.

Tab. I. Means  $\pm$  s. sd. of gestational age and maternal variables according to maternal smoking habits.

	Smokers	Non-smokers	Significance
Number	105	100	
Gestational age (weeks)	39,4 $\pm$ 1,4	39, 8 $\pm$ 1,5	n.s.
Maternal age (years)	25,5 $\pm$ 4,9	26,5 $\pm$ 5,5	n.s.
Maternal height (cm)	162,5 $\pm$ 4,8	162,5 $\pm$ 5,7	n.s.
Parity	1,7 $\pm$ 0,8	1,6 $\pm$ 0,8	n.s.
Maternal weight at conception (kg)	53,7 $\pm$ 7,8	54,3 $\pm$ 6,9	n.s.

### 2.2 Relation between smoking and birthweight

In each group the average birth weight of boys and girls and also standard deviations was calculated. The birthweight is different in the two groups and this difference is statistically significant at the 1% level. It therefore seems that maternal smoking during pregnancy causes a decrease in mean birthweight of 330 g in boys and 320 g in girls, as is shown in Tab. II.

Tab. II. Birth-weight and placental weight (m  $\pm$  s.d.) according to sex and maternal smoking habits.

	Smokers	Non-smokers	Significance
<i>Boys</i> Number	74	45	
Birth-weight (g)	3045 $\pm$ 534	3374 $\pm$ 415	P < 10 <sup>-3</sup>
Placental weight (g)	611 $\pm$ 141	637 $\pm$ 126	n.s.
<i>Girls</i> Number	31	55	
Birth-weight (g)	2857 $\pm$ 462	3176 $\pm$ 439	p < 10 <sup>-3</sup>
Placental weight (g)	581 $\pm$ 105	613 $\pm$ 121	n.s.

### 2.3 Smoking and retarded intra-uterine growth

The number of children defined as small for dates, according to the accepted criteria, is much greater in the smoking group (28%) than in the control group (12%), a statistically significant difference.

### 2.4 Placental weight

The weight of the placenta does not seem to be affected by smoking in pregnancy, as is shown in Tab. II.

### 2.5 Mother's gain in weight and extrauterine weight gain

The result figuring in Tab. III show no difference between the two groups for mother's gain in weight.

Tab. III. Maternal weight gain (m  $\pm$  s.d.) according to maternal smoking habits.

	Smokers	Non-smokers	Significance
Maternal weight gain (kg)	10,7 $\pm$ 3,8	10,8 $\pm$ 3,6	n.s.

Extrauterine weight gain was calculated as the difference between maternal weight gain and both weights of the fetus and the placenta. This amounts to an average of 7044 g in the smoking and 6899 in the non-smoking group which demonstrates even more clearly that smoking is not accompanied by reduced weight gain.

### 3 Discussion

The results reported above show that smoking during pregnancy does have a bearing on the lower birthweight of the child. This is in conformity with the literature, where there is general agreement on this point [6, 9, 10, 12] It is also generally agreed that smoking does not affect the placental weight [13, 15]. Opinions still differ mainly on the possible causality of this relationship and on the presumable mechanism of the action of smoking. As to the last point, two theories have been advanced: One is based on the malnutrition of the fetus the other on chronic fetal hypoxia.

#### 3.1 Fetal malnutrition

Tobacco, because it is anorexigenic and a factor of food malabsorption, causes a decrease in the calories supplied to the child. The insufficient fetal growth, due to fetal malnutrition, would result in a decreased birthweight. This theory is upheld in several works, in particular those of RUSH [11] and DAVIES and GRAY [3].

a) In his work on a group of live-born children of smoking and nonsmoking mothers, RUSH [11] studied the relation between maternal smoking during pregnancy, the maternal gain in weight and the child's birthweight. He observed that, in the smoking group, the children's birthweight was lower and the mother's weight gain less marked. He concluded that the mechanism of the action of smoking is essentially of a nutritional order, explained by the fact that smokers eat less. According to him, there is no evident reason why other mechanisms should retard fetal growth, reasons such as the direct toxicity of tobacco constituents, the reduction in vascular supplies or the increase in carbon monoxide levels.

b) The conclusions made by RUSH [11] are, partly at least, confirmed by the work of DAVIES and GRAY [3] on 1159 pregnant women in South Wales. These authors studied the correlation between smoking during the second half of pregnancy, maternal weight gain and child's birthweight. Their study establishes the fact that the mother's weight gain is smaller in smokers and the birthweight of smoker's children is 8% smaller than that of non-smokers' children. After comparing this reduction in birthweight with the reduction observed in Germany at the end of the last World War, they attributed the diminished birthweight to fetal malnutrition as a consequence of the smoking mothers's food restriction. However, as this food restriction cannot be compared with that which can be observed in time of famine, DAVIES and GRAY do not exclude the possibility that smoking may have a direct effect on the fetus.

In the present study, a reduction in the birthweight of children of mothers who smoked during pregnancy is indeed confirmed. However, no statistically significant difference in the weight increase nor in extrauterine weight gain of smokers and non-smokers is to be found. This is in agreement with the results reported by MAU [8] and SPIRA [14]. Hence, the physio-pathological mechanism responsible for the decrease in birthweight does not seem, in the opinion of the present team, to be a nutritional order as far as weight gain during pregnancy would be correlated to nutritional intake [4]. Therefore the mechanism could well be due to the direct action of smoking, an action which is of hypoxic order.

#### 3.2 Chronic fetal hypoxia

The other physio-pathological mechanism put forward by several authors to explain the lower birthweight of smokers' children is the higher level of carbon monoxide in the blood of pregnant women. This phenomenon would cause hypoxia of the fetus resulting from the mother's hypoxia.

a) GINSBERG and MYERS [5] gave a slight dose of carbon monoxide to rhesus monkeys, whose

central nervous system and placenta are akin to man's. Although this did not produce clinical symptoms in the mother, it nevertheless caused serious deterioration of the homeostasis in the fetus and led to severe cerebral lesions. Fetal hypoxia, according to GINSBERG and MYERS, is essentially caused by maternal hypoxia and not by carbon monoxide passing through the placenta and its fixation by the foetal haemoglobin. This passing of carbon monoxide through the placenta does take place, but to a limited degree, and the amount of carboxyhaemoglobin which is formed in the fetus is also limited.

Fetal hypoxia is caused by rapidly increasing carboxyhaemoglobin forming in the mother's blood and, therefore, a diminished transfer of oxygen through the placenta.

- b) COLE et al. [2] studying the effects of tobacco on a population of smoking and non-smoking pregnant women, showed that the amount of carboxyhaemoglobin in the mother's blood is 3 times greater in smokers than in non-smokers.
- c) Finally, ASTRUP et al. [1] examining the consequences of gravid rabbits being exposed to carbon monoxide and pregnant women being

exposed to cigarette smoke note a direct relation between the amount of carboxyhaemoglobin in the mother and the reduction in birthweight of the offspring.

#### 4 Conclusion

If the action of tobacco on the lower birthweight of children cannot be denied, its physio-pathological mechanism remains debatable. The present study having revealed no statistically significant difference in the weight gain of mothers, whether smokers or non-smokers, the hypothesis of fetal malnutrition cannot be accepted. It seems feasible to accept the hypothesis that retarded fetal growth is caused by chronic fetal hypoxia resulting from increased carboxyhaemoglobin in the mother's blood and the passing of carbon monoxide to the fetus. It cannot, of course, be ruled out that relation which has been observed between smoking during pregnancy and a lower birthweight is not one of cause and effect but merely indicates certain characteristics particular to smokers as compared to non-smokers.

#### Summary

The present work studies the effects of maternal smoking during pregnancy.

It deals with a group of 105 smokers (smoking at least 10 cigarettes a day) and a control group of 100 non-smokers, chosen at random and statistically comparable as to age, height, parity and weight at the time of conception.

The findings are:

- A significantly lower weight in the children born of mothers who smoke (2857, 1 g  $\pm$  462,1 as against 3176, 2 g  $\pm$  438,8 for the girls. 3044,5 g  $\pm$  533,6 as against 3374 g  $\pm$  415, 2 for the boys,  $p = 1\%$ ).
- A greater proportion of small for dates babies: 28,5% for the smokers as against 12,0% for the controls.
- No significant difference as to the mother's weight gain during pregnancy: 10,3 kgs  $\pm$  3,1 as against 10,5 kgs  $\pm$

3,6 for the birth of boys, 10,9 kgs  $\pm$  4 as against 11,2 kgs  $\pm$  3,7 for the birth of girls.

- No significant difference as regards the weight of the placenta (581,3 g  $\pm$  105, 1 for the birth of girls. 611, 4 g  $\pm$  140,7 for the birth of boys.
- A comparable period of gestation in both groups (39,3  $\pm$  1,4 as against 39,8  $\pm$  1,4 weeks).

In the light of these results and the data in the literature, the mechanisms of the action of smoking are discussed. If it seems that fetal malnutrition due to the mother's diminished caloric provision is to be ruled out, retarded growth through hypoxia resulting from a decrease in the oxygen provided and from a transfer of carbon monoxide to the fetus deserves consideration.

**Keywords:** Birth weight, maternal weight gain, smoking during pregnancy.

#### Zusammenfassung

**Rauchen während der Schwangerschaft und mütterliche Gewichtszunahme**

Die vorliegende Arbeit untersucht den Einfluß von Nikotinguß durch die Mutter während der Schwangerschaft.

Die Studie umfaßt eine Gruppe von 105 Rauchern (Mindestmaß: 10 Zigaretten pro Tag) sowie eine Kontrollgruppe von 100 Nichtrauchern; die Gruppen waren zufallsmäßig ausgewählt und statistisch vergleichbar hinsicht-

lich des Alters, der Größe, der Parität und des Gewichts der Probanden zum Zeitpunkt der Konzeption.

Wir haben gefunden:

- ein signifikant niedrigeres Geburtsgewicht bei Kindern, deren Mütter Raucher waren (in der Gruppe der Mädchen: 2857, 1 g  $\pm$  462, 1 gegenüber 3176, 2 g  $\pm$  438, 8, bei den Jungen: 3044, 5 g  $\pm$  533, 6 gegenüber 3374 g  $\pm$  415, 2, p = 1%)
- einen höheren Anteil an 'Small-for-dates-Babies', nämlich 28,5% in der Gruppe der Raucher gegenüber 12% innerhalb der Kontrolle.
- keinen signifikanten Unterschied hinsichtlich der mütterlichen Gewichtszunahme während der Schwangerschaft; bei der Geburt von Jungen betrug diese 10,3 kg  $\pm$  3,1 gegenüber 10,5 kg  $\pm$  3,6; bei der Geburt von Mädchen betrug sie 10,9 kg  $\pm$  4,0 gegenüber 11,2 kg  $\pm$  3,7.

- keinen signifikanten Unterschied beim Plazentagewicht (Jungengeburten: 581,3 g  $\pm$  105,1; Mädchengeburten: 611,4 g  $\pm$  140,7).
- eine vergleichbare Schwangerschaftsdauer in beiden Gruppen (38,3  $\pm$  1,4 bzw. 39,8  $\pm$  1,4 Wochen).

Unter Einbeziehung dieser Ergebnisse sowie anderer Daten aus der Literatur wurden die Mechanismen, die durch das Rauchen ausgehört werden, diskutiert. Es scheint, daß eine fetale Mangelernährung, die auf eine zu geringe Kalorienaufnahme durch die Mutter zurückzuführen ist, ausgeschlossen werden kann. Vielmehr verdient Beachtung, daß dem retardierten Wachstum möglicherweise eine Hypoxie zugrunde liegt, die ihrerseits durch einen Abfall in der Sauerstoffversorgung sowie durch einen Transfer von Kohlenmonoxid auf den Feten bedingt ist.

**Schlüsselwörter:** Geburtsgewicht, mütterliche Gewichtszunahme, Rauchen in der Schwangerschaft.

### Résumé

**Relation entre la consommation de tabac pendant la grossesse, la prise de poids maternelle et le poids de naissance de l'enfant**

Ce travail a trait aux effets de la consommation maternelle de tabac pendant la grossesse. Il porte sur une série de 105 femmes fumeuses (au moins 10 cigarettes par jour) et une série témoin de 100 femmes non fumeuses, choisies au hasard par tirage au sort et statistiquement comparables du point de vue âge, taille, parité et poids au moment de la conception.

Il fait apparaître:

- une réduction significative du poids des enfants nés de mères fumeuses (2857, 1 g  $\pm$  462,1 g contre 3176,2 g  $\pm$  438,8 g pour les filles; 3044,5 g  $\pm$  533, 6 g contre 3374 g  $\pm$  415,2 g pour les garçons, p = 1%).
- une augmentation de la proportion de nouveau-nés hypotrophiques/ 28,5% chez les fumeuses contre 12% dans la série témoin.

- une absence de différence significative en ce qui concerne le gain de poids maternel réalisé pendant la grossesse: 10,3 kg  $\pm$  3,1 contre 10,5 kg  $\pm$  3,6 pour les naissances de garçons; 10,9 kg  $\pm$  4 contre 11,2 kg  $\pm$  3,7 pour les naissances de filles.
- une absence de différence significative portant sur le poids du placenta (581,3 g  $\pm$  105,1 pour les naissances de filles, 611,4 g  $\pm$  140,7 pour les naissances de garçons).
- un terme d'accouchement comparable dans les deux séries (39,3  $\pm$  1,4 contre 39,8  $\pm$  1,4 semaines).

A la lumière de ces résultats et des données de la littérature, les mécanismes d'action du tabac sont discutés. Si la malnutrition foetale par restriction des apports caloriques maternels semble devoir être écartée, l'insuffisance de croissance par hypoxie chronique due à une diminution du transfert d'oxygène et au passage d'oxyde de carbone vers le fœtus mérite, par contre, d'être retenue.

**Mots-clés:** Poids de naissance, prise de poids maternelle, tabac et grossesse.

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