

The relationship of smoking to the outcome of pregnancy

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DURING the past decade much has been written regarding the effects of tobacco products on various organs and systems. Due to the increasing percentage of women smoking, plus the acute awareness of environmental effects upon the fetus, the relationship of smoking to the outcome of pregnancy has become an important issue. The purpose of this paper is to attempt to further answer these questions by comparing the outcome of pregnancies in a large series of smokers and nonsmokers.

Essenberg, Schwind, and Patras,¹ as early as 1940, reported the effects of cigarette smoke upon the pregnancy of rats. With the rats being exposed to cigarette smoke corresponding to the human exposure of one pack per day, they found that two thirds of the newborn rats were underweight and that there was a significant increase in perinatal mortality. Schoeneck² in 1941 carried out a similar experiment on rabbits. He found the offspring 17 per cent smaller, a stillborn rate

ten times greater, and a one third increase in perinatal mortality in the rabbits exposed to cigarette smoke as compared to the controls. Thienes and co-workers³ found that when white rats were clinically exposed to nicotine proportionately corresponding to 40 cigarettes per day in man, a decreased fertility in the rats as well as a decrease in the number of litters and number per litter occurred. The resulting offspring also had decreased fertility.

Hatcher and Crosby⁴ in 1927 showed that nicotine was secreted in breast milk from cows and cats when given intramuscularly. With large doses, suppression of lactation occurred. Traces of nicotine were found in breast milk of women who smoked heavily. Wilson⁵ failed to find any decreased lactation in mice nor any decrease in growth of the newborn mice nursing from mothers given oral nicotine. Thompson⁶ showed that human breast milk from heavy smokers contained nicotine, and there appeared to be a decrease in lactation; however, he warned against false ideas since heavy smokers are usually nervous excitable women.

Sontag and Wallace⁷ in 1935 reported in human beings an average increase in fetal heart rate of five beats per minute during maternal smoking, postulating that nicotine or some other toxic product of cigarette smoke crossed the placenta. This did not occur if the smoke was not inhaled. Hell-

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man and co-workers⁸ also found a fetal tachycardia with smoking. They, however, found the response to occur quicker than when intravenous medications were given. In fact, it occurred occasionally as the patient lit the cigarette, suggesting that the tachycardia was not due to some toxin carried by the blood. They felt the response was due to vasomotor changes in the placenta secondary to anticipation.

Simpson⁹ reported in a retrospective study of 7,499 women an almost twofold increase in prematurity in the smokers. She found a direct relationship between the increase of prematurity and the number of cigarettes smoked per day. Lowe¹⁰ reported, in 1959, that infants born to mothers who smoke have an average birth weight of 170 grams less than nonsmokers. Again the greater the number of cigarettes smoked per day the greater the difference. Women who smoked during the first trimester, but later stopped, failed to show any difference in the birth weights between smokers and nonsmokers. Also infants born prior to 260 days' gestation were of equal size. He, therefore, theorizes that the effect of cigarette smoke on birth weight occurs in the latter weeks of pregnancy. Frazier and associates,¹¹ however, show a consistent difference in birth weights between smokers and nonsmokers throughout the third trimester, with a 156 gram difference at term. Herriot, Billewicz, and Hytten¹² reported similar relationships of birth weights and prematurity to smoking; however, they found a greater difference in women of the semi- and unskilled social brackets as compared to the professional and managerial groups. Savel, Lewis, and Roth¹³ in 1962 again confirmed the decreased birth weights of infants born to mothers who smoke. A difference of 363 grams in white patients and 205 grams in Negro patients was found between nonsmokers and heavy smokers. Smoking did not influence fetal wastage, stillbirths, or neonatal deaths.

All investigations to date have shown a definite decrease in the birth weight along with an increase in prematurity among in-

fants born to mothers who smoke. With interest stimulated by these reports, a similar study was undertaken at the Medical College of South Carolina and Roper Hospitals.

Material and method

Between Feb. 1, 1960, and Dec. 31, 1961, 4,440 puerperal women were interviewed by an obstetrical resident at the Medical College of South Carolina and Roper Hospitals. Through these questionnaires the histories pertaining to 16,158 pregnancies were obtained. It was significant that during each of the two years the statistics were obtained by separate residents; however, a marked similarity in the results was found. Because of economic status which influences diet, prenatal care, and sociological factors, these patients have been divided into three groups. Each group is divided into nonsmokers and smokers, which are further subdivided into less than one-half, between one-half and one, and over one pack of cigarettes smoked per day. A mother was classified as a smoker if she smoked throughout the latter half of pregnancy.

Group I. Roper Hospital is entirely private and represents mothers of above average economic status. There were 1,487 questionnaires representing 4,126 pregnancies.

Group II. The white patients from the Medical College Hospital consist of near equal numbers of unwed mothers from the Florence Crittenton Home and indigent patients from Charleston County. A few private patients were included. This represents mothers of mostly average or below economic status. There were 508 questionnaires representing 1,216 pregnancies.

Group III. The Negroes from the Medical College Hospital, 99 per cent of which were indigent patients from Charleston County, represent the third group. They were of a low economic group. There were 2,445 questionnaires representing 10,815 pregnancies.

The results herein disclosed were obtained from the 16,158 pregnancies represented by the 4,440 questionnaires, except the birth weights which for accuracy represent only the present pregnancy.

Table I. Number and percentage of women in study divided into their respective groups

Group	Nonsmokers		Smokers (packs per day)					
	No.	%	< 1/2		1/2 to 1		> 1	
	No.	%	No.	%	No.	%	No.	%
I	865	58.2	134	9.0	207	13.9	281	18.9
II	257	50.6	62	12.2	68	13.4	121	23.8
III	1,790	73.2	395	16.1	171	6.9	89	3.8

Table II. Birth weights in grams

Group	Non-smokers	Smokers (packs per day)		
		< 1/2	1/2 to 1	> 1
I	3,522	3,349	3,236	3,169
II	3,304	3,171	3,146	3,092
III	3,126	2,938	2,965	3,011

Table III. Prematurity, abortions, stillbirths, and fetal wastage

	Non-smokers (%)	Smokers (packs per day)		
		< 1/2 (%)	1/2 to 1 (%)	> 1 (%)
Group I				
Prematurity*	4.5	4.2	5.9	7.2
Abortions	8.2	9.6	8.7	9.8
Stillbirths	2.1	0.9	0.8	2.3
Fetal wastage†	10.3	10.5	9.5	12.1
Group II				
Prematurity	7.5	12.6	12.3	15.9
Abortions	4.9	6.6	3.7	6.7
Stillbirths	1.4	0.8	0	1.4
Fetal wastage	6.3	7.4	3.7	8.1
Group III				
Prematurity	9.9	14.1	14.8	10.2
Abortions	5.2	7.2	10.1	5.6
Stillbirths	1.0	1.5	1.1	1.8
Fetal wastage	6.2	8.7	11.2	7.4

*Under 2,500 grams.

†Abortions and stillbirths combined.

Table IV. Major fetal anomalies per 1,000 births

Group	Nonsmokers	Smokers
I	7.9	5.2
II	8.9	4.5
III	3.2	2.3

Results

Table I illustrates the number of patients in each group along with its respective percentage. In contrast to the study of Herriot, Billewicz, and Hytten,¹² the lowest socioeconomic group smoked much less. This may be due to the poverty of the Charleston Negro because the large majority of the Negro smokers use less than one-half pack of cigarettes per day. In Groups I and II, 41.8 and 49.4 per cent, respectively, smoked.

As has been shown by others⁹⁻¹³ infants of nonsmokers were heavier than ones born to smokers, and this difference increased directly with the number of cigarettes smoked per day (Table II). Only infants weighing over 1,000 grams were tabulated. One also notices that with a decreasing economic status a progressive decrease in differences of birth weights between smokers and nonsmokers occurs. In Group I, nonsmokers' infants weighed 353 grams more than heavy smokers, whereas Group II showed only 213 grams difference, and Group III only 115 grams difference. This difference of 353 grams in the private white patient was comparable to the 363 grams difference reported by Savel and Roth¹³ in white patients and much greater than previous reports. A statistical analysis comparing nonsmokers with each of the three categories of smokers in each of the three groups revealed: Group I to be significant in all three categories with $p < .001$; Group II shows category of less than one-half pack per day not significant in that $p > .05$, however, one-half to one pack per day is significant at $p < .025$ and over one pack per day significant at $p < .001$; Group III is significant in all three

categories— $p < .001$, $p < .001$ and $p < .025$, respectively. These data indicate that smoking during pregnancy is associated with a decrease in the birth weight of newborn infants; however, other factors, possibly nutritional, also play an important role.

A significant increase in prematurity (under 2,500 grams) was found among the smokers, again directly proportional to the number of cigarettes smoked per day (Table III). The lower the socioeconomic group the higher the incidence of prematurity. The one exception to these findings was in Group III that smoked over one pack per day. This was probably due to the small number of cases since only 3.8 per cent of the Negroes fell into this group. The twofold increase in Groups I and II was comparable to Simpson's findings of 6.16 to 12.13 and 5.21 and 10.5 per cent, respectively, between non-smokers and smokers in two private hospitals in California. A significant increase in prematurity was present in all three groups of smokers when comparing all smokers against nonsmokers—Group I $p < .025$ and Groups II and III $p < .001$. However, if comparing only those that smoked less than one-half pack per day Groups I and II are not significant in that $p > .05$ but Group III is significant with $p < .001$. If everyone that smoked less than one pack per day is compared, Group I is not significant with

$p > .05$, however, Groups II and III are significant with $p < .05$ and $p < .001$, respectively.

The abortion rate is slightly increased among smokers as was the total fetal wastage (abortion rate plus stillborn rate) (Table III). The stillborn rate itself, however, was not affected by smoking (Table III) ($p > .05$ in all categories). The low percentage of abortions in Group II was due to the large number of unwed mothers (primigravida) from the Florence Crittenton Home. It is hard to explain the 5.2 per cent abortion rate in Group III, unless this is caused by a poor history or lack of diagnosis of early pregnancy. Groups I and II show no significant increase in abortions in each of the three categories— $p > .05$. Group III is significant for smokers of less than one-half pack per day and one-half to one pack per day with $p < .001$, however, not significant in smokers of one plus pack per day ($p > .05$).

The occurrence of major fetal anomalies was consistently lower among smokers (Table IV). The decrease was not significant at $p > .05$ in all categories. The number was very small and chance could have played a part. The low incidence in Group III was probably due to a poor history. No pattern to any particular anomaly was established. Our figures were much

Table V. Maternal complications

	Group I		Group II		Group III	
	Nonsmokers (2,406 pregnancies)	Smokers (1,720 pregnancies)	Nonsmokers (557 pregnancies)	Smokers (660 pregnancies)	Nonsmokers (7,775 pregnancies)	Smokers (3,040 pregnancies)
Toxemia	101	45	38	24	751	314
Bleeding unknown cause	16	15	7	7	30	13
Abruptio placentae	8	4	1	7	28	18
Placenta previa	10	14	1	4	19	10
Premature ruptured mem- brane	30	23	10	29	180	107
Prolapse cord	5	2	0	0	7	1
Miscellaneous	6	4	11	10	87	51
Total	176	107	68	81	1,102	514
Per cent	7.3	6.2	12.2	12.3	14.2	16.9

lower than the ones reported by Lowe (11 and 15 major anomalies per 1,000 for non-smokers and smokers, respectively).

Maternal complications of pregnancy were shown only as smokers or nonsmokers (Table V). The lower the socioeconomic group the higher the incidence of complications. A twofold increase in the maternal complications exists between Groups I and

III (7.3 and 14.2 per cent, respectively). The high incidence of toxemia was the major reason for this difference. Groups I and II show no statistical difference between smokers and nonsmokers ($p > .05$). Group III, however, is significant ($p < .001$), mainly because of premature rupture of membranes ($p < .001$), which is also shown in Group II ($p < .02$). No other individual complication is significantly elevated in smokers. Of course, these figures were below the true incidence, since by history many patients had either forgotten or did not know of certain complications.

In an attempt to balance the statistics on breast feeding, only the results of the first pregnancy were recorded (Table VI). The low incidence of breast feeding in Group II was due to the high incidence of the unwed mothers from the Florence Crittenton Home who usually place their babies for adoption. A slightly higher percentage of the smokers breast fed in all three groups. Thirty-five per cent of the private and 50 per cent of the Negroes breast fed. The important factor was the percentage which had inadequate breast milk (Table VI). Here, only a slight increase in inadequacy was found in smokers over nonsmokers in Groups I and III. The statistics were variable in Group II, and, as previously stated, probably due to the Florence Crittenton girls. From these data it does not appear that smoking interferes with nursing ($p > .10$).

It is common knowledge that smoking decreases the appetite. However, on observing Table VII one is surprised that the weight gain for smokers and nonsmokers during pregnancy is approximately the same. In many cases, especially in the Negro, the weight gain was not known; therefore, these cases were omitted in this section.

To explore other possible contributing factors, mothers who drank coffee and alcohol were tabulated (Table VIII). If a patient indulged in social drinking, she was included in the alcohol group. It was interesting to note that a higher percentage of smokers drank coffee and alcohol. The significance of this was questionable other than the fact

Table VI. Percentages of women who did and did not breast feed babies

	Non-smokers (%)	Smokers (packs per day)		
		< 1/2 (%)	1/2 to 1 (%)	> 1 (%)
Group I				
Breast fed	34.2	41.9	35.6	34.6
Inadequate milk	39.3	45.6	48.6	42.1
Group II				
Breast fed	19.8	19.0	12.8	21.4
Inadequate milk	14.0	16.6	45.5	44.0
Group III				
Breast fed	46.3	52.7	54.9	58.3
Inadequate milk	12.3	10.2	14.3	18.5

Table VII. Maternal weight gain in pounds

Group	Non-smokers	Smokers (packs per day)		
		< 1/2	1/2 to 1	> 1
I	20.7	23.5	20.9	19.7
II	21.9	22.3	21.6	21.4
III	21.2	23.2	20.1	21.6

Table VIII. Percentages of women who drank coffee and alcohol

	Non-smokers (%)	Smokers (packs per day)		
		< 1/2 (%)	1/2 to 1 (%)	> 1 (%)
Group I				
Coffee	90	99	93	96
Alcohol	25	49	51	62
Group II				
Coffee	69	84	90	97
Alcohol	27	55	56	48
Group III				
Coffee	55	60	63	58
Alcohol	21	39	36	56

that generally speaking the smoker was a tense, somewhat anxious woman thereby possibly using more than one outlet for her nervous energy. The average number of hours slept each night in all three groups was between 7 and 8 hours.

Comment

In this investigation we have further substantiated the findings of others that infants born to mothers who smoke are smaller and the incidence of prematurity is greater. Many suggestions for this etiology have been offered, but none have been solely accepted. The findings of Haddon, Nesbitt, and Garcia¹⁴ that the carbon monoxide blood levels in women who smoke were increased by twofold was significant. They found that 5 to 6 per cent of the available hemoglobin was combined with carbon monoxide in smokers as compared normally to 1 to 2 per cent. Cord blood and maternal blood levels were approximately equal. Since cord blood hemoglobin is higher than maternal, slightly less than 5 to 6 per cent of the fetal hemoglobin would be methemoglobin but still significantly elevated. Roth¹⁵ reported cardiovascular changes in man from smoking that may last up to 30 minutes. These include an increased blood pressure by a systolic of 20 millimeters and a diastolic of 14 millimeters of mercury, an increased pulse rate of 36 per minute, and a decreased skin temperature of the toes by 2.5° C. due to vasospasm. She states that the standard cigarette needs its nicotine content reduced by 60 per cent before these changes failed to occur. Another possible factor is the direct action of nicotine or some similar toxin within cigarette smoke that could effect the fetus. Bogen¹⁶ reported cigarette smoke from one domestic cigarette to contain: 320 c.c. of carbon dioxide, 8 c.c. of carbon monoxide, 4.2 c.c. of alkali, 14 mg. of nicotine, 2.2 mg. of ammonia, 1.4 mg. of aldehyde, and 0.4 mg. of furfural. Several of these products can be toxic. The possibility that the increased incidence of prematurity among smokers was responsible for the birth weight differences was disproved by Frazier and

associates.¹¹ Throughout the third trimester fetuses of equal gestational age showed birth weight differences between nonsmokers and smokers. The true etiology of the effect that cigarette smoke has on the fetus is probably a summation of all these factors, with some playing a more significant role than others.

By no means do we intend to indicate that cigarette smoke is the only factor governing the birth weight and incidence of prematurity. Socioeconomic factors certainly have some influence. Whether this is due to nutritional, environmental, emotional, or medical reasons, can only be one's supposition. Our statistics show that the lower the socioeconomic status, the less the difference in the birth weights and the higher the percentage of prematurity between nonsmokers and smokers. Behrend and Thienes¹⁷ reported that the decreased birth weight in rats exposed to cigarette smoke was due to a lack of subcutaneous and abdominal fat. McKeown and Record¹⁸ reported a direct relationship between antenatal maternal weight and birth weight of their newborn. Lowe¹⁹ reported the antenatal weight of nonsmoking mothers less than 4 pounds greater than smokers. This slight weight difference probably does not play a part but has to be considered. Race contributes to the birth weight. In our study the average private white infant weighed 396 grams more than the Negro in the nonsmoking groups. Inheritance, multiparity, metabolic diseases, maternal complications of pregnancy, and maternal anomalies of the genital tract all have their influence upon the fetus and the outcome of pregnancy.

A significant question that remains unanswered is whether the decreased birth weight of infants born to smokers is detrimental. Perinatal mortality was not evaluated in our study, but would be of utmost importance in future studies.

It appears that in women of normal fertility, smoking probably does not cause any true difficulty. However, if a patient has an infertility problem or a poor obstetrical history it would probably behoove the obstetrician to have the patient cease smoking.

Summary

1. Four thousand four hundred and forty postpartum women representing 16,158 pregnancies were interviewed regarding smoking habits and previous pregnancies.

2. A significant decrease in birth weights of infants born to mothers who smoke was found. This increased directly with the number of cigarettes smoked per day and the socioeconomic status.

3. A twofold increase in prematurity occurred in smokers again directly proportioned to the cigarettes smoked per day.

4. A slight increase in abortion rate was found among smokers, but generally not significantly elevated.

5. No significant increase in stillbirths, major fetal anomalies, or maternal complications occurred between smokers and non-smokers, although there was a suggestion of an increase in the incidence of premature rupture of membranes in smokers.

6. Smoking does not interfere with breast feeding to any significant degree.

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