A Comparison of Blood Pressure in Term, Low Birth-Weight Infants of Smoking and Nonsmoking Mothers

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Abstract

Infants exposed to the components of cigarette smoke in utero are at an increased risk for perinatal death, low birth weight, sudden infant death syndrome, and premature delivery. The purpose of this pilot study was to compare blood pressure values in term low-birth weight infants (≤ 2500 grams) born to smoking mothers to the blood pressure values of term, low-birth weight infants born to nonsmoking mothers. Data were collected through a retrospective chart review of 30 low-birth weight, term infants at a hospital in the Rocky Mountain region of the United States. Systolic, diastolic, and mean arterial pressure values were obtained from each chart. Fifteen of the infants were born to women who smoked cigarettes during pregnancy, while another 15 infants were born to mothers who did not smoke during pregnancy. While hospitalized at birth, the infants of smoking mothers shared a trend toward higher blood pressure readings for all measures, with the *t*-test differences reaching statistical significance for systolic arm ($p = .024$), diastolic leg ($p = .03$), and mean arterial pressure of the arm ($p = .038$).

Journal of Perinatal Education, 13(4), 17–26; maternal smoking, infant blood pressure, low birth-weight.

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Introduction

Overview of Problem

Tobacco use is the leading preventable cause of death in the United States, killing approximately 440,000 U.S. citizens each year (Centers for Disease Control [CDC], 2002). From an economic standpoint, smoking is responsible for approximately 8% of total health-care

A Comparison of Blood Pressure in Term, Low Birth-Weight Infants of Smoking and Nonsmoking Mothers

costs in the U.S., or \$157 billion in annual health-related economic losses. Adverse effects to infants of mothers who smoke have been well documented. Authors reviewing the literature on this topic conclude that neonates exposed to the components of cigarette smoke in utero are at an increased risk for perinatal death, low birth weight, sudden infant death syndrome, and premature delivery (DiFranza & Lew, 1995; Haustein, 1999). Data from previous research related to smoking and pregnancy outcomes show that 25% of pregnancies ending with unfavorable results could be attributed to smoking (DiFranza & Lew, 1995).

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Researchers estimate that over 20% of American pregnant women smoke throughout their pregnancies. Numerous studies have documented a significant dose-response relationship between cigarette smoking and prenatal complications (Beratis, Panagoulas, & Varvarigou, 1996). One of the main factors responsible for fatal complications in pregnancy outcomes is a direct result of the chronic reduction in placental intervillous blood flow caused by nicotine, leading to the production of carboxyhemoglobin in the fetus and resulting in hypoxia (Larsen, Clausen, & Jonsson, 2002).

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Previous studies report elevated blood pressures in full-term infants of smoking mothers (Beratis et al., 1996; Stepan & Fuller, 1999). Newborns born to

smoking mothers had mean diastolic blood pressures between 3 and 8.2 mmHG higher than newborns of nonsmoking mothers (Beratis et al., 1996; Stepan & Fuller, 1999). Newborns of smoking mothers experienced mean systolic blood pressures that were 3 to 12.5 mmHG higher than infants born to nonsmokers (Beratis et al., 1996). This relationship was dose-related, with 15 or more cigarettes per day producing notable effects. Preliminary studies indicate that maternal smoking during pregnancy may lead to elevated blood pressure during infancy and childhood (Blake et al., 2000). Retinal arterial narrowing and straightening have also been associated with elevated blood pressure in infants born to smoking mothers (Beratis, Varvarigou, Katsibris, & Gartaganis, 2000).

Systemic hypertension in the neonate is frequently an indicator of other renal or cardiovascular abnormalities (Jones & Jose, 2004). Instrument vaginal delivery, prolonged ventilatory support, presence of patent ductus arteriosus, and high blood pressure during the neonatal period have also been associated with elevated blood-pressure values in low birth-weight infants during initial visits to a neonatal follow-up clinic (Dgani & Arad, 1992). However, only neonatal hypertension continued to be associated with elevated blood-pressure values during subsequent clinic visits.

Purpose

The purpose of this study was to pilot a retrospective comparison of blood pressure in term, low birth-weight infants of smoking mothers to the blood pressure of infants of nonsmoking mothers. Specifically, this study examined whether there is evidence that systolic, diastolic, and mean blood pressures in term, low birth-weight infants of smoking mothers are higher than blood-pressure measurements of term, low birth-weight infants of nonsmoking mothers.

Significance in Clinical Practice

It is important to document the blood-pressure differences in low birth-weight infants of smoking and nonsmoking mothers because mild to moderate elevations in blood pressure in asymptomatic newborns require close observation (Taeusch & Ballard, 1998). Because

prolonged hypertension in infants can result in end-organ damage, routine blood pressure measurement is recommended as part of outpatient follow-up procedures in high-risk newborns (Goble, 1993). Infants born with birth weight at the lower end of the normal range have an increased rate of coronary heart disease as adults (Barker, 1995).

According to the literature, documentation of hypertension in infants is rare, but “the incidence of hypertension in infancy has risen in recent years, reflecting both better monitoring methods and increasingly successful salvage of smaller and smaller newborns” (Goble, 1993, p. 120). Blood pressure can be difficult to measure in newborn infants due to increased levels of activity, but it serves as a window to evaluate current and future health. The presence of the risk factor of maternal smoking can be a predictor of future health risks for the infant. Elevated blood pressure associated with smoking has been documented in babies born at higher birth weights at term but has not been investigated in term infants of low birth weight. Goble (1993) reports that prolonged hypertension in infants can result in end-organ damage and further recommends routine blood-pressure measurement as part of outpatient follow-up care in high-risk newborns. Preliminary evidence suggests that neonatal sodium restriction can result in lowering blood pressure measurements during adolescence (Geleijnse et al., 1997). If low birth-weight infants of smoking mothers are identified as being at higher risk for elevated blood pressure, preventative efforts can be started immediately.

Review of Literature

Nicotine in cigarettes has been linked to a higher risk of cardiovascular disease and hypertension in adults. Vascular changes in infants of mothers who smoke could have a lifetime effect. Maternal smoking during pregnancy is related to fetal growth restriction and vascular changes in the fetus resulting in fetal hypoxia and an increased risk of low birth weight. Low birth weight is also a major contributor to infant mortality and morbidity. According to Behrman and Shiono (1997), infants born at low birth weight or less than 2500 grams are 40 times more likely to die during infancy than those born at normal birth weight. The authors also report that infants born at a lower birth weight

have an increased incidence of hypoglycemia, nutritional deprivation, hypothermia, meconium aspiration, congenital infections, polythemia, and congenital malformations. Because of these problems, the postdelivery care of low birth-weight infants is connected with large financial costs. Oster, Delea, and Colditz (1998) estimate that 41.8% of smokers’ infants weighing 2500 grams or less at birth require admission to the neonatal intensive care unit. In this review of the literature, the effects of cigarette smoking as it relates to hypertension and pregnancy will be discussed.

Smoking and Hypertension

A significant risk factor for hypertension is smoking (Roberts & Banning, 1998). The acute effects of smoking on the adult cardiovascular system include those caused by nicotine. Early studies established that nicotine intake from smoking acutely increases catecholamine levels in the blood and causes a rise in the heart rate and blood pressure (Cryer, Haymond, Santiago, & Shah, 1976).

Those who smoke cigarettes have 2–3 times the risk of hypertension compared to those who do not smoke (Sleight, 1993). Smoking has long-term effects on various components of the cardiovascular system, including reduced life span of thrombocytes, higher levels of fibrinogen, lipid abnormalities, arterial wall rigidity, and target organ damage due to blood-pressure variability (Kochar & Bindra, 1996).

Smoking During Pregnancy

In 1999, despite the documented adverse effects of smoking, 22.5% of American women of reproductive age (18–44 years old) smoked cigarettes (CDC, 2001). The effects of maternal smoking include increasing the rate of premature delivery and decreasing the birth weight in the final trimester. Studies have suggested carbon monoxide and nicotine are among the main ingredients in cigarette smoke responsible for adverse fetal effects (Haustein, 1999). In pregnant women, carbon monoxide and high doses of nicotine interfere with the oxygen supply to the fetus. Nicotine readily crosses the placental barrier and reduces fetal blood supply, altering oxygen delivery to the fetus (Oncken, Hardardottir, & Smeltzer, 1998). According to Sachs (1989), the carbon monoxide from smoking also causes fetal hypoxia and blunts the adaptive response that would normally

A Comparison of Blood Pressure in Term, Low Birth-Weight Infants of Smoking and Nonsmoking Mothers

occur. Carbon monoxide has an affinity for hemoglobin 200 times that of oxygen itself, which results in decreased oxygen-carrying capacity of the blood and a decrease in the available oxygen at the tissue level.

Haustein (1999) reviewed the literature related to the effects of cigarette smoking and nicotine on pregnancy outcomes. Results of seven studies reviewed indicated that the mean birth weight of infants of women who smoke during pregnancy is 200–300 grams less than that of infants of nonsmokers. Newborns born to smokers are smaller at every gestational age. Additionally, low levels of zinc and cadmium (a zinc antagonist) in maternal and cord blood are evident and related to intrauterine growth restriction (Kuhnert, B., Kuhnert, P., Debanne, & Williams, 1987; Sachs, 1989). Recent studies suggest that smoking during pregnancy also affects the vasculature of the placenta (Larsen et al., 2002). Fetal undernourishment may occur as a result of the reduced size of fetal capillaries in villi, which affects placental blood flow and diminishes the area for the exchange of gases and nutrients between the mother and the fetus. The placenta may grow large in an effort to compensate.

Literature reviews across multiple studies show a clear association between maternal smoking and perinatal loss (Fanaroff & Martin, 1997; Haustein, 1999). Prenatally, women who smoke during pregnancy have a higher risk of placental abruption, spontaneous abortions, and premature birth. Postnatally, the most dramatic effect of maternal smoking is the increased risk of sudden infant death syndrome (SIDS). DiFranza and Lew (1995) reported that maternal smoking triples the risk of SIDS. These authors suggest two-thirds of the SIDS deaths are attributable to smoking.

Blood Pressure in Infants

Blood-pressure measurement in newborn infants constitutes a useful parameter in the assessment of well-being. Parameters for neonatal hypertension are defined as persistent blood pressures of more than 90/60 mmHg in the term infant to 1 week of age (Goble, 1993). The causes of hypertension in infancy are vascular disorders such as coarctation of the aorta, renal disorders, increased intracranial pressure, and cocaine intoxication in breastfed infants. Overall mortality and morbidity rates for uncontrolled hyperten-

sion in infants are unknown. Systemic hypertension is defined as a blood pressure that persistently exceeds the mean + 2 standard deviations for infants of normal gestational age, size, and postnatal age (Fanaroff & Martin, 1997). Normal ranges can be difficult to specify because of different measurement techniques, the range of birth weights and gestational ages, rapidly changing body size, the marked rise in blood pressure in the first hours and days of life (Tan, 1987), and the sleep-awake state (Earley, Fagers, & Ng, 1990). According to the Second Task Force on Blood Pressure Control in Children (National Heart, Lung, and Blood Institute, 1987), a significant correlation exists between the infant's systolic blood pressure and weight. In small-for-gestational-age newborns, blood pressure is more closely related to the size of the infant than to gestational age.

Blood pressures in healthy, term infants at 3 days of age are not different among racial groups (Caucasian, African American, Hispanic) (Hulman, Edwards, Chen, Polansky, & Falkner, 1991). These authors also found no relationship between blood pressure and the presence of maternal conditions such as toxemia, diabetes, and substance abuse in the infant's first three days of life.

Increased Blood Pressure in Term Infants of Smoking Mothers

The effects of intrauterine exposure to smoke on subsequent newborn blood pressure are few. Research has documented that infants of mothers who smoke during pregnancy have higher systolic and diastolic blood pressures than infants of nonsmokers (Beratis et al., 1996; Stepan & Fuller, 1999). These differences existed during the 1st–72nd hour of life, but disappeared by 6 weeks of age (Stepan & Fuller, 1999). Retinal abnormalities have also been associated with elevated blood pressure in neonates born to smoking mothers (Beratis et al., 2000). In studies of older children, intrauterine exposure to the mother's cigarette smoke resulted in an increase in blood pressure in children up to 8 years of age (Blake et al., 2000; Morley, Leeson Payne, Lister, & Lucas, 1995).

Gaps in the Literature

Research of childhood diseases may provide a window to early opportunities for the prevention of chronic

diseases in adults. A better understanding of the origins of adult diseases in fetal life may improve longevity and decrease morbidity (Fanaroff & Martin, 1997). The incidence of elevated blood pressure in term infants of smoking mothers has been documented, but the magnitude of this relationship has not been investigated in low birth-weight infants. In the clinical practice setting, the infant's blood pressure and tissue perfusion are generally considered to be adequate as long as urine output and capillary refill are within normal limits. This brief clinical assessment may be appropriate for infants having normal blood pressure, but not for those at risk for increased blood pressure. The symptoms associated with hypertension are nonspecific; however, prolonged elevated blood pressure can result in end-organ damage and, therefore, should be assessed in those infants at risk by virtue of their having been exposed to intrauterine smoking.

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Epidemiologic studies suggest that growth-restricted offspring, especially those born with a large placenta, may be at increased risk of developing hypertension as adults (Stewart, Rogerson, & Mason, 1995). These infants would logically be at highest risk for elevated blood pressure and benefit from follow-up measures as part of their infant care.

Methods

Research Design

This retrospective study was designed to investigate blood-pressure measurements in low birth-weight infants born to smoking and nonsmoking mothers.

Methodology

This pilot study was accomplished by performing a retrospective review of charts of low birth-weight infants.

A low birth-weight infant was defined as a term infant (37–42 weeks gestation) weighing 2500 grams or less but >1500 grams, and falling at or below the 10th percentile on the growth chart. The infants studied were born at one Rocky Mountain area hospital between 1999 and 2001. The information gathered included systolic, diastolic, and mean arterial blood pressures taken at an unrecorded time, which ranged from 12–92 hours, before hospital discharge. Other data gathered included gender, Apgar scores, weight, and gestational age. This information was collected from the hospital records of the 30 infants. Fifteen infants were born to smoking mothers and 15 were born to nonsmoking mothers.

Sampling

The setting for data collection was in the Rocky Mountain region in a major metropolitan hospital serving a population of approximately 3 million. This facility documents an average of 3000 deliveries per year. Before data collection began, internal review board approval was gained from both the University of Wyoming and the hospital where data were collected.

Infant blood pressure data were identified using retrospective chart audits. An audit of 70 charts secured 30 participants who were not restricted from the study based on exclusion criteria. These participants were 15 infants of mothers who smoked during pregnancy and 15 infants of mothers who were nonsmokers. All charts of low birth-weight infants born at the identified hospital in the years 1999, 2000, and the beginning of 2001 were screened for potential inclusion in the study.

Preliminary screening for low birth-weight infants began in the logbook in the newborn nursery that documents weight and gestational age. The policy of the institution where data were obtained requires documentation of the blood pressure of an infant measured in the right arm and right leg prior to discharge from the hospital.

The criteria for exclusion from the study were:

1. documented maternal use of recreational drugs;
2. maternal bed rest restriction for longer than 2 weeks;
3. maternal complications of HELLP syndrome (characterized by hemolysis, elevated liver

A Comparison of Blood Pressure in Term, Low Birth-Weight Infants of Smoking and Nonsmoking Mothers

enzyme levels, and a low platelet count), pregnancy induced hypertension, or chronic hypertension;

4. infant Apgar scores <7 at 5 minutes of age;
5. supplemental oxygen for infants for >12 hours;
6. infant birth weight >1500 grams, but <2500 grams; and
7. infant gestational age <37 weeks.

Medical charts were pulled for infants who met the inclusion criteria and were further screened to rule out those with exclusion criteria. The chart data related to maternal smoking included questions about whether the woman smoked cigarettes during pregnancy and about the number of cigarettes smoked per day.

Measurements

For this retrospective study, systolic, diastolic, and mean numbers were collected from documented blood-pressure measurements recorded prior to hospital discharge on infants identified as being low birth-weight at 37–42 weeks gestation. The information was collected at one institution only so that the instrument of measurement was consistent. This particular nursery used only one instrument to measure blood pressure: the Dinamap monitor model 1846 (Critikon, Inc., 1984). Documentation of calibration of the instrument was received from the biomedical department at the hospital and is documented and performed yearly during the month of February.

Although the most accurate way of blood-pressure monitoring in infants is through direct arterial line measurement, the procedure is performed only in critically ill newborns. A noninvasive technique requires the use of automatic oscillometric methods. Cuff application is straightforward because no specific transducer application is required. This method provides accurate, reproducible, and convenient estimates of blood pressure in the infant (Goble, 1993).

In an effort to discern the technique of those taking blood-pressure measurements in this nursery, the author observed multiple nurses during all shifts in the newborn nursery of the institution during the measurement of blood pressure. It is important to choose a cuff of the correct size when measuring blood pressure. The appro-

priate cuff size should encircle at least two-thirds of the upper arm and should be long enough to surround the circumference of the arm (Park & Lee, 1989). A cuff that is too small gives a false high reading. In the observations made, measurements performed by nurses were made only when the infants were in a calm and quiet state. An appropriately sized cuff was used consistently by all nurses who were observed. This observation was used as the basis of an assumption that appropriate technique was used to measure the blood pressure of the infants who were studied.

Limitations

Because of the retrospective nature of this study, several limitations are evident. No documentation exists regarding the activity level of infants when measurement of blood pressure was obtained, and only one measurement from the right arm and right leg was recorded for each infant. An increased level of activity could have increased diastolic blood pressure. Another limitation of the study is the lack of documentation that the cuff size used was appropriate, even though the observation was made that nurses currently use a suitable cuff.

An additional study limitation is that the age of the infants was not recorded at the time the blood pressure was taken. The time of hospital discharge averaged between 12 hours and 4 days of age. Park and Lee (1989) found that blood pressure differences existed between infants less than 36 hours of age and those older than 36 hours for the arm and leg.

Only infants born at 5600 feet above sea level were included in the study. Altitude is known to negatively affect birth weight (Jensen & Moore, 1997; Sohl & Moore, 1998); in turn, weight affects blood pressure (Blake et al., 2000). Jensen and Moore (1997) found that pregnancy-associated hypertension was 2.5 times more common at high altitudes. The study described here was conducted at an elevation of approximately 5600 feet above sea level. Thus, the results cannot be generalized to infants born at lower altitudes.

No data were available on socioeconomic or maternal nutritional status. Thus, another study limitation is the lack of documentation on the drug history of the mother. The omission of information regarding maternal use of drugs or alcohol could lead to incorrect

conclusions. Research findings report a higher incidence of illicit drug use among those who smoke during pregnancy. Sees and Clark (1993) found that research shows that illicit drug users also smoke cigarettes and drink alcohol. Other studies reveal that the pattern of tobacco use predicts the pattern of abuse of other psychoactive drugs, revealing nicotine as a “gateway drug” (Jessup, 1996; Sees & Clark, 1993).

Another limitation is the small number of subjects meeting the inclusion criteria for this analysis. If a larger sample had been available, differences might have been explored between light and heavy smokers, as opposed to collapsing them into a dichotomous variable of smoking or nonsmoking. Given the small number of subjects and the potential influence of these limiting factors, the results of this pilot study must be viewed with considerable caution.

Results

The sample of infants of smoking mothers ($n = 15$) contained 9 girls (60%) and 6 boys (40%), while the sample of infants of nonsmoking mothers ($n = 15$) was made up of 11 girls (73%) and 4 boys (27%). Infants of smoking mothers were Caucasian (40%), African American (27%), and Hispanic (33%), while infants of nonsmoking mothers were mostly Caucasian (67%) with fewer African Americans (20%) and Hispanics (13%) (see Table 1).

The average maternal age for those smoking during pregnancy was 28 years compared to 29 years for the nonsmoking group, a difference that was not statistically significant. The average number of cigarettes smoked per day numbered 11, with a standard deviation of 7, and ranged from 4 to 20. No statistically significant difference existed between the groups for weight, gestational age, Apgar scores at 5 minutes of age (after exclusion of <7), or maternal age (see Table 2). All infants were born in the hospital with uncomplicated deliveries.

Table 1 Maternal Demographics for Smokers and Nonsmokers

	Caucasian	African American	Hispanic
Smoking	6 (40%)	4 (27%)	5 (33%)
Nonsmoking	10 (67%)	3 (20%)	2 (13%)

Table 2 Birth Information Comparing Infants of Smokers and Nonsmokers

	Mean	SD	<i>t</i>	<i>p</i>
Weight				
Infants of Smokers	2330	169	-1.22 ₍₂₈₎	.233
Infants of Nonsmokers	2393	104		
Gestation				
Infants of Smokers	37.8	.86	-1.27 ₍₂₈₎	.244
Infants of Nonsmokers	38.2	.86		
Apgars at 5 Minutes of Age				
Infants of Smokers	9	.0	1 ₍₂₈₎	.326
Infants of Nonsmokers	8.9	.2		
Maternal Age				
Smoking Mothers	29	6.86	1 ₍₂₈₎	.481
Nonsmoking Mothers	27	7.92		

Data Collection

The number of charts reviewed for data collection for this study totaled 70 in order to obtain a sample of 30 for analysis. The difficulties of data gathering were related to a high incidence of pregnancy-induced hypertension.

Blood Pressure

Both groups exhibited blood pressure within the normal range for newborns according to weight, as established in 1995 by Zubrow, Hulman, Kushner, and Falkner (Kattwinkel, Cook, Hurt, Nowacek, & Short, 2003). For example, a newborn weighing between 2300 and 2400 grams is expected to have a systolic blood pressure that ranges between 40 and 75 mmHg, while diastolic pressures range from approximately 20 to 50 mmHg.

The means of all blood pressure measurements tended to be higher for infants of smoking mothers (see Table 3). A statistically significant difference was found in the mean diastolic pressure of the leg, as well as in the mean systolic blood pressures of the arm ($p = .024$) and the mean arterial pressure of the arm ($p = .038$) when $p = .05$ is used as the measure of significance. In pilot week, $p = .10$ can be used to identify differences of potential interest. Both diastolic arm pressures and systolic leg pressures fall in the $p = .076-.079$ range. Thus, the evidence is in the direction of higher blood pressure measures for subjects whose mothers smoked.

A Comparison of Blood Pressure in Term, Low Birth-Weight Infants of Smoking and Nonsmoking Mothers

Table 3 Comparisons of Blood Pressures in Infants of Mothers Who Smoke ($n = 15$) with Those of Infants of Mothers Who Do Not Smoke ($n = 15$): t -tests

Measurement	Mean	SD	t	p
Diastolic Leg				
Infants of Smokers	45.7	6.7	2.0 ₍₂₈₎	.033*
Infants of Nonsmokers	41.0	4.5		
Diastolic Arm				
Infants of Smokers	47.0	7.0	1.8 ₍₂₈₎	.076
Infants of Nonsmokers	42.7	6.0		
MAP of Leg				
Infants of Smokers	54.0	8.5	1.4 ₍₂₈₎	.162
Infants of Nonsmokers	50.2	5.6		
MAP of Arm				
Infants of Smokers	58.6	7.4	2.1 ₂₈	.038*
Infants of Nonsmokers	52.5	7.9		
Systolic Leg				
Infants of Smokers	70.0	9.9	1.8 ₂₈	.079
Infants of Nonsmokers	64.2	7.2		
Systolic Arm				
Infants of Smokers	73.2	6.4	2.3 ₂₈	.024*
Infants of Nonsmokers	66.3	9.0		

* $p < .05$

Discussion

Given the limitations of the study, evidence suggests that maternal smoking impacts the blood pressure of term, low birth-weight infants at birth. An elevation occurred in the blood-pressure readings of those infants born to mothers who smoked during their pregnancy compared to the infants born to mothers who did not smoke. When comparing the mean blood pressure of the infants in both groups to the documented normal limits of blood pressure, both groups of infants were within the normal range.

Blood-pressure readings were in a higher direction for low birth-weight infants of smoking mothers when compared with infants of nonsmoking mothers. Only the mean arterial blood pressure for the right leg had a difference with $p = < .10$. These findings are consistent with those of Beratis and colleagues (1996) who determined that an association exists between maternal smoking during pregnancy and increased blood pressure in the term newborn infant born at normal birth weight. Stepan and Fuller (1999) also found a higher diastolic blood pressure at birth in infants of mothers who smoked during pregnancy when compared with infants of mothers who did not smoke during pregnancy.

Nicotine in cigarettes has been linked to a higher risk of cardiovascular disease and hypertension in adults who smoke. This risk may also be present for infants born to mothers who smoke during pregnancy. Beratis and colleagues (1996) found that an increased blood pressure in the newborn infants of smoking mothers is maintained through the first year of life. Studies over the past decade have documented that babies of low birth weight have higher blood pressure as children and adults (Curhan et al., 1996; Law & Shiell, 1996). The present pilot study suggests that an infant having the combination of low birth weight and a smoking mother carries blood-pressure risks that need more definitive study in prospective research.

Implications for Practice

It is well documented that a woman who smokes during pregnancy subjects herself and her developing fetus to special risks, including premature birth, low birth weight, and a higher risk of infant mortality. Despite its limitations, this study adds to that body of literature. Prenatal education should advise pregnant women of the multiple risks and consequences associated with smoking. Studies have shown that more than 25% of adults in the U.S. smoke and that 70% of them would like to quit (CDC, 2001). Thus, perinatal education should not assume that smoking, pregnant women are recalcitrant to working toward smoking cessation.

A higher percentage of women stop smoking during pregnancy, both spontaneously and with assistance, than at any other time in their lives. Using pregnancy-specific programs can increase smoking cessation rates, improving infant health and reducing health-care costs (CDC, 2001). For every dollar invested in smoking cessation for pregnant women, about \$6 is saved in neonatal intensive care costs and long-term care associated with low birth-weight deliveries (Marks, Koplan, Hogue, & Dalmat, 1990). Additionally, women need to know that

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smoking during pregnancy can potentially affect the long-term cardiovascular health of their infants.

Smoking cessation programs that have been shown to be beneficial during pregnancy include at least 10 minutes of counseling interventions (Association of Women's Health, Obstetric and Neonatal Nurses [AWHONN], 2000a). In addition, it is recommended that counseling interventions include three types of counseling: "practical counseling, social support as part of treatment, and social support arranged outside of treatment" (AWHONN, 2000b, paragraph 6).

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Further Research

Research regarding blood pressure in low birth-weight infants of smoking mothers should be conducted with a larger sample and at a variety of altitudes. A comprehensive, prospective, longitudinal study should be conducted because of the concern that neonates of mothers who smoked during pregnancy may be at risk for the development of essential hypertension later in life (Beratis et al., 1996). In addition to more programs that help women of childbearing ages to stop smoking, work is needed to define the ideal health care for infants who have been exposed to intrauterine smoking.

Summary

Studies indicate the need for education on the reduction or cessation of tobacco use for women who are pregnant or plan to become pregnant. The results of this pilot study indicate an elevation in systolic and diastolic blood pressure in term, low birth-weight infants of smoking mothers when compared to infants born to nonsmoking mothers. Although the long-term results of elevated blood pressure are not known for infants, research indicates that adult health and disease may begin with intrauterine development (Alaine & Stoddard, 1997).

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A Comparison of Blood Pressure in Term, Low Birth-Weight Infants of Smoking and Nonsmoking Mothers

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