

How smoking during pregnancy affects the mother and fetus

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Abstract

The prevalence of smoking during pregnancy remains unacceptably high. There are serious adverse effects on both the mother and fetus; various toxins in cigarette smoke contribute to placental changes, reduced blood flow, leading to inadequate nutrient availability and tissue necrosis. Complications include reduced fetal growth, shortened gestation and an increased risk of congenital abnormalities and stillbirth. All women who smoke during pregnancy should be biochemically identified, counselled on these adverse effects, and guided towards all available sources of help and advice, including smoking cessation services and pharmacies.

Key words: Smoking; Pregnancy; Congenital abnormalities; Breastfeeding; Nicotine; Smoking cessation

Smoking cigarettes during pregnancy is an avoidable cause of adverse pregnancy outcomes and short- and long-term negative effects for the mother and the unborn child (Mund, 2013). Many women will quit smoking when they find out that they have conceived; however, about 40% of pregnant smokers will continue their habit, and the reported rate of smoking at delivery is as high as 13% (Health and Social Care Information Centre, 2013). A small number of women will quit smoking early on in pregnancy once advised to do so by health professionals, particularly midwives, but unfortunately many will relapse. Often women who continue to smoke during pregnancy are of lower socio-economic status (Page et al, 2012), have low educational achievement (Batista et al, 2013) and are not married to the child's father (Page et al, 2012).

Effects of smoking on the mother

The adverse effects of smoking on the mother and the developing fetus became known in the 1930s and were consolidated in the early 1960s after the emergence of the evidence of smoking's association with small birth weights, premature delivery and an increased rate of abortion (Zabriskie, 1963).

These well-established facts are accompanied by other emerging problems, such as increased prevalence

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of stillbirth, small-for-gestational-age infants and major congenital anomalies, compared with the babies of non-smokers, resulting in increased admission of newborns to the neonatal intensive care unit (Räisänen et al, 2014). Fetal hypoxia and intrauterine growth restriction arise as a result of diminished utero-placental perfusion and reduced oxygen-carrying capacity of maternal blood, as a consequence of high carboxyhaemoglobin levels from inhaled carbon monoxide (Räisänen et al, 2014).

Smoking has profound effects on placental development and function, including calcification, which may result in placental tissue necrosis and fibrosis (Klesges et al, 1998), and a reduction in the diameter of the chorionic villi, which results in the restriction of the uptake of amino acids (Sastry, 1991). There is a general reduction in placental weight (Naeye, 1987) and enhanced umbilical artery resistance (Kho et al, 2009). Other effects include placenta previa, placental abruption and premature rupture of membranes, all of which give rise to low birthweight, preterm birth and increased perinatal mortality (Castles et al, 1999).

Nicotine

While it is unclear which component(s) of cigarette smoke leads to these changes, nicotine is thought to be a major contributor. Nicotine is the addictive substance in cigarette smoke and affects the brain and neurological functions, particularly in the sympathetic nervous system via stimulation of specific nicotinic acetylcholine receptors (nAChR). These receptors have been located in the normal healthy human placenta and their stimulation by nicotine influences cell growth and protein synthesis. The influence on these receptors is believed to contribute to some of the adverse effects of smoking, such as vasoconstriction, calcification, restricted tissue growth and resultant necrosis (Machalani et al, 2014).

Pre-eclampsia

While most effects of smoking on maternal physiology are harmful, there is some evidence to suggest that smoking can provide protection against pre-eclampsia; according to Conde-Agudelo et al (1999), smokers have a reduced risk of the condition of between 30–50% compared with never-smokers. This association is

interesting, particularly as pre-eclampsia is a serious complication of pregnancy, characterized by the onset of hypertension and proteinuria after 20 weeks' gestation in women without a previous history of chronic hypertension or proteinuria (Magee et al, 2008). The potential protective effect of smoking against pre-eclampsia could be due to inhaled carbon monoxide, which is known to have cytoprotective effects on endothelial cells and protective effects on the human placenta (Bainbridge et al, 2006), or it could come as a result of changes to maternal placental growth factor (Llurba et al, 2013).

A report from Luo et al (2014), however, has pointed out that the current body of evidence comes largely from studies based on self-reported smoking status. Misclassification and inaccurate reports of exposure to tobacco smoke, especially during pregnancy, are well known. This misclassification may distort the actual association between the factors. The use of a biomarker to validate and measure cigarette smoke exposure removes the reliance on self-reported smoking. Using plasma cotinine, a major metabolite of nicotine, the risk of developing pre-eclampsia was found to be no different between current smokers and never-smokers, although there was an increased risk of developing the condition for ex- and passive smokers (Luo et al, 2014).

Effects of smoking on the fetus

The consequences of smoking-related placental damage and toxins entering the fetal circulation are many and varied. Intrauterine growth retardation leads to small-for-gestational-age babies (Bickerstaff et al, 2012) and concomitant decrease in birth length and head circumference (Zhang et al, 2011), but smoking also has a negative impact on the fetus at the genetic and cellular level. Genetic and epigenetic (heritable changes in gene activity) mechanisms play a role in the pathogenesis of malformations and adverse outcomes associated with smoking and pregnancy. Various genes have been shown to undergo methylation changes, which alter the gene expression during development; epigenetic changes play an important role in the progression of many smoking-related conditions, particularly in the case of signalling pathways, which mediate the clearance and detoxification of the poisonous compounds, thus the effects of circulating tobacco-related toxins are magnified (Joubert et al, 2012).

These damaging effects are manifest by an increased risk of neural tube defects, especially anencephaly, spina bifida and encephalocele (Wang et al, 2014), as well as facial defects (Hackshaw et al, 2011), which may be related to low whole-blood folate concentrations in women who smoke during pregnancy (Prasodjo et al, 2014).

The risk of fetal congenital heart defects, and particularly the risk of fetal septal defects, has been shown to be at least partially linked to exposure to

Table 1. Information to discuss with pregnant women unwilling to make an attempt to quit smoking

Relationship between the patient's smoking habits and personal life, finances, children and illnesses

Risk of smoking

- Ask patient what she knows about the risks of smoking, and particularly the risks in pregnancy
- Stress the benefits of cessation for her, her baby, and other family members
- Stress that having experience no problems in previous pregnancies does not guarantee that there will not be problems in current one

Rewards of quitting smoking for the individual situation

- Improve oxygen perfusion and healthy development of the baby
- More money
- Less second- and third-hand smoke exposure for others
- Better-tasting food
- More energy

Barriers to quitting

- Irritability
- Other smokers (family and friends smoking around her)
- Triggers (smoking with coffee or after a meal) and cravings
- Weight gain
- Patient-identified barriers

Repeat steps at every visit

Phelan (2014)

maternal smoking in early pregnancy (Alverson et al, 2011; Lee and Lupo, 2012). A dose-dependent relationship between the number of cigarettes consumed during pregnancy and fetal kidney volume was also found; this could predispose the child to the development of chronic kidney disease and hypertension later in adult life (Taal et al, 2011). Similarly, smoking during pregnancy is linked with a decrease in pulmonary function in offspring, leading to suboptimal lung development and increased respiratory distress soon after birth (Lee and Lupo, 2012).

These developmental problems play an important part in the increase of paediatric hospitalization and mortality, particularly as a result of respiratory infections in early childhood (Sahinli et al, 2012). Older children born to mothers who smoked throughout pregnancy have an increased risk of wheezing and asthma in early childhood, which appears to be dependent on the amount and duration of cigarette consumption during the pregnancy, particularly during the first trimester (Zhang et al, 2011).

Fetal and neonatal respiratory problems that arise as a result of maternal smoking are due to stimulation of

the nAChRs, which cause abnormal lung development (Fu et al, 2009). These problems have been implicated in the increased risk of sudden infant death or cot death in mothers who smoked during pregnancy (Phelan, 2014).

Maternal smoking also appears to alter the function of the neonate's digestive tract; smoking during pregnancy increases the risk of infantile colic, even after adjusting for maternal age, birthweight, gestational age, breastfeeding and paternal smoking (Søndergaard et al, 2001). Linear growth is affected and the exposed fetus is at a higher risk of increased body mass index as a child, leading to an increased risk of obesity in adult life (Raum et al, 2011).

Smoking during pregnancy is also associated with substandard nervous function among offspring, owing to the impairment of some aspects of neurological development or activity (Julvez et al, 2007). This impairment can affect cognitive and verbal skills as well as quantitative abilities, working memory and executive function in children, which hampers their development and leads to challenging behavioural traits. This may also lead to an increased prevalence of mental illness in smokers in adulthood (Yang et al, 2013).

Maternal post-delivery effects

Smoking has been shown to have negative effects on the mother post-delivery; following caesarean deliveries, smokers have twice the rate of wound-healing, owing to wound dehiscence (Avila et al, 2012).

Smoking also affects breastfeeding. Smokers tend to have shorter breastfeeding durations than those who do not smoke, although there has been some suggestion that this is merely a reflection of poor health motivation in those who smoke (Bahadori et al, 2013). However, several studies have reported that current smoking suppresses prolactin levels and therefore reduces milk production, changes milk constituency, and increases the concentration of selected saturated fatty acids and unsaturated fatty acids in breast milk (Szlगतыs-Sidorkiewicz et al, 2013).

Animal studies suggest that chronic nicotine administration boosts dopaminergic activity in the brain, specifically in the tuberoinfundibular tract (part of the hypothalamus rich in dopamine neurones), which functions to inhibit prolactin release. This increase in dopaminergic activity may reflect a nicotine-mediated suppression of hypothalamic activity (Bahadori et al, 2013).

Identification of smokers

Smoking is an important factor for poor pregnancy outcomes—all smokers should be identified and counselled to stop smoking. Mothers are asked about their smoking habits at the beginning of antenatal care, but many smokers feel compelled to misrepresent their current status (Gorber et al, 2009); around 23% of pregnant women deny their habit (Dietz

et al, 2011), but this percentage varies depending on the level of smokers' perceived pressure to quit. Demographic factors predicting nondisclosure include educational level and exposure to second-hand smoke (Aurrekoetxea et al, 2013).

Self-reported smoking is therefore an inaccurate means of collecting data, so there is a need to use simple biochemical tests to identify and quantify smoking habit that can be carried out in the clinical environment, without the need to send samples off to the lab for processing. Measuring expired-air carbon monoxide (eCO) levels is a well-established method. Simple hand-held monitors provide measurements of tobacco use, but CO is not specific to tobacco smoke (it is generated by traffic exhausts and faulty domestic heaters), which can give rise to false positives. eCO is a by-product of carboxyhaemoglobin, which has a short half-life (3 hours), meaning a test for eCO levels can only monitor smoking habit over a 6–8 hour period (Christenhusz et al, 2007). A test for cotinine, which can be detected in urine or saliva, is more sensitive and specific and can be carried out using 5-minute point of care tests (Cope et al, 2012). These can monitor smoking habit of up to 3 days before the test and provide useful feedback; however, health professionals should be aware that those using nicotine replacement therapy (NRT) will test positive for cotinine.

Helping pregnant mothers to quit

Nurses, preferably those whom have received some specialist training, should discuss tobacco usage with pregnant mothers who have been identified as smokers. The nurse should explore the 'when', 'where' and 'with whom' of the mother's smoking habits, and warn them of the damaging effects of smoking on both themselves and the developing fetus (*Table 1*).

Mothers' level of understanding of the mechanisms involved in smoking-related damage is generally poor (Wigginton and Lee, 2013)—mothers often fail to understand that cigarette toxins circulate in both the maternal and fetal blood streams, and subsequent harm at the cellular level may affect both the younger and adult lives of children.

The nurse should deliver both verbal information and literature, together with behavioural and pharmacological support, to provide a multi-component approach. This approach has been evaluated among reluctant quitters in the SCRIPT (Smoking Cessation and Reduction In Pregnancy Treatment) trial, which demonstrated an improvement of up to 50% in the cessation rate among pregnant smokers as a result of counselling, troubleshooting, and education throughout pregnancy (Windsor et al, 2011).

As well as monitoring and receiving advice, the patient should also be encouraged to attend the local smoking cessation service (SCS) for support on how to quit. Attendance at these clinics by pregnant

women is generally low (Radley et al, 2013), but it can be improved if the nurse books the mother an appointment with the SCS and stresses the importance of the service in their treatment. The SCS usually involves group sessions delivering advice on NRT. This should ideally involve a slow-release formula, such as a patch in combination with a rapid-release form, such as gum or lozenge, but patients should be advised not to exceed the recommended course of treatment. There are alternative non-nicotine pharmaceutical aids to quitting, notably varenicline (Champix) or bupropion (Zyban), but these are not licensed or recommended for use during pregnancy.

The efficacy of NRT to improve smoking cessation can be hampered by low adherence to the correct dosages and daily use (Hollands et al, 2013). Optimization of NRT based on baseline cotinine levels has been suggested as a means of achieving greater adherence and efficacy (Berlin, 2009).

Electronic cigarettes

The electronic cigarette, or e-cigarette, has emerged as a possible means of reducing tobacco consumption. The devices currently unregulated and are sold over the counter as an alternative source of nicotine. They contain lower levels of carcinogens and other toxins, such as CO, compared with regular cigarettes, but little is known about their long-term effects, especially during pregnancy, so pregnant mothers should be discouraged from using them.

Pharmacies

Pharmacies are a useful source of good advice on behaviour and pharmaceutical aids for smoking cessation (Taskila et al, 2012). Patients should also be directed to the NHS Smokefree website (www.nhs.uk/smokefree), which provides help-to-quit resources, and also to its telephone helpline, 0800 022 4 332. Financial incentive schemes through community pharmacies with eCO validation have been trialled to increase the efficacy of smoking cessation intervention; these schemes have achieved higher rates of engagement and quitting than other non-incentive-based pregnancy interventions. While pregnant mothers from less disadvantaged areas were found to derive most benefit, the scheme enabled substantial reach to those in more disadvantaged circumstances and made a modest contribution to reducing health inequalities (Radley et al, 2013).

Conclusions

Despite the adverse effects of smoking during pregnancy, many women continue to do so. Pregnant smokers put themselves, and their unborn children at risk of serious consequences, including placental problems and stillbirth. Reduced oxygen and nutrient availability and high toxin levels can lead to intrauterine

Key Points

- About 40% of female smokers continue to smoke during pregnancy
- Placental problems lead to vasoconstriction and diminished oxygen perfusion
- Congenital defects include neuronal and multi-organ deformity
- Women who smoke during pregnancy will often deny their habit
- Every opportunity should be taken to identify pregnant smokers and support them to quit

growth retardation and an increased risk of congenital defects to several organs, including the heart, digestive tract and respiratory system. Harmful effects to the neonate extend to the neurological system, resulting in suboptimal cognitive and behavioural development, which may have effects in adolescent and adult life.

All mothers who smoke during pregnancy should be identified, preferably with a biochemical test. The nurse should discuss the probable effects with the mother and provide information and support on assistance with smoking cessation.

Every health professional involved in antenatal care should be aware of the smoking statuses of their patients and take every opportunity to intervene and reinforce the message that smoking is harmful, and every effort should be made to help the mother to quit. This message should acknowledge the influence of partners, family and friends on success or failure (Phelan, 2014).

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