PAPERS AND ORIGINALS

Effects of stopping smoking for 48 hours on oxygen availability from the blood: a study on pregnant women

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Summary and conclusions

The effects of stopping smoking for 48 hours on factors governing the availability of oxygen from the blood—that is, carboxyhaemoglobin (COHb), haemoglobin-oxygen (HbO_2) affinity, and haemoglobin concentration—were measured in women in the last trimester of pregnancy. Three groups were studied: smokers, smokers who stopped smoking for 48 hours, and non-smokers. The 22 smokers had higher initial COHb values and greater HbO_2 affinity than the 10 non-smokers, but their total haemoglobin concentrations were also higher, so that their oxygen availability was not significantly reduced. In the 11 smokers who stopped the reduction in COHb and decrease in HbO_2 affinity led to a significant increase of 8% in "available oxygen" in 48 hours.

Since even small improvements in oxygen delivery to the tissues may confer critical benefit to the fetus, particularly during labour or when exposed to general anaesthesia, smoking should be discouraged for 48 hours before elective deliveries. The same consideration might reasonably be applied to patients undergoing general anaesthesia for all elective operations.

Introduction

It is generally agreed that women who smoke should be advised to stop during pregnancy. Smoking results in the formation of carboxyhaemoglobin (COHb) and hence a reduction in functional haemoglobin. Also the affinity of haemoglobin for oxygen is increased by carbon monoxide, thus impairing the release of oxygen—that is, a fall occurs in the tension of oxygen required to half-saturate the haemoglobin (P_{50} value). The availability of oxygen from the blood to the tissues in smokers is thus reduced.

The time available to hospital doctors to persuade patients to stop smoking may be limited. Most patients are admitted not more than two days before operation or labour. Since even a small improvement in oxygen availability might have important effects on the fetus, especially during the stress of anaesthesia and labour, we have measured changes in factors determining oxygen availability from the blood in a group of mothers who stopped smoking for 48 hours. We compare the findings with those in a group of mothers who continued to smoke and a group of non-smoking mothers.

Patients and methods

We studied 32 mothers during the last trimester of pregnancy. All gave informed consent. The smoking habits of those who smoked were documented, particularly details during the two days before the study. Of the 32 mothers, 11 continued to smoke during the 48-hour study period (group 1), 11 agreed to stop smoking (group 2), and 10 were non-smokers (group 3). The three groups were similar in weight, age, parity, gestation, and clinical characteristics. Venous blood (10 ml) and blood from the radial artery (2 ml) were taken on two occasions 48 hours apart at midday.

"Available oxygen" is defined here as the amount available to the tissues per dl blood, as assessed from the measured arterial oxygen tension and with an assumed mixed venous tension of 2·67 kPa (20 mm Hg).[1] To avoid the influence on available oxygen of variations in haemoglobin concentration each patient's initial haemoglobin concentration was used in subsequent calculations. The blood was taken in heparinised plastic syringes and kept in iced water. With use of the IL 217 Blood Gas Laboratory (Instrumentation Laboratory, UK) COHb was measured in venous blood and pH and pressure of carbon dioxide (Pco_2) in the arterial sample to permit calculation of base deficit. Haemoglobin-oxygen (HbO_2) affinity was derived from the simultaneously measured HbO_2 saturation and oxygen pressure (Po_2) in fresh whole blood at oxygen saturations of about 45%, 50%, and 55%. The P_{50} standard (pH 7·4; Pco_2 5·33 kPa (40 mm Hg)) and P_{50} value in vivo (corrected for the calculated mixed venous pH and base deficit) were calculated as described.[2] Red-cell 2,3-diphosphoglycerate (2,3-DPG) was measured in immediately deproteinised blood, according to Sigma Technical Bulletin No 35-UV (Sigma Laboratories, USA).

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TABLE I—*Haematological variables in each group. (Results are means ± SD)*

		Haemoglobin (g/dl)	Venous COHb(%)	P_{50} (kPa) Standard	P_{50} (kPa) In vivo	2,3-DPG (μmol/g Hb)	"Available oxygen," corrected for COHb (ml/dl)	Arterial pH	Base deficit (mmol/l)
Group 1 (smokers not stopping (n = 11))	Initial	12·1 ± 0·9	4·6 ± 2·0	3·10 ± 0·173	3·12 ± 0·200	15·0 ± 2·0	9·1 ± 1·0	7·44 ± 0·0	2·15 ± 1·99
	After 48 h		4·0 ± 1·4	3·12 ± 0·133	3·17 ± 0·093	15·2 ± 2·3	9·3 ± 0·8	7·43 ± 0·0	3·70 ± 2·23
Group 2 (smokers stopping (n = 11))	Initial	11·8 ± 1·2	5·1 ± 1·2	3·16 ± 0·160	3·13 ± 0·187	18·7 ± 3·3	8·8 ± 1·1	7·45 ± 0·0	4·14 ± 1·95
	After 48 h		1·2 ± 1·2	3·16 ± 0·160	3·23 ± 0·200	17·8 ± 3·7	9·5 ± 1·2	7·44 ± 0·0	3·83 ± 2·4
Group 3 (non-smokers (n = 10))	Initial	11·4 ± 0·5	0·9 ± 1·3	3·27 ± 0·240	3·32 ± 0·280	15·6 ± 3·2	9·5 ± 1·0	7·43 ± 0·0	2·95 ± 1·09
	After 48 h		0·4 ± 0·8	3·24 ± 0·187	3·33 ± 0·253	15·8 ± 3·2	9·5 ± 0·8	7·42 ± 0·0	2·95 ± 1·82

Conversion: SI to traditional units—P_{50}: 1 kPa ≈ 7·5 mm Hg. 2, 3-DPG: 1 μmol/g Hb ≈ 261 μg/g Hb. Base deficit: 1 mmol/l = 1 mEq/l.

TABLE II—*Differences in mean haematological variables between groups. (Results expressed ± SE)*

		COHb (%)	P_{50} (kPa) Standard	P_{50} (kPa) In vivo	2, 3-DPG (μmol/g Hb)	"Available oxygen," corrected for COHb (ml/dl)
Initial values	Group 2 *minus* group 3	4·21 ± 0·56 (P < 0·0001*)	−0·105 ± 0·085	−0·187 ± 0·103 (P < 0·05*)	3·12 ± 1·49 (P = 0·05†)	−0·67 ± 0·45
	Group 1 *minus* group 3	3·79 ± 0·76 (P < 0·0001*)	−0·18 ± 0·091 (P < 0·05*)	−0·189 ± 0·104 (P < 0·05*)	−0·54 ± 1·15	−0·36 ± 0·45
Values after 48 h *minus* initial values	Group 2	−3·83 ± 0·48 (P < 0·0001‡)	−0·003 ± 0·039	0·101 ± 0·056 (P = 0·05‡)	−0·88 ± 0·75	0·67 ± 0·17 (P < 0·005§)
	Group 1	−0·68 ± 0·65	0·033 ± 0·040	0·055 ± 0·044	0·19 ± 0·68	0·18 ± 0·14
	Group 3	−0·41 ± 0·44	−0·029 ± 0·068	0·016 ± 0·095	0·28 ± 0·7	0·008 ± 0·25

*One-tailed unpaired *t* test. †Two-tailed unpaired *t* test. ‡One-tailed paired *t* test. §Two-tailed paired *t* test.

We used the one-tailed *t* test to analyse changes that would occur in a predictable direction. In other analyses of differences we used the two-tailed *t* test.

Results

Mothers who stopped smoking and those who did not stop smoked a mean of 43·9 ± SD 13·8 and 44·9 ± 12·6 cigarettes respectively during the 48 hours before the study. The mean intervals between the last cigarette and taking the initial samples in the two groups were 23·6 ± SD 19·1 and 27·3 ± 19·4 minutes respectively.

Mothers who continued to smoke consumed significantly fewer cigarettes than usual (30·6 ± 15·2) during the study period (P < 0·05). All patients had normal blood films, haemoglobin concentrations, and cell counts (measured on a Coulter model S).

Table I gives the findings in the three groups. The initial COHb values were much higher in the smoking than non-smoking mothers (tables I and II). Table II shows the differences in initial values between the three groups and the changes over 48 hours in each group.

Discussion

Despite the carboxyhaemoglobinaemia in the smokers in our series their increased total haemoglobin concentration gave an amount of *functioning* haemoglobin similar to that in non-smokers. Stopping smoking for 48 hours caused the COHb value to fall almost to the value in non-smokers.

The initial P_{50} value in vivo was significantly lower (by 0·187 kPa (1·4 mm Hg)) in smokers than in non-smokers (table I). A similar difference (0·147 kPa (1·1 mm Hg)) was found in a study of male smokers and non-smokers.[3] In our study stopping smoking increased the P_{50} value in vivo by 0·101 kPa (0·76 mm Hg). Smokers who did not stop reduced their consumption, which produced a rise of 0·055 kPa (0·41 mm Hg) in P_{50} value in vivo. There was no significant change in the in-vivo P_{50} value in non-smokers.

Smokers' initial amounts of "available oxygen" were not significantly different from those in non-smokers; the higher haemoglobin concentrations in smokers largely compensated for the adverse effects on oxygen transport of the COHb and increased HbO_2 affinity. Other workers[3 4] also found higher haemoglobin concentrations in smokers than in non-smokers.

The initial 2, 3-DPG concentrations showed a different pattern from the other measurements. The initial concentration in smokers who stopped was higher than in non-smokers (P = 0·05; tables I and II) and also higher than in smokers who did not stop (P < 0·05). There may be a constitutional difference between women able to stop smoking and those unable to stop or this could be a chance observation, despite the statistical significance.

"Available oxygen" reflects the changes in P_{50} in vivo and COHb. There was a significant increase of 8% in "available oxygen" when mothers stopped smoking for 48 hours. This was due partly to a 4% increase in functioning haemoglobin after the loss of carbon monoxide and partly to the increase in P_{50} in vivo. This increase in P_{50} in vivo must reflect the small changes in base deficit and pH over the two-day period; the P_{50} standard did not change, presumably reflecting the opposing influences of a reduction in concentrations of both COHb and 2,3-DPG. Fetal hypoxia may occur during pregnancy and labour.[5] An 8% increase in maternal "available oxygen" should result in a definite improvement in fetal oxygenation. This is important in conditions of acute stress and chronic placental insufficiency.

We recognise that allocation to the groups was not random. A randomised trial was not feasible, since many mothers cannot stop smoking. Nevertheless, the improved oxygen availability seen in group 2 may be expected in patients who can stop smoking, which is realistic in clinical conditions.

It is difficult to stop many mothers from smoking throughout pregnancy. Our study shows that improved oxygen transport should result from stopping smoking for 48 hours, which should be encouraged before elective deliveries. This conclusion could reasonably be applied to all elective surgical procedures performed under general anaesthesia, especially in patients with anaemia.[6]

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Requests for reprints should be sent to Dr J M Davies.

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