

Effect of Tobacco Smoking on Semen Quality in Men With Subfertility

Alaa Hussein,¹ Ayman AlGadaa,² Mohamed ElFaras,¹ Medhat ElFiky¹

¹In Vitro Fertilization Center, King Fahd Specialized Hospital, Buridah, Kingdom of Saudi Arabia; ²Department of Surgery, Faculty of Medicine, Qassim University, Qassim Province, Kingdom of Saudi Arabia

Submitted November 10, 2010 - Accepted for Publication December 14, 2010

ABSTRACT

INTRODUCTION: Smoking is considered a risk factor for male infertility, but studies have not shown a conclusive reduction in fertility associated with paternal smoking. The aim of the present study was to investigate the effects of smoking cigarette or shisha tobacco on semen parameters in men with subfertility.

METHODS: This was a prospective study of 100 patients with subfertility. There were 50 smokers with mean (SD) age of 37.1 (8.3) years and 50 nonsmokers with a mean age of 39.5 (9.0) years. The outcome measures were sperm abnormal forms (%), sperm count (M/mL), semen volume (mL), sperm motility (%), duration of infertility, and type, amount, and duration of smoking. Group differences (smoker vs nonsmoker and cigarette vs shisha) in semen volume and sperm parameters were analyzed with *t* tests. Pearson correlations were calculated to determine the association between smoking index and smoking duration and the semen parameters.

RESULTS: When compared with nonsmokers, the smokers had a significantly higher mean percentage of abnormal sperm forms (92.3 % vs 89.4%) ($P < .01$), a significantly lower mean sperm count (20.6 M/mL vs 44.9 M/mL), a significantly lower mean semen volume (2.01 mL vs 2.52 mL), and a significantly lower mean percentage of sperm motility (25.7 vs 37.9) (all with $P < .01$). There were no statistically significant differences in semen parameters between men smoking cigarettes or shisha. There were statistically significant negative correlations between smoking index and the percentage of sperm motility ($r = -0.38$; $P = .006$) and between smoking duration and the percentage of sperm motility ($r = -0.32$; $P = .026$). There was also a marginally significant positive correlation between smoking index and the percentage of abnormal sperm forms ($r = 0.28$; $P = .046$). Correlations with other semen parameters were not significant.

CONCLUSION: Results showed significant deleterious effects of tobacco smoking on semen parameters. The correlation analysis placed special emphasis on the negative impact of smoking on sperm motility. Evidence from this and other studies seems sufficient to recommend that male smokers with subfertility should stop smoking to prevent detrimental effects on semen quality.

KEYWORDS: Smoking; Subfertility; Semen quality

CORRESPONDENCE: Dr. Alaa Hussein, King Fahd Specialized Hospital, IVF Center, PO Box 2290, Buridah, Qassim Region, Kingdom of Saudi Arabia (husseinlaa@hotmail.com).

CITATION: *UroToday Int J.* 2011 Feb;4(1):art 11. doi:10.3834/uij.1944-5784.2011.02.11

Abbreviations and Acronyms

DNA, deoxyribonucleic acid
ROS, reactive oxygen species

INTRODUCTION

Semen volume and sperm concentration, motility, and morphology are valuable and generally accepted indicators of exposure to occupational and environmental factors that can affect male fertility. Even exposure to episodic, seasonal air pollution can have deleterious effects on human sperm [1]. Among different air pollutants, cigarette smoke contains toxic chemicals and mutagenic and carcinogenic compounds that can adversely impact male fertility [2].

Cigarette smoking is among the best-studied factors affecting reproduction in humans. Smoking is reasonably considered a risk factor for male infertility, although the real effect of tobacco on male fertility is still being debated [3]. The majority of the data show that smoking is associated with reduction in sperm concentration and motility, but this association appears to be stronger in healthy men than in patients with infertility [4].

Previous studies on the effects of smoking on fertility show conflicting results. Marinelli et al [5] conducted a review of studies on the effect of smoking and drinking habits on conventional semen parameters. They found that smoking had a limited influence. Ramlau-Hansen and his colleagues [6] documented an inverse dose-response relationship between smoking, semen volume, total sperm count, and percentage of motile sperm. Wong et al [7] reported a higher frequency of cigarette smoking in men with subfertility than in men who were fertile; men who smoked had an abnormal sperm morphology with an odds ratio of 1.7 (95% confidence interval, 0.9-3.2). Another study showed that men with varicocele who smoked more than 10 cigarettes per day had impaired sperm motility and morphology [3].

Despite a reported modest reduction in sperm quality, studies have not shown a conclusive reduction in fertility associated with paternal smoking [4]. Much of the reduced fecundity associated with smoking may be reversed within 1 year of cessation. Therefore, if a definite link between paternal smoking and infertility is found, effective interventions targeted at helping patients quit smoking should be addressed for the benefit of general health and fertility [8]. The purpose of the present study was to investigate the effects of smoking cigarette or shisha tobacco on semen parameters in men with subfertility.

METHODS

This was a prospective study that was approved by the Ethics Committees of both King Fahd Specialized Hospital, Buridah, and the College of Medicine, Qassim University, Kingdom of

Saudi Arabia. The participants were selected from patients attending King Fahd Specialty Hospital between January 2009 and June 2010. All provided informed consent.

Participants

All Saudi Arabian men who attended the infertility clinic were reviewed for possible inclusion in the study. All had subfertility, defined by the World Health Organization 2000 guidelines as the inability of a sexually active, noncontracepting couple to achieve pregnancy in 1 year. The inclusion criteria were: (1) subfertility for at least 1 year, (2) no apparent cause of infertility, (3) no previous treatment for subfertility, and (4) no prior history of paternity.

Men who met the inclusion criteria were included in the potential pool of participants. They were then grouped into smokers and nonsmokers and a simple computer-based random-selection method was used to select 50 patients from each group. We computed our sample size on the difference in sperm motility percentage between smokers and nonsmokers; we assumed that the percentage of sperm motility would be 25% among smokers compared with 30% among nonsmokers. At a confidence level of 95% and power of 90%, we required 25 patients in each group. However, we increased this sample size to 50 to increase the likelihood of detecting an even smaller difference in the percentage of sperm motility and mean sperm count.

The 50 smokers had a mean age of 37.1 years (SD, 8.3; range, 20-50 years) with no history of alcohol or drug intake. The 50 nonsmokers had a mean age of 39.5 years (SD, 9.0; range, 21-53 years). None of the participants had a history of alcohol or drug intake, and the nonsmokers had no prior history of smoking.

Data Collection and Analysis

Data were collected from the patients during their visits to the andrology clinic during the study period. The data available on each participant included age, smoking habits, type, amount, and duration of smoked material, and duration of subfertility. Physical examination and essential laboratory investigations (complete blood count; liver and renal function tests) were done for all participants. Semen collection was done by special nontoxic condoms, and semen analysis was done for both groups according to World Health Organization (WHO) protocol 2010 [9].

The outcome measures were semen volume and sperm parameters (count, motility, abnormal forms), duration of infertility, and type, amount, and duration of smoking. Group differences (smoker vs nonsmoker and cigarette type vs shisha)

Table 1. Patient Demographic Characteristics (N = 100).

doi: 10.3834/uj.1944-5784.2011.02.11t1

Characteristic	Smokers (n = 50)	Nonsmokers (n = 50)	P
Age, years; mean (SD)	37.1 (8.3)	39.5 (9.0)	.18
Smoking duration, years; mean (SD)	11.3 (6.4)	0	
Smoke dose/day; mean (SD)	13.6 (9.8)	0	
Infertility duration; years, mean (SD)	6.0 (3.1)	5.5 (2.7)	.36
Infertility type, n (%n)			
Primary	24 (48)	17 (34)	.19
Secondary	26 (52)	33 (66)	

in semen volume and sperm parameters were analyzed with 2-tailed *t* tests. Pearson correlations were used to determine the association between smoking index and smoking duration and semen volume and the sperm characteristics. The statistics were analyzed using SPSS Version 16 (IBM Corp, Somers NY, USA).

RESULTS

The demographic characteristics of the 50 smokers and 50 nonsmokers are summarized in Table 1. There were no statistically significant differences between the 2 groups regarding age, duration of infertility, or infertility type (primary or secondary).

Table 2 contains the means and standard deviations for the outcome measures of sperm abnormal forms (%), sperm count (M/mL), semen volume (mL), and sperm motility (%) for smokers and nonsmokers and the probability of significant group differences. When compared with nonsmokers, the smokers had a significantly higher mean percentage of abnormal sperm forms (92.3 % vs 89.4%) (*P* < .01). The smokers had a significantly lower mean sperm count (20.55 M/mL vs 44.9 M/mL), a significantly lower mean semen volume (2.01 mL vs 2.52 mL), and a significantly lower mean percentage of sperm

motility (25.7 vs 37.9) when compared with the nonsmokers (all with *P* < .01).

Table 3 contains the means and standard deviations for the outcome measures of semen volume and the sperm parameters and the probability of significant differences according to the smoking type. A total of 30 patients smoked cigarettes and 20 patients smoked shisha. There were no statistically significant differences in semen volume or abnormal sperm forms, sperm count, or sperm motility between men smoking cigarettes or shisha. There were also no significant differences in the duration of infertility for men smoking either type.

Smoking index was defined as the smoke dose per day x 365 days x duration of smoking in years [10]. Table 4 contains the correlations between smoking index and smoking duration and semen volume and the sperm characteristics. There were statistically significant negative correlations between smoking index and the percentage of sperm motility (*r* = -0.38; *P* = .006) and between smoking duration and the percentage of sperm motility (*r* = -0.32; *P* = .026). These results indicated that as smoking index and smoking duration increased, the percentage of sperm motility decreased. There was also a marginally significant positive correlation between smoking index and

Table 2. Semen parameters for Smokers and Nonsmokers; Probability of Significant Group Differences (N = 100).

doi: 10.3834/uj.1944-5784.2011.02.11t2

Outcome Measure	Smokers (n = 50)		Nonsmokers (n = 50)		<i>t</i>	<i>P</i>
	Mean	SD	Mean	SD		
Sperm abnormal forms, %	92.34	3.50	89.42	3.87	3.955	<.01
Sperm count, M/mL	28.55	18.64	44.9	24.74	-5.558	<.01
Semen volume, mL	2.012	0.64	2.52	0.612	-4.06	<.01
Sperm motility, %	25.72	14.71	37.86	15.32	-4.04	<.01

Table 3. Semen Parameters for Cigarette Smokers and Shisha Smokers; Probability of Significant Differences (N = 100).

doi: 10.3834/uj.1944-5784.2011.02.11t3

Outcome Measure	Cigarette (n = 30)		Shisha (n = 20)		t	P
	Mean	SD	Mean	SD		
Sperm abnormal forms, %	92.63	3.51	91.9	3.54	0.72	.48
Sperm count, M/mL	20.30	18.59	20.92	19.20	-0.114	.91
Semen volume, mL	1.99	0.64	2.05	0.66	-0.336	.74
Sperm motility, %	24.03	14.44	28.25	15.12	-0.98	.33
Infertility duration, years	6.07	3.07	5.90	3.23	0.18	.86

the percentage of abnormal sperm forms ($r = 0.283$; $P = .046$), indicating that as smoking index increased, the percentage of abnormal sperm forms also increased. There were no significant correlations between smoking duration or smoking index for any other semen parameters.

DISCUSSION

The effect of smoking on male infertility, particularly on conventional semen parameters, is of growing interest to the professional community. It has been investigated in many studies, most of which have included men with subfertility. However, their results are conflicting and the real impact of tobacco smoking on semen parameters remains unknown.

Table 4. Correlations Between Smoking Index and Smoking Duration and the Semen Parameters.

doi: 10.3834/uj.1944-5784.2011.02.11t4

Outcome Measure	Pearson Correlation	P
Smoking Index^a		
Sperm abnormal forms, %	0.283	.046
Sperm count, M/mL	-0.206	.151
Semen volume, mL	-0.219	.126
Sperm motility, %	-0.380	.006
Smoking Duration		
Sperm abnormal forms, %	0.168	.242
Sperm count, M/mL	-0.104	.472
Semen volume, mL	-0.188	.192
Sperm motility, %	-0.316	.026

^aSmoke dose per day x 365 x duration of smoking in years [10].

The results of the present study showed that there was a statistically significant difference between smokers and nonsmokers for all semen parameters. Our results are in accordance with previous studies that demonstrate a negative impact of tobacco smoking on some aspects of semen quality. In 1985, Kulikauskas and his group [11] found that smokers had a significantly decreased spermatozoa count and motility when compared with nonsmokers, but they found no significant difference in abnormal sperm morphology. In our study, we also found a significantly decreased sperm count and motility and, in contrast with Kulikauskas et al, a significant increase in abnormal sperm forms. Later studies of men with infertility by Zhang et al [12] and Mehrannia [13] showed that semen volume, sperm concentration, and sperm motility were much lower in smokers than in nonsmokers.

Vine [4] conducted a meta-analysis on smoking and male reproduction and showed that the sperm concentration of smokers was 13% lower than that of nonsmokers. Künzle and his team [14] demonstrated that smokers had 15% lower sperm concentration than nonsmokers in a large prospective study of 662 infertile men. A 2008 study of 160 infertile men by Kumosani and his group [15] showed a significantly decreased percentage of motile spermatozoa in smokers than in nonsmokers (42% vs 64%, respectively). However, the authors failed to demonstrate significant differences in other semen parameters.

Ramlau-Hansen et al [6] studied semen quality of 2500 healthy men. They observed an inverse dose-response relationship between smoking and semen volume, sperm concentration, and percentage of motile sperm. Heavy smokers had 20% lower sperm concentration than other types of smokers. In our study, we found a statistically significant negative correlation between both smoking duration and smoking index (a cumulative dose of smoking) and the percentage of sperm motility. We also found a marginally significant positive correlation between

smoking index and percentage of abnormal forms, but no significant correlation with other semen parameters.

Contrary to our results, some studies have failed to demonstrate any significant negative impact of tobacco smoking on semen quality. Marinelli et al [5] conducted a mini-review of the literature and concluded that smoking has limited effect. This conclusion was further supported by a large multicenter study of young men from 5 different European countries by Jensen and his group [16]. However, these studies were done using healthy men rather than men with subfertility or infertility.

Sevaniak et al [17] demonstrated no significant differences between smokers and nonsmokers in conventional semen parameters. However, they showed that the spermatozoa of smokers have a significantly higher deoxyribonucleic acid (DNA) fragmentation than those of nonsmokers (32% vs 26%, respectively). They also found some trend toward lower sperm motility in spermatozoa with DNA fragmentation > 35%.

There are many toxic substances in cigarettes. Among them is cadmium, which has been proven experimentally to disrupt spermatogenesis and decrease sperm concentration in smokers [18]. Tobacco smoking was also associated with a significantly reduced level of zinc in seminal plasma, which is thought to be one of the important factors that affect sperm motility [19]. Other harmful substances associated with smoking are alkaloids, nitrosamines, and cotinine, which produce reactive oxygen species like free radicals and peroxides. These species attack the integrity of DNA in the sperm nucleus by causing base modification, DNA strand breaks, and chromatin packing. The result is DNA fragmentation that can increase the sperm abnormal forms in smokers [10]. It has been emphasized that human spermatozoa are particularly susceptible to oxidative stress-induced damage by reactive oxygen species (ROS) because their plasma membranes are rich in polyunsaturated fatty acids [20]. The ROS in tobacco smoking induce lipid peroxidation of the sperm plasma membrane; this is considered to be the key mechanism in inducing sperm damage that leads to decreased sperm viability, sperm concentration, sperm motility, and increased morphology defects [21,22].

The present study has a number of limitations. First, it has a relatively small cohort. The cause of the subfertility and results of the laboratory investigations were not included in the results, so the homogeneity of the population is not certain. Additional studies are needed to confirm the present results.

CONCLUSION

Our study showed significant deleterious effects of tobacco

smoking on semen volume and sperm concentration, motility, and abnormal forms. The correlation analysis placed special emphasis on the negative impact of smoking on sperm motility. We feel that the evidence from this and other studies is sufficient to recommend that male smokers with subfertility who are seeking treatment should stop smoking to prevent the toxins contained in tobacco smoke from causing detrimental effects on semen quality.

ACKNOWLEDGEMENTS

The study was sponsored by the Deanship of Research, Qassim University.

Conflict of Interest: none declared.

REFERENCES

1. Evenson DP, Wixon R. Clinical aspects of sperm DNA fragmentation detection and male infertility. *Theriogenology*. 2006;65(5):979-991.
2. Martinet Y, Bohadana A. *Le Tabagisme* [The Tobacco]. Paris: Elsevier Masson; 2004:336.
3. Collodel G, Capitani S, Iacoponi F, Federico MG, Pascarelli NA, Moretti E. Retrospective assessment of potential negative synergistic effects of varicocele and tobacco use on ultrastructural sperm morphology. *Urology*. 2009;74(4):794-799.
4. Vine MF. Smoking and male reproduction: a review. *Int J Androl*. 1996;19(6):323-337.
5. Marinelli D, Gaspari L, Pedotti P, Taioli E. Mini-review of studies on the effect of smoking and drinking habits on semen parameters. *Int J Hyg Environ Health*. 2004;207(3):185-192.
6. Ramlau-Hansen CH, Thulstrup AM, Aggerholm AS, Jensen MS, Toft G, Bonde JP. Is smoking a risk factor for decreased semen quality? A cross-sectional analysis. *Hum Reprod*. 2006;22(1):188-196.
7. Wong WY, Thomas CM, Merkus HM, Zielhuis GA, Doesburg WH, Steegers-Theunissen RP. Cigarette smoking and the risk of male factor subfertility: minor association between cotinine in seminal plasma and semen morphology. *Fertil Steril*. 2000;74(5):930-935.
8. Bassiony MM. Smoking in Saudi Arabia. *Saudi Med J*. 2009;30(7):876-881.
9. World Health Organization. *WHO Laboratory Manual for Examination and Processing of Human Semen*. 5th ed. Geneva, Switzerland: WHO Press; 2010.

10. Elshal MF, El-Sayed IH, Elsaied MA, El-Masry SA, Kumosani TA. Sperm head defects and disturbances in spermatozoal chromatin and DNA integrities in idiopathic infertile subjects: association with cigarette smoking. *Clin Biochem.* 2009;42(7-8):589-594.
11. Kulikauskas V, Blaustein D, Ablin RJ. Cigarette smoking and its possible effects on sperm. *Fertil Steril.* 1985;44(4):526-528.
12. Zhang JP, Meng QY, Wang Q, Zhang LJ, Mao YL, Sun ZX. Effect of smoking on semen quality of infertile men in Shandong, China. *Asian J Androl.* 2000;2(2):143-146.
13. Mehrania T. The effect of cigarette smoking on semen quality of infertile men. *Pak J Med Sci.* 2007;23:717-720.
14. Künzle R, Mueller MD, Hänggi W, Birkhäuser MH, Drescher H, Bersinger NA. Semen quality of male smokers and nonsmokers in infertile couples. *Fertil Steril.* 2003;79(2):287-291.
15. Kumosani TA, Elshal MF, Aljonaid AA, Abduljabar HS. The influence of smoking on semen quality, seminal microelements and Ca²⁺-ATPase activity among infertile and fertile men. *Clin Biochem.* 2008;41(14-15):1199-1203.
16. Jensen TK, Vierula M, Hjollund NH, et al; the Danish First Pregnancy Planner Study Team. Semen quality among Danish and Finnish men attempting to conceive. *Eur J Endocrinol.* 2000;142(1):47-52.
17. Sepaniak S, Forges T, Gerard H, Foliguet B, Bene MC, Monnier-Barbarino P. The influence of cigarette smoking on human sperm quality and DNA fragmentation. *Toxicology.* 2006;223(1-2):54-60.
18. Martelli A, Rousselet E, Dycke C, Bouron A, Moulis JM. Cadmium toxicity in animal cells by interference with essential metals. *Biochimie.* 2006;88(11):1807-1814.
19. Chia SE, Ong CN, Chua LH, Ho LM, Tay SK. Comparison of zinc concentrations in blood and seminal plasma and the various sperm parameters between fertile and infertile men. *J Androl.* 2000;21(1):53-57.
20. Gulaya NM, Margitich VM, Govseeva NM, Klimashevsky VM, Gorpynchenko II, Boyko MI; N. M. Gulaya, V. M. Margitich, N. M. Phospholipid composition of human sperm and seminal plasma in relation to sperm fertility. *Arch Androl.* 2001;46(3):169-175.
21. Arabi M, Moshtaghi H. Influence of cigarette smoking on spermatozoa via seminal plasma. *Andrologia.* 2005;37(4):119-124.
22. Kao SH, Chao HT, Chen HW, Hwang TI, Liao TL, Wei YH. Increase of oxidative stress in human sperm with lower motility. *Fertile Steril.* 2008;89(5):1183-1190.