



Research Journal of
**Environmental
Toxicology**

ISSN 1819-3420



Academic
Journals Inc.

www.academicjournals.com

Reproductive Toxicity of Tobacco Shisha Smoking on Semen Parameters and Hormones Levels among Adult Egyptian Men

¹Irene A. Fawzy, ²Nashwa N. Kamal and ³Ahlam M. Abdulla

¹Department of Forensic Medicine and Toxicology, El-Minia University, Egypt

²Department of Public Health, Minia University, Egypt

³Department of Biochemistry, Minia University, Egypt

*Corresponding Author: Irene A. Fawzy, Department of Forensic Medicine and Toxicology, El-Minia University, Egypt
Tel: +0020862348699 +0125819184 Fax: 0020862342813*

ABSTRACT

There is limited data about the reproductive toxic effects of shisha smoking. The aim of this study was to investigate the toxic effects of this habit on semen parameters and hormones levels by comparing the results with those of cigarette smokers and non-smokers. Forty-two shisha smokers and 81 healthy nonsmokers participated in this study. Additionally, 65 cigarette smokers were recruited for comparison. Tobacco intoxication was evaluated by determination of blood carboxyhaemoglobin. The results showed that shisha intoxication is more than cigarette as evidenced by the significant increase in COHb level and the significant decrease in the percentage of sperm motility in comparison to non smokers. Both shisha and cigarette smoking significantly lowered semen volume, sperm count and the percentage of sperms with normal morphology. Additionally, they significantly delayed the liquefaction time. Present data revealed that shisha smoking affects semen parameters more than cigarette smoking with significant decrease in percentage of sperms with normal morphology among shisha users. Significant higher levels of testosterone, FSH and LH were found among shisha and cigarette smokers. In addition, heavy shisha smokers revealed significant higher levels of testosterone than light users. There was statistically significant negative correlation between the smoking index and semen volume and the sperm count and a significant positive correlation between the smoking index and the testosterone levels. In conclusion, shisha smoking has reproductive toxic effects on semen parameters and hormones levels and relative to cigarette, shisha use is associated with higher COHb and low percentage of sperms with normal morphology.

Key words: Reproductive toxicity, shisha smoking, cigarette, semen, hormones

INTRODUCTION

There is limited data about the reproductive toxic effects of shisha smoking. However, all stages of reproductive functions may be affected by cigarette smoke toxicants (Blank *et al.*, 2011). Smoking is a major public health problem. Globally, more than 5 million deaths each year are attributed to tobacco use and this may increase to 10 million within the next 20-30 years (WHO, 2009). Tobacco is commonly consumed in different ways including cigarette, pipe, cigar and waterpipe smoking. Waterpipe tobacco smoking usually involves heating flavored tobacco with charcoal and inhaling the resulting smoke after it has passed through water (Blank *et al.*, 2011). Research demonstrates that numerous toxic agents, including carcinogens, heavy metals, other particulate matter and nicotine are efficiently delivered through waterpipes (Martinasek *et al.*,

2011). Waterpipes have different names depending on the geographic region of use. Names include “shisha” or “goza” (Egypt and Saudi Arabia), “narghile,” “nargile” or arghile” (Jordan, Lebanon and Syria), “hookah (Africa and the Indian subcontinent) and “hubble bubble” (in many regions) (Wolfram *et al.*, 2003).

The prevalence of waterpipe (narghile, gosa, shisha, hookah) tobacco smoking (WTS) in the Middle East region and worldwide is increasing (Maziak, 2008). Youth WTS is on the rise as compared to cigarette smoking. Waterpipe smoking is also increasing in Egypt with a progressively wider distribution of cafés attracting new customers (Jha and Chaloupka, 2000). Tobacco used for gosa smoking known as “Maassel”, as a proper transliteration, meaning “honeyed” in Arabic. Maassel contains about 30% tobacco and up to 70% honey or molasses/sugar cane, in addition to glycerol and flavoring essences. The uptake of tobacco nicotine in shisha is equivalent to 2-12 cigarettes per portion of tobacco used (hagar). However, it is known that waterpipe smoking produces more smoke than cigarette smoking and it has been estimated that smoke exposure could be as much as 100-200 cigarettes per session. Therefore, the types and magnitudes of health hazards of waterpipe smoking are likely to be higher than those of cigarette smoking (WHO, 2006).

Shisha smoke has been found to contain high concentrations of carbon monoxide (CO), nicotine, “tar” and heavy metals (Knishkowsky and Amitai, 2005; Shafagoj *et al.*, 2002; Shihadeh, 2003). Also, commonly used heat sources like charcoal or wood cinders may increase health risks because they produce toxicants as CO, metals and carcinogens (Shihadeh, 2003; Shihadeh and Salehm, 2005).

One reason for the global spread of waterpipe tobacco smoking may be due to the belief that waterpipes are less risky than cigarettes (Aljarrah *et al.*, 2009). This belief seemingly is contradicted by demonstrations that various constituents of waterpipe smoke are known to cause cancer (e.g., Polycyclic Aromatic Hydrocarbons [PAH]; Sepetdjian *et al.*, 2008) lung disease (e.g., volatile aldehydes; Al Rashidi *et al.*, 2008) cardiovascular disease (e.g., carbon monoxide [CO] Shihadeh and Salehm, 2005) and also dependence (i.e., nicotine; Shihadeh, 2003). At least some of these smoke toxicants have been found in waterpipe tobacco smokers during smoking, including nicotine and CO (El-Nachef and Hammond, 2008).

Among different air pollutants, cigarette smoke contains toxic chemicals, mutagenic and carcinogenic compounds, which can adversely affect male fertility (Zenzes, 2000; Martinet and Bohadana, 2004). Cigarette smoke is made up of gas and organic compounds. One of the most abundant organic particles in cigarette smoke is nicotine, which is responsible for some positive or negative effects on the various organs. Also, cigarette smoke contains a mixture of harmful components such as carbon monoxide (CO), hydrogen cyanide (HCN), ammonia, volatile hydrocarbons, Alcohol, aldehydes and ketones (Jorsaraei *et al.*, 2008).

The effect of smoking on male reproduction has been studied where semen quality was investigated in many cross-sectional studies including infertile patients with conflicting results (Mostafa, 2010). Although, the reproductive toxicity associated with cigarette smoking has been extensively investigated, studies evaluating such toxicity in shisha users are still lacking. So, this study was carried out to investigate the toxic effects of waterpipe (gosa) tobacco smoking on semen parameters and hormones levels and correlate the results with those of cigarette smokers and non-smokers.

MATERIALS AND METHODS

A cross sectional study was performed on 42 shisha smoker and 65 cigarette smoker subjects. As a control, 81 nonsmoking subjects were selected to match cigarette and shisha smokers for age and geographical area. All subjects were recruited from adult males undergoing screening for

marriage at the Andrology Clinic, El Raey El saleh samalout Hospital at the period from 15th of January 2011 to 15th of June 2011. All the subjects gave informed consent to participate in the study in accordance with the ethical standards approved by the committee of Minia University.

Selection criteria: All subjects were healthy adult males, shisha smokers were those who use only shisha to smoke tobacco and cigarette smokers were those who use only cigarettes to smoke tobacco for at least 3 years. Shisha smokers (42 subjects) were into three groups (a) heavy group (Who use shisha daily), (b) medium group (Who use shisha in 4-5 days/week) and (c) light group (Who use shisha in <3 days/week). Shisha smokers included in this study were habitual shisha smokers for at least 3 years and they smoked an average of 20 g Maassel which is generally used in the shisha bowl per session for a period of 45 min (Bacha *et al.*, 2007; Shafagoj *et al.*, 2002).

Exclusion criteria: Those who smoke other type of tobacco products, for example, cigar, pipe or those who smoked both cigarettes and shisha at same time. Also, those who were using other habitual substances or those with history of orchitis, testicular trauma, sexually transmitted disease, varicocele, inguinal hernia operation and cryptorchism.

Smoking index: Number of cigarettes per day X period of smoking of cigarette smokers was calculated.

Semen analysis: A total of 188 semen specimens from 42 gosa smokers, 65 cigarette smokers and 81 nonsmokers fulfilled the selection criteria were obtained via masturbation. The semen samples were collected in sterile plastic containers and allowed to liquefy for 30 min. Thereafter, samples were analysed within 2 h after collection (Kunzle *et al.*, 2003) according to WHO (1992) criteria. Semen volume, pH and the time to liquefaction were measured. The percentage of morphologically normal sperm, Sperm concentration (count) and sperm motility were determined.

Hormone analysis: Blood samples (5 mL) were obtained at 8:00-10:00 a.m. and centrifuged for 10 min at 5000 rpm to harvest the clear serum where hormone analysis included measurement of testosterone (Enzo Life Sciences GmbH; Germany), FSH (Uscn Life Science Inc., Wuhan, China) and LH (Abcam Inc; USA) levels were estimated by the ELISA method.

Determination of blood carboxyhaemoglobin (COHb): Blood COHb level was determined using Blood Gas Analyzer; Bayer 855.

Statistical analysis: The Statistical Program SPSS for Windows version 11 was used for data entry and analysis (SPSS Inc., Chicago, IL, USA). Men were grouped into cigarette smokers, shisha smokers and non-smokers. A descriptive analysis of the data was performed and the variables were further analyzed with at-test and analysis of variance (ANOVA) multiple comparisons of shisha smokers with light, medium and heavy groups were done using ANOVA. Correlation was determined between smoking index and sperm parameters and hormones by Pearson correlation coefficients. Statistical significance was determined at the 95% confidence interval level.

RESULTS

A total of 42 shisha smokers (mean age 25.9±5.4 years) 65 cigarette smokers (mean age 26.5±6.4 years) and 81 strict non-smokers (mean age 26.4±5.84 years) who fulfilled the

selection criteria were included in this study. The age of patients was not significantly different in all groups Based on their detailed shisha smoking history, the shisha smokers (n = 42) were divided into 3 groups as shown in Table 2 according to the number of sessions per week.

Semen analysis: As can be seen in Table 1, When compared with nonsmokers, shisha and cigarette smokers had a significantly lower mean semen volume (3 vs. 3.8 mL, 3.05 vs. 3.8 mL, respectively F = 29.2, p = 0.001) a significantly lower mean sperm count (34 vs. 59 M mL⁻¹ for shisha smokers and 43 vs. 59 M mL⁻¹ for cigarette smokers, F = 5.7, p = 0.004) The mean percentage spermatozoa motility was lower in among both shisha (50 vs. 57%) and cigarette (54 vs. 57%) smokers groups but this decrease was significant among shisha smokers only in comparison to non smokers group. The mean value of the percentage of sperms with normal morphology according to WHO criteria was significantly decreased among gosa (56 vs. 70%) and cigarette(61 vs. 70%) smokers compared to the non smokers group (F = 15.6, p = 0.001). The mean pH of ejaculate from shisha and cigarette smokers were significantly higher than that of ejaculate from nonsmokers(7.9 vs. 7.6, 7.8 vs. 7.6, respectively F = 27.8, p = 0.001). Gosa and cigarette smokers had a significantly delayed mean liquefaction time (24 min and 23 min, respectively) vs. 21 min in non smokers (F = 15.04, p = 0.001). There were no statistically significant differences in semen parameters between men smoking cigarettes or shisha except in the percentage of sperms with normal morphology (p<0.05).

Table 1: Semen and hormone analysis results among the studied groups (values are Mean±SD)

Parameter	Cigarette smokers (n = 65)	Shisha smokers (n = 42)	Non-smokers (n = 81)	F	p-value
Semen volume (mL)	3.05±0.7 ^a	3.0±0.24 ^b	3.8±0.8	29.2	0.001
Semen pH	7.8±0.15 ^a	7.9±0.14 ^b	7.6±0.2	27.8	0.001
Liquefaction time (min)	23.9±3.3 ^a	24.7±3.4 ^b	21.1±4.5	15.04	0.001
Sperm count (10 ⁶ mL ⁻¹)	43.0±38.58 ^a	34.0±37.78 ^b	59.0±38.81	5.7	0.004
Sperm motility (%)	54.4±11.7	50.8±12.2 ^b	57.005±15.8	2.8	0.06
WHO morphology (%normal)	61.7±14.4 ^{a,c}	56.4±12.8 ^b	70.2±12.5	15.6	0.001
FSH (mIU mL ⁻¹)	3.6±0.4 ^a	3.7±0.5 ^b	3.3±0.34	17.05	0.001
LH (mIU mL ⁻¹)	3.47±0.37 ^a	3.5±0.4 ^b	3.3±0.3	5.1	0.007
Testosterone (ng mL ⁻¹)	4.6±0.2 ^{a,c}	4.7±0.2 ^b	4.45±0.1	28.2	0.001

^ap<0.05 vs. the corresponding values of the cigarette smokers and Non-smokers (control), ^bp<0.05 vs. the corresponding values of the Shisha smokers and non-smokers controls and ^cp<0.05 vs. the corresponding values of the cigarette smokers and Shisha smokers

Table 2: Semen and hormone analysis results among the Shisha smoker groups (values are Mean±SD)

Parameters	Group 1 (n = 17)	Group 2 (n = 16)	Group 3 (n = 9)	Non-smokers (n = 81)	F	p-value
Semen volume (mL)	2.9±0.2 ^c	3.02±0.2 ^c	2.85±0.5 ^{b,f}	3.8±0.8	13.9	0.001
Semen pH	7.8±0.15 ^c	7.9±0.12 ^c	7.8±0.18 ^f	7.6±0.2	11.5	0.001
Liquefaction time (min)	24.9±3.5 ^e	24.4±3.3 ^e	24.9±3.4 ^f	21.1±4.5	6.7	0.001
Sperm count (10 ⁶ mL ⁻¹)	50.0±47.21	30.0±25.92 ^e	12±21.95 ^{b,f}	59.0±38.81	5.5	0.001
Sperm motility (%)	51.8±12.7	46.8±13.2 ^e	48.1±13.5	57.005±15.8	2.9	0.03
WHO morphology (%normal)	56.3±10.6 ^c	56.3±12.3 ^c	56.7±18.4 ^f	70.2±12.5	10.7	0.001
FSH (mIU mL ⁻¹)	3.58±0.43 ^c	3.83±0.56 ^c	3.74±0.46 ^f	3.3±0.34	11.6	0.001
LH (mIU mL ⁻¹)	3.49±0.38	3.59±0.44 ^e	3.39±0.44	3.3±0.3	3.3	0.02
Testosterone (ng mL ⁻¹)	4.6±0.22 ^c	4.7±0.25 ^e	4.8±0.25 ^{b,f}	4.45±0.1	25.3	0.001

Group 1: Light shisha users, group 2: Medium shisha users, group 3: Heavy shisha users, ^ap<0.05 vs. the corresponding values of the group 1 and group 2, ^bp<0.05 vs. the corresponding values of the group 1 and group 3 and ^cp<0.05 vs. the corresponding values of the group 1 and non-smoker group, ^dp<0.05 vs. the corresponding values of the group 2 and group 3, ^ep<0.05 vs. the corresponding values of the group 2 and non-smoker group and ^fp<0.05 vs. the corresponding values of the group 3 and non-smoker group

As shown in Table 2, there were significant differences in semen volume, PH, liquefaction time and the percentage of sperms with normal morphology between the non smokers group and each of the 3 shisha groups (p = 0.001). In addition there were significant differences in semen volume and sperm count between the light and heavy shisha groups (p<0.05) and between the medium shisha smokers group and the non smokers group in the percentage of the sperm motility (p<0.05). The mean of smoking index of cigarette smokers' group was 70.46±32.7. There was negative correlation between the smoking index and all semen parameters except the liquefaction time which showed positive correlation with it. The negative correlation was statistically significant between the smoking index and semen volume (r = -0.24; p<0.05) and the sperm count (r = -0.41; p<0.01). Correlations with other semen parameters were not significant (Table 3).

Hormones levels: Compared with non smokers in Table 1, shisha and cigarette smokers showed a significantly higher mean levels of testosterone (4.7 vs. 4.45 ng mL⁻¹, 4.6 vs. 4.45 ng mL⁻¹, respectively F = 28.2, p = 0.001), LH (3.5 vs. 3.3 mIU mL⁻¹, 3.47 vs. 3.3 mIU mL⁻¹, F = 5.1, p = 0.007) and FSH hormones (3.7 vs. 3.3 mIU mL⁻¹, 3.6 vs. 3.6 mIU mL⁻¹, F = 17.05, p = 0.001).

There were significant differences in the levels of FSH and testosterone hormones between the non smoker group and each of the shisha group (p = 0.001). Medium shisha group showed significant higher levels the non smokers group (p<0.05). Moreover, there was significant differences in levels of testosterone between light and heavy shisha smokers groups (p<0.05) (Table 2).

Table 3 showed positive correlation between the smoking index and all hormones levels and this correlation was statistically significant with the testosterone levels (r = 0.27, p<0.05)

Blood COHb level: The mean COHb as shown in Table 4 was 0.93% for non smokers, 1.06 and 1.7% for cigarette and shisha smokers, respectively. It was shown a significant higher level of COHb among both cigarette and shisha smokers compared to non smokers (p<0.001). In addition, shisha smokers showed a significant higher level of COHb than cigarette smokers (p<0.05).

Table 3: Pearson's correlation coefficients between smoking index and semen parameters and hormones levels in smokers

Parameter	Smoking index (r)
Semen volume (mL)	-0.24*
Semen pH	-0.023
Liquefaction time (min)	0.022
Sperm count (10 ⁶ mL ⁻¹)	-0.41**
Sperm motility (%)	-0.12
WHO morphology (%normal)	-0.22
FSH (mIU mL ⁻¹)	0.05
LH (mIU mL ⁻¹)	0.18
Testosterone (ng mL ⁻¹)	0.27*

*Significant correlation (p <0.05), **Significant correlation (p<0.01)

Table 4: Carboxyl Hb levels among the studied groups (values are Mean±SD)

Parameter	Cigarette smokers (n = 65)	Gosa smokers (n = 42)	Non-smokers (n = 81)	F	p-value
COHb levels	1.06%±0.2 ^{ac}	1.7%±0.75 ^b	0.93%±0.09	56.9	0.001

^ap<0.05 vs. the corresponding values of the cigarette smokers and Non-smokers (control), ^bp<0.05 vs. the corresponding values of the Gosa smokers and non-smokers controls and ^cp<0.05 vs. the corresponding values of the cigarette smokers and Gosa smokers

DISCUSSION

Shisha smokes likely contains an abundance of several of the toxicants that are thought to render shisha users more prone to health risks and addiction (Shihadeh and Salehm, 2005).

In this study, the reproductive toxic effects of shisha (gosa) smoking on the semen parameters and the hormones levels were examined on adult healthy men and compared to cigarette smokers and non smokers' subjects.

In the current study, relative to cigarette users, waterpipe users showed significant greater COHb level. This is in accordance with (Eissenberg and Shihadeh, 2009) who revealed that peak waterpipe COHb levels were three times higher than those for the cigarette. In the same line, Theron *et al.* (2010) observed that water-pipesmoker had significantly higher increases in blood COHb levels than cigarette smokers.

The present study found that in comparison to non smokers, shisha smokers caused a significant lowering in the percentage of sperm motility and both shisha and cigarette smokers showed a significant decrease in semen volume, sperm count, percentage of sperms with normal morphology, a significant delaying of time of liquefaction and a significant increase in semen pH. Studies evaluating such toxicity in shisha users are still lacking. However, there are many debates regarding the toxic effects of cigarette smoke on human reproduction (Vine *et al.*, 1996). In agreement to our results, different articles have demonstrated a negative impact of smoking on human semen parameters (Evans *et al.*, 1981; EL Mulla *et al.*, 1995) such as concentration (Handelsman *et al.*, 1984; Lewin *et al.*, 1991), motility (Handelsman *et al.*, 1984; Shaarawy and Mahmoud, 1982) and normal morphology (Shaarawy and Mahmoud, 1982; Evans *et al.*, 1981). Also, Zhang *et al.* (2000) showed that the semen volume was much lower in heavy and long-term smokers than in nonsmokers and there were modifications in semen pH, sperm concentration, motility and morphology. Present data revealed that shisha smoking affects the semen parameters more than cigarette smoking although the difference was not statistically significant except in lowering the percentage of sperms with normal morphology. On the other hand, the semen volume and the sperm count was significantly lower in the heavy shisha smokers group than mild users which indicates that toxic effects of tobacco in shisha increases with increasing the number of smoking sessions/week.

The mechanism for the potentiated toxicity of shisha smoking on semen parameters compared with that of regular cigarettes is unknown. In general, tobacco and charcoal might contribute to the toxicity observed in semen quality of shisha users, since the toxicity of shisha smoking on semen parameters may be attributed to the high levels of nicotine which are efficiently delivered through shisha. Nicotine is a very toxic alkaloid (Branian and Hansen, 2002) and it has a significant influence on sperm count and sperm morphology (Gornig and Schirren, 1996). Nicotine and its major metabolites, cotinine and trans-3-hydroxycotinine have been implicated to mediate the effects of smoking on sperm parameters as these toxic substances cross the blood-testis barrier (Pacifci *et al.*, 1993; Vine *et al.*, 1996). So, the seminal plasma of smokers can be considered as a toxic environment for spermatozoa (Sepaniaka *et al.*, 2006). Also, toxins in cigarette smoke reach the male reproductive system and their effects are mainly due to their direct interaction with seminal fluid components and the accessory glands, which contribute their secretions to the seminal fluid, leading to reduce its seminal volume and delayed in the liquefaction time (Gaur *et al.*, 2007).

Shisha smoke has been shown to contain more concentrated and diverse toxic compounds compared with cigarette smoke (Shihadeh and Salehm, 2005). Studies on the mainstream smoke aerosol of the shisha showed that the "tar" (volatile aldehydes) of a single smoking session is

startlingly high, two order of magnitude greater than that produced from smoking a single cigarette (Al Rashidi *et al.*, 2008). In addition, CO exposure is greater in shisha smoking compared with cigarette smoking (Bacha *et al.*, 2007; Eissenberg and Shihadeh, 2009; Maziak *et al.*, 2009). Furthermore, the quantities of 3- or 4-ring compounds of Polycyclic Aromatic Hydrocarbon (PAH) in shisha smoke are many times more than that of cigarette smoke (Shihadeh *et al.*, 2004; Shihadeh and Salehm, 2005; Monzer *et al.*, 2008; Sepetdjian *et al.*, 2008). Recently, it has been found that the levels of carboxyhemoglobin after shisha smoking are approximately triple when compared with those obtained after cigarette smoking (Eissenberg and Shihadeh, 2009). Also, the style of shisha smoking results in a dramatically higher exposure volume to smoke, more tobacco consumption per smoking event and a longer smoke inhalation period (Bacha *et al.*, 2007; Eissenberg and Shihadeh, 2009; Cobb *et al.*, 2010). Shisha smoke has been reported to increase the amount of free radicals in the bodies of smokers (Sharma *et al.*, 1997). Free radicals can cause oxidative DNA damage and chromosomal damage (Salmon *et al.*, 2004).

One of the constituents of massel used in shisha is heavy metals where Al-Attar (2011) mentioned that the toxicity of heavy metals caused alteration in sperm morphology, count, motility as well as hormones (Chowdhury, 1992). Also, Salem *et al.* (1990) revealed higher levels of lead in the water (in water pipes) after smoking which causes a decrease of sperm motility in men most likely due to increased lipid peroxidation (Kasperczyk *et al.*, 2008).

The lower values for sperm motility in smokers may be also caused by disturbances in spermatogenesis or epididymal sperm maturation process secondary to secretory dysfunction at the level of the Leydig and Sertoli cells. Epididymal dysfunction in smokers will likely have detrimental effects on the various cytb structural modifications and biochemical change that spermatozoa normally undergo during epididymal maturation and may lead to decrease in sperm motility and sperm fertilizing capacity (Sofikitis *et al.*, 1995).

Contradict to our study, Some researches could not find a relationship between cigarette smoking and seminal quality (Dikshit *et al.*, 1987; Trummer *et al.*, 2002; Baldelli *et al.*, 2002) found no deleterious effect of cigarette smoking on semen quality except for a non-significant trend toward decreased ejaculate volume. This could be explained as their studies were performed on a different number of samples than our study.

The current study revealed a significant higher levels of testosterone, FSH and LH hormones among both shisha and cigarette smokers than in non smokers. This is in agreement with Trummer *et al.* (2002), Vogt *et al.* (1986), Field *et al.* (1994). These results could be explained as smoking has an effect on the various metabolic and biological processes in the body including secretion of hormones. These are mediated chiefly through behavioral and pharmacological actions of nicotine but also occur as a result of increases in the physical effects of stress on the body caused by smoking. Also, the significantly elevated LH in smokers suggests a central activation of Leydig cells, which explains elevated testosterone (Rahman *et al.*, 2011).

Our data is against Sofikitis *et al.* (1995) and Pasqualotto *et al.* (2006) who reported that, there were no significant differences in the serum levels of follicle-stimulating hormone, luteinizing hormone and testosterone between smokers and nonsmokers and Ochedalski *et al.* (1994) who reported that the mean levels of LH and FSH were lower among smokers compared with non-smokers, while the mean levels of testosterone did not differ. A possible explanation is that smoking may, over time lead to a degeneration of Leydig cells (Rahman *et al.*, 2011).

In conclusion, Shisha intoxication is more than cigarette as evidenced by the significant increase in COHb level among shisha smokers than cigarette smoking. Also, shisha tobacco smoking

has deleterious effects on male fertility as it has significant toxic effects on semen parameters and levels of testosterone, FSH and LH hormones and this toxicity is higher than that induced by cigarette smoking with significant decrease in the percentage of sperms with normal morphology among shisha smokers than cigarette smokers. Therefore, shisha smoking seems to induce more toxic effects and the results of the current study highlight the fact that smoking via shisha is not a safer alternative to smoking cigarettes. Also, heavy shisha smokers showed a significant decrease in semen volume and sperm count than the light group. In addition our study concluded statistically significant negative correlations between smoking index and the semen volume and sperm count as well as a significant positive correlation between it and the testosterone level. So, this correlation placed special emphasis on the negative impact of smoking on semen quality and level of testosterone. Thus, it is recommended that men who have a habit of shisha smoking as an alternative to cigarette smoking tobacco should be informed about the potential adverse effects of their habit on sperm quality and hormones levels to stop it.

REFERENCES

- Al Rashidi, M., A. Shihadeh and N.A. Aliba, 2008. Volatile aldehydes in the mainstream smoke of the narghile waterpipe. *Food Chem. Toxicol.*, 46: 3546-3549.
- Al-Attar, A.M., 2011. Antioxidant effect of vitamin E treatment on some heavy metals-induced renal and testicular injuries in male mice. *Saudi J. Biol. Sci.*, 18: 63-72.
- Aljarrah, K., Z.Q. Ababneh and W.K. Al-Delaimy, 2009. Perceptions of hookah smoking harmfulness: Predictors and characteristics among current hookah users. *Tob. Induced Dis.*, 5: 16-16.
- Bacha, Z.A., P. Salameh and M. Waked, 2007. Saliva cotinine and exhaled carbon monoxide levels in natural environment waterpipe smokers. *Inhal. Toxicol.*, 19: 771-777.
- Baldelli, R., C. Dieguez and F.F. Casanueva, 2002. The role of leptin in reproduction: Experimental and clinical aspects. *Ann. Med.*, 34: 5-18.
- Blank, M.D., C.O. Cobb, B. Kilgalen, J. Austin, M. Weaver, A. Shihadeh, T. Eissenberg, 2011. Acute effects of waterpipe tobacco smoking: A double-blind, placebo-control studies. *Drug Alcohol Depend.*, 116: 102-109.
- Branian, J.D. and K.A. Hansen, 2002. Leptin and ovarian folliculogenesis: Implications for ovulation induction and ART outcomes. *Semin. Reprod. Med.*, 20: 103-112.
- Chowdhury, A.R., 1992. Toxicological assessment of reproductive health in occupation and community environment. *Proc. Zool. Soc.*, 45: 103-114.
- Cobb, C., K.D. Ward, W. Maziak, A.L. Shihadeh and T. Eissenberg, 2010. Waterpipe tobacco smoking: An emerging health crisis in the United States. *Am. J. Health Behav.*, 34: 275-285.
- Dikshit, R.K., J.G. Buch and S.M. Mansuri, 1987. Effect of tobacco consumption on semen quality of a population of hypofertile males. *Fert. Ster.*, 48: 334-336.
- EL Mulla, K.F., F.M. Konh, A.H. EL Behiery and W.B. Schill, 1995. The effect of smoking and varicocele on human sperm acrosin activity and acrosome reaction. *Hum. Reprod.*, 10: 3190-3194.
- Eissenberg, T. and A. Shihadeh, 2009. Waterpipe tobacco and cigarette smoking: Direct comparison of toxicant exposure. *Am. J. Prev. Med.*, 37: 518-523.
- El-Nachef, W.N. and S.K. Hammond, 2008. Exhaled carbon monoxide with waterpipe use in US students. *J. Am. Med. Assoc.*, 299: 36-38.
- Evans, H.J., J. Fletcher, M. Torrance and T.B. Hargreave, 1981. Sperm abnormalities and cigarette smoking. *Lancet*, 317: 627-629.

- Field, A.E., G.A. Colditz, W.C. Willett, C. Longcope and J.B. McKinlay, 1994. The relation of smoking, age, relative weight, and dietary intake to serum adrenal steroids, sex hormones and sex hormone-binding globulin in middle-aged men. *J. Clin. Endocrinol. Metab.*, 79: 1310-1316.
- Gaur, D.S., M. Talekar and V.P. Pathak, 2007. Effect of cigarette smoking on semen quality of infertile men. *Singapore Med. J.*, 48: 119-123.
- Gornig, V.M. and C. Schirren, 1996. Effect of exogenous toxins on fertility. *Fortschr Med.*, 114: 169-171.
- Handelsman, D.J., A.J. Conway, L.M. Boylan and J.R. Turtle, 1984. Testicular function in potential sperm donors: Normal ranges and the effects of smoking and varicocele. *Int. J. Androl.*, 7: 369-382.
- Jha, P. and F.J. Chaloupka, 2000. Tobacco control in developing countries. Oxford University Press, Oxford, ISBN: 9780192632463, Pages: 489.
- Jorsaraei, S.G.A., H.M.D. Shibahara, A. Wait, Y. Hirano and Y. Shiraishi *et al.*, 2008. The *in-vitro* effects of nicotine, cotinine and leptin on sperm parameters analyzed by CASA system. *Iranian J. Reproductive Med.*, 6: 157-165.
- Kasperczyk, A., S. Kasperczyk, S. Horak, A. Ostalowska and E. Grucka-Mamczar *et al.*, 2008. Assessment of semen function and lipid peroxidation among lead exposed men. *Toxicol. Appl. Pharmacol.*, 228: 378-384.
- Knishkowsy, B. and Y. Amitai, 2005. Water-pipe (narghile) smoking: an emerging health risk behavior. *Pediatrics*, 116: 113-119.
- Kunzle, R., M.D. Mueller, W. Hanggi, M.H. Birkhauser, H. Drescher and N.A. Bersinger, 2003. Semen quality of male smokers and nonsmokers in infertile couples. *Fert. Ster.*, 79: 287-291.
- Lewin, A., O. Gonen, R. Orvieto, J.G. Schenker, 1991. Effect of smoking on concentration, motility and zona-free hamster test on human sperm. *Arch Androl.*, 27: 51-54.
- Martinasek, M.P., R.J. Mc Dermott and L. Martinim, 2011. Waterpipe (hookah) tobacco smoking among youth. *Curr. Probl. Pediatr Adolesc. Health Care*, 41: 34-57.
- Martinet, Y. and A. Bohadana, 2004. Cigarette Smoking. *Le tabagisme*. Masson, Paris, Pages: 336.
- Maziak, W., 2008. The waterpipe: Time for action. *Addiction*, 103: 1763-1767.
- Maziak, W., S. Rastam and I. Ibrahim, K.D. Ward, A. Shihadeh and T. Eissenberg, 2009. CO exposure, puff topography and subjective effects in waterpipe tobacco smokers. *Nicotine Tob. Res.*, 11: 806-811.
- Monzer, B., E. Sepetdjian, N. Saliba and A. Shihadeh, 2008. Charcoal emissions as a source of CO, carcinogenic PAH in mainstream narghile waterpipe smoke. *Food Chem. Toxicol.*, 46: 2991-2995.
- Mostafa, T., 2010. Cigarette smoking and male infertility. *J. Adv. Res.*, 1: 179-186.
- Ochedalski, T., A. Lachowicz-Ochedalska, W. Dec and B. Czechowski, 1994. Evaluating the effect of smoking tobacco on some semen parameters in men of reproductive age. *Ginek. Pol.*, 65: 80-86.
- Pacifici, R., I. Altieri, L. Gandini, A. Lenzi and S. Pichini *et al.*, 1993. Nicotine, cotinine and trans-3-hydroxycotinine levels in seminal plasma of smokers: Effects on sperm parameters. *Ther. Drug. Monit.*, 15: 358-363.
- Pasqualotto, F.F., B.P. Sobreiro, J. Hallak, E.B. Pasqualotto and A.M. Lucon, 2006. Cigarette smoking is related to a decrease in semen volume in a population of fertile men. *BJU Int.*, 97: 324-326.

- Rahman, U., M. Faisal, M. Safeer, M. Tariq, Ubaidullah and J. ur Rehman, 2011. The effect of cigarette smoking on testosterone in young male adults of Peshawar. *J. Med. Sci.*, 19: 106-108.
- Salem, E.S., S.M. Meserga, M.A. Shallouf and M.I. Nosir, 1990. Determination of lead levels in cigarette and gouza smoking components with a special reference to its blood values in human smokers. *Egypt. J. Chest Dis. Tubercul.*, Vol. 37, No. 2.
- Salmon, T.B., B.A. Evert, B. Song and P.W. Doetsch, 2004. Biological consequences of oxidative stress-induced DNA damage in *Saccharomyces cerevisiae*. *Nucl. Acids Res.*, 32: 3712-3723.
- Sepaniaka, S., T. Forgesa, H. Gerarda, B. Foligueta, M.C. Beneb and P. Monnier-Barbarino, 2006. The influence of cigarette smoking on human sperm quality and DNA fragmentation. *Toxicology*, 223: 54-60.
- Sepetdjian, E., A. Shihadeh, N.A. Saliba, 2008. Measurement of 16 polycyclic aromatic hydrocarbons in narghile waterpipe tobacco smoke. *Food Chem. Toxicol.*, 46: 1582-1590.
- Shaarawy, M. and K.Z. Mahmoud, 1982. Endocrine profile and semen characteristics in male smokers. *Fert. Ster.*, 38: 255-257.
- Shafagoj, Y.A., F.I. Mohammedm and K.A. Hadidim, 2002. Hubble-bubble (waterpipe) smoking: levels of nicotine and cotinine in plasma, saliva and urine. *Int. J. Clin. Pharmacol. Ther.*, 40: 249-255.
- Sharma, R.N., C. Deva, D. Behera and K.L. Khanduja, 1997. Reactive oxygen species formation in peripheral blood neutrophils in different types of smokers. *Indian J. Med. Res.*, 106: 475-480.
- Shihadeh, A., 2003. Investigation of mainstream smoke aerosol of the argileh water pipe. *Food Chem. Toxicol.*, 41: 143-152.
- Shihadeh, A., S. Azarm, C. Antoniosm and A. Haddad, 2004. Towards a topographical model of narghile water-pipe cafe smoking: A pilot study in a high socioeconomic status neighborhood of Beirut Lebanon. *Pharmacol. Biochem. Behav.*, 79: 75-82.
- Shihadeh, A. and R. Salehm, 2005. Polycyclic aromatic hydrocarbons, carbon monoxide, tar and nicotine in the mainstream smoke aerosol of the narghile water pipe. *Food Chem. Toxicol.*, 43: 655-661.
- Sofikitis, N., I. Miyagawa, D. Dimitriadis, P. Zavos, S. Sikka and W. Hellstrom, 1995. Effects of smoking on testicular function, semen quality and sperm fertilizing capacity. *J. Urol.*, 154: 1030-1034.
- Theron, A., C. Schultz and J.A. Ker, 2010. Carboxyhaemoglobin levels in water-pipe and cigarette smokers. *S. Afr. Med. J.*, 100: 122-124.
- Trummer, H., H. Habermann, J. Haas and K. Pummer, 2002. The impact of cigarette smoking on human semen parameters and hormones. *Human Reprod.*, 17: 1554-1559.
- Vine, M.F., C.K.J.P.C. Tse Hu and K.Y. Truong, 1996. Cigarette smoking and semen quality. *Fert. Ster.*, 65: 835-842.
- Vogt, H.J., W.D. Heller and S. Borelli, 1986. Sperm quality of healthy smokers, ex-smokers and never smokers. *Fert. Ster.*, 45: 106-110.
- WHO, 1992. Laboratory Manual for the Examination of Human Semen and Sperm Cervical Mucosa Interaction. Vol. 3, 3rd Edn., Cambridge University Press, UK.
- WHO, 2006. Tobacco use in shisha: Studies on waterpipe smoking in Egypt. WHO Regional Office for the Eastern Mediterranean, Egyptian Smoking Prevention Research Institute. Egypt.
- WHO, 2009. The tobacco epidemic: A global public health emergency. Tobacco or Health Programme on Substance Abuse. *Tob. Alert Spec. WHO*, Geneva, Switzerland, pp: 28.

- Wolfram, R.M., F. Chehne, A. Oguogho and H. Sinzinger, 2003. Narghile (water pipe) smoking influences platelet function and isoeicosanoids. *Life Sci.*, 74: 47-53.
- Zenzes, M.T., 2000. Smoking and reproduction: Gene damage to human gametes and embryos. *Human Reprod. Update*, 60: 122-131.
- Zhang, J.P., Q.Y. Meng, L.J. Zhang, Y.L. Mao and Z.X. Sun, 2000. Effect of smoking on semen quality of infertile men in Shandong, china. *Asian J. Androl.*, 210: 143-146.