A COMPARATIVE STUDY BETWEEN THE POTENTIAL HEALTH RISKS ASSOCIATED WITH SUBCHRONIC SMOKE EXPOSURE TO ELECTRONIC CIGARETTES AND TOBACCO CIGARETTES

BY

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ABSTRACT

Electronic cigarettes (e-cigarettes) are increasingly used worldwide even though, only rare information is available on their health effects. Hence, the electronic cigarette smoking effects were examined in comparison to the conventional reference cigarette (tobacco cigarettes) using the commercially available cigarettes (Cleopatra), on a fixed puffing regimen based on a subchronic smoke exposure study. A ninety day-exposure study in rats showed marked anemia, with reduced RBCs, WBCs, and platelets count with electronic cigarette smoke. The smoke related clinical pathology changes, revealed disturbed hepatic and renal functions with the electronic cigarettes. The changes included also hypercholesterolemia, acidosis and hyperkalemia, together with hyponatremia and reduced total serum Ca level with the electronic cigarettes. The histopathological findings were of a more pronounced derangement in the lower respiratory tract in rats exposed to electronic cigarette smoke. The hepatic and renal histopathological findings revealed more hemorrhage and degeneration with electronic cigarette smoke. Collectively, the biological effects seen for the smoke of electronically heated cigarettes and conventional cigarettes were comparable with more pronounced toxicological health hazards following subchronic exposure to electronic heated cigarette smoke.

Key Words: *Electronic cigarettes, tobacco cigarettes, subchronic exposure, health effects.*

INTRODUCTION

Claims have been raised that the use of the electronic cigarette device still might carry health risks due to its novelty and possibly overstated claims of safety. The device uses heat or ultrasonic to vaporize a propylene-glycol liquid solution into an aerosol mist, similar to the way of nebulizer or humidifier which vaporizes solutions for inhalation. Such an electrical device simulates the act of tobacco smoking by producing an inhaler mist bearing flavor and nicotine content of the inhaled tobacco smoke; though without its odor (Bullen et al., 2010).

E-cigarettes vaporize nicotine, along with other compounds in the cartridge, in the form of aerosol created by heating, and it is unlike conventional cigarettes which burn tobacco and produce thousands of chemicals and toxicants created by tobacco consumption. All electronic cigarettes share such essential components; light cover, power supply (battery), replaceable cartridge that contains nicotine and other chemicals, and an atomizer that converts the chemicals into inhalable vapor. The atomizer serves as the heating element responsible for vaporizing the liquid. The cartridge serves as a mouthpiece and usually acts as a small reservoir holding the liquid that is to be vaporized. When the liquid in the cartridge has been depleted, the user can choose between refilling it, or replacing it with another prefilled cartridge (Terpstra et al., 2003; Coggins et al., 1989).

Upon inhalation of an e-cigarette, the smokers draw air through it, the airflow sensors will activate the battery which turns the tip of the cigarette red to simulate smoking and heats the atomizer to vaporize the propylene glycol and nicotine. The aerosol vapor delivers a dose of nicotine into the smoker's lungs, after which residual aerosol is exhaled into the environment. E-cigarettes contain a light-emitting diode in the tip that glows when the user puffs, to resemble the burning end of a cigarette (Patskan and Reininghaus, 2003; Roething et al., 2005).

Nicotine and flavors are dissolved in hygroscopic components, which turn the water in the solution into a smoke-like vapor upon heating. The nicotine liquids contain 4 types of doses:- I)"Low" doses of nicotine tend to correspond to a concentration between 6-9 milligrams of nicotine per millimeter of liquid. II)"Midrange" or medium doses tend to correspond to a concentration of 10-17 mg/ml. III) "High" doses tend to correspond to a concentration of approximately 18-22 mg/ml. IV) Lastly, "extra-high" doses tend to correspond to a concentration of 22-36 mg/ml. The commonly used hygroscopic components include propylene glycol (PG), vegetable glycerin (VG), and polyethylene glycol 400 (PEG400) (Schep et al., 2009).

The design of electronically heated cigarettes produces particularly no side stream smoke between puffs. As a result of the controlled heating, there is a lower temperature (500^{o}C) applied to tobacco than that found in the burning cone of the conventional cigarettes (950^{o}C). The composition of main stream from electronic cigarettes differs considerably from that of the conventional cigarettes (Stabbert et al., 2003).

Food and Drug Administration (FDA) showed that the e-cigarettes contain

carcinogens including nitrosamines, and tobacco-specific components suspected to be harmful to humans (anabasine, myosmine, and beta-nicotyrine), and toxic chemicals such as diethylene glycol. FDA also found that e-cigarette cartridges labeled as containing no nicotine did in fact contain low levels of nicotine (Etter and Bullen, 2011).

There are several claims on safety of e-cigarettes: the FDA analysis of e-cigarettes, recorded higher nicotine doses between 26.8 and 43.2 micrograms per puff, the dose of nicotine delivered with each puff may vary substantially, FDA also detected nicotine in products labeled as nicotine free. E-cigarettes containing variable toxic and carcinogenic compounds in doses generally smaller than those found in "real" cigarette, but it is not zero. E-cigarettes deliver an array of chemicals including diethylene glycol which is a highly toxic compound, various nitrosamines (powerful carcinogens found in tobacco) and at least another four chemicals suspected of being harmful to humans (Simon, 2011).

Diethylene glycol (DEG) with the formula $(HOCh_2CH_2)_2O$, is an organic compound which is a colorless, odorless, poisonous hygroscopic liquid with a sweetish taste. Diethylene glycol is a widely used solvent. It is a humectant for tobacco, printing ink, glue, and cork. The ethylene glycol antifreeze contains a few percent diethylene-glycol present as an inadvertent byproduct through glycol production. In summary, e-cigarettes contain toxic components, and they are not currently manufactured to the same rigorous standards as pharmaceutical products, and are therefore almost certainly less safe than nicotine replacement therapy (NRT) products (Clay and Murphy, 1977; Slikker et al., 1991).

Aim of the work:-

The objective of this study was to investigate and compare the toxicological effects of subchronic exposure to the smoke of the electronic cigarettes and the conventional reference cigarettes (tobacco cigarettes) in rats.

MATERIALS & METHODS

Animals:- A total of 20 adult male Albino rats aged four weeks, weighing about (200±5gm), were employed for a subchronic cigarette smoke exposure study. Subchronic exposure means multiple or continuous exposures lasting for approximately ten percent of an experimental species lifetime, usually over a three-month period. Animals were obtained from the faculty of Agriculture- Minia University. Animals were kept at the constant environmental conditions and housed for one week for acclimatization prior to the experiment. The rats were

assigned to ensure that the groups had similar mean and range of body weights.

Materials:- The rats would have licked smoke off their fur in addition to their inhalation exposure (not nose only inhalation but whole body exposure).

1- Conventional reference cigarettes (tobacco cigarette named Cleopatra) were obtained commercially from markets, where it is readily available to the general community, and therefore can serve as a reference cigarette.
2- Electronic cigarettes obtained commercially from Medica- Pure Company (Egypt).
3- Special exposure boxes made of glass together with a manual pump, designed in the faculty of Medicine in Minia University.

Methods:

Method of smoke generation:- The exposure protocol was designed according to Slikker et al. (1991), the smoke from the tobacco cigarettes (Cleopatra) and e-cigarettes was delivered to rats in a special exposure boxes made of glass measured 100 x 60 x 30 cm^3 (length x width x height). The smoke stream was allowed via glass tubing to the exposure chamber by the aid of a manual pump once each minute under conditions of 2 second puff duration, 50ml puff volume, 30 second exposure interval followed by a 30 second purge with fresh air each minute until the next puff was generated. The puff count X±SD was (8.00±0.3) for the e-cigarettes, and (8.2±0.2) for the tobacco cigarettes (by the aid of the manual pump).

The fresh air was delivered with the help of an electric aerator to purge the test smoke. The expired air from the chamber was removed by a mechanical suction. The animals were thus exposed to fresh cigarette smoke intermittently in a fashion analogous to human smoking. Such arrangement permitted regulation of puff volume, puff duration, puff frequency, exposure time, and purge duration. Separate exposure boxes were used, each with its own equipment was used for each exposure group to prevent possible contamination of the tested animals. Mid-range" or "medium" doses tend to correspond to a nicotine concentration of 10-17 mg/ml.

Study design :

This work was carried out according to Werley et al. (2008). Group (A):- 10 animals were exposed to the smoke of the reference conventional cigarettes (Cleopatra). Group (B):- 10 animals were exposed to the smoke of the e- cigarettes. The exposure regimen of the inhalation toxicity study was 6 hours per day, 7 days per week, for 90 days. Sacrifice of rats was carried out the next day following the period

of exposure by decapitation after light ether anesthesia.

Collection of samples :- The next day following the period of exposure and according to Frost-Pineda et al.(2008), morning blood samples were drawn between 06:30 and 07:00 a.m. under fasting conditions.

I) Blood sampling and biochemical analysis:- Blood samples were collected by cardiac puncture (approximately 6ml. per each animal). Each blood sample was divided into 2ml. mixed roughly with EDTA immediately after sampling, for assessment of the complete blood picture, and the remaining 4ml. blood was centrifuged at 4000rpm for 10 min. then the serum was mixed in plastic tubes with a solution of D-ascorbic acid 50mM (50ul/ml serum) and then stored at -20°C until analysis. The following serum biomarkers were investigated: AST (serum aspartate transaminase), ALT (serum alanine transaminase), ALP (serum alkaline phosphatase), Serum urea and creatinine levels, Serum cholesterol level, Serum pH, Serum Na, K, and total Ca levels and complete blood picture (CBC). The biochemical assay was done according to the manufacturer's instructions and the standard methods within two days of serum separation. All chemical parameters (urea, creatinine, AST, ALT, ALP, Na, Ca, and K) were investigated using minidray automated clinical chemistry and reagents are supplied from Alkan Company.

II) Tissue samples:- Trachea - lungs - kidney and liver were subjected to light microscopic examination.

Statistical Analysis: -All data were presented as mean ±SD and compared by Student's t-test. A p value ≤ 0.05 was taken into consideration for determining significance. All statistical procedures were computed using SPSS 10.0 software.

RESULTS

Physical characteristics of animals:- Animals exposed to the smoke of the conventional reference cigarettes show normal behavior and alertness. Meanwhile, CNS effects are manifested in the form of somnolence with e-cigarette smoke, nearly in all exposed rats.

Biochemical results:- As shown in table (1), in comparison to the tobacco cigarettes, the electronic cigarette smoking reveals a highly significant elevated levels of serum urea and creatinine together with acidosis. Compared to rats exposed to tobacco cigarette smoke, the rats exposed to e-cigarette smoke manifest hyperkalaemia, hyponatraemia, and reduced total calcium level.

The same table shows disturbed he-

patic function with electronic cigarette smoking and a highly significant elevation in serum AST, ALT and ALP levels. Electronic cigarette smoking can result into a significant hypercholesterolemia when compared to the reduced serum cholesterol level produced by tobacco cigarette exposure.

Table (2) shows that in comparison to tobacco cigarettes, the electronic cigarette smoking reveals a highly significant reduction in the number of platelets, white blood cells, and a significant decrease of hemoglobin level. Electronic cigarettes cause a highly significant reduced percentage of lymphocytes and also a significant lowering in the mean corpuscular hemoglobin and the mean corpuscular volume.

Histopathological results:

In tobacco and electronic cigarette groups, the trachea shows inflammatory cellular infiltration in both groups. Group (A) shows disturbed epithelium, amalgamated cilia and sub epithelial hemorrhage (Figure 1a). Group (B) shows stratification of the epithelial lining of the trachea, subepithelial inflammatory cells (Figure 1b).

The lung tissue in group (A) reveals enlarged some alveolar spaces, thinning of alveolar wall in other areas together with extensive destruction of alveolar septal wall, in addition to perivascular perivascular inflammatory cellular infiltration with congested some blood vessels (Figure 2a). Group (B) reveals alveolar septal thickening, septal infiltration by erythrocytes and inflammatory cells (mostly macrophages), and also black carbon particles can be seen within the dust cells (Figure 2b).

The renal cortex in group (A) shows degeneration of some renal tubules with some areas of hemorrhage. The lumen of some tubules is obliterated (Figure 3a). Group (B) shows cystic luminal dilatation in some tubules, together with some areas of hemorrhage (Figure 3b).

The liver tissue in group (A) reveals congested central vein and some hepatic sinusoids (Figure 4a). Group (B) reveals cytoplasmic vacuolations of some hepatocytes together with inflammatory cellular infiltration around the portal tract (Figure 4b).

DISCUSSION

One strategy to reduce the adverse biological effects of smoking is to reduce the yield of certain toxic smoke constituents by generating smoke at temperatures below those found in conventional cigarettes. The electronic cigarette, consisting of an electrically controlled heater/lighter device and such specially designed cigarettes are put into practice.

E-cigarettes enable lung inhalation of nicotine and subsequently allow nicotine to pass rapidly into the blood and thus rapidly relieve craving and tobacco withdrawal symptoms. E-cigarette has the potency to be at least as effective as currently approved nicotine replacement therapy (NRT) products. Although (NRT) cannot deliver nicotine to the lung. In addition, the similarities in shape, actions, and inhalation between e-cigarettes and tobacco cigarettes could help also smokers quit. Some distributors present their products suggesting that e-cigarettes can be used to aid smoking cessation as an alternative to tobacco smoking (Terpstra et al., 2003).

In the present work, this subchronic (90-day) smoke exposure study was performed for an equivalent response comparison between the toxicological effects induced by the two cigarette types (electronic cigarette and tobacco cigarette). The main objective was to determine whether the electronic cigarettes showed significant reduction in various biological endpoints compared to the conventional reference cigarettes or not. As well as to describe the potential toxic hazards associated with e-cigarettes. The duration of the current research is in agreement with the duration of the study done by Roemer et al. (2008), in which their study revealed that the 90- day inhalation study of e-cigarettes caused biochemical toxic effects together with the pulmonary and respiratory histological derangement were highly evident with e-cigarettes compared with the conventional reference cigarettes.

As an explanation of rat somnolence which was found in the current study, several mechanisms are responsible for the CNS effects seen in ethylene glycol poisoning. Early in the course of poisoning, CNS effects are the results of the direct action of ethylene glycol, like ethanol, low doses of ethylene glycol can produce euphoria, somnolence, and intoxication, whereas high doses can result into CNS depression leading to coma. Persistent coma may be due to encephalopathy or cerebral edema (Ichinose, 2009).

The current study revealed significant changes of the biochemicals parameters with e- cigarettes when compared with tobacco cigarettes. E- cigarettes caused significant metabolic acidosis, significant disturbances of renal and hepatic functions (the levels of serum urea and creatinine, ALT, AST, ALP and cholesterol are increased).

Kraut and Kurtz, (2008) explained the significant biochemical changes with e-cigarettes by the fact that Ethylene glycol is one of the components of EHCSS. Ethylene glycol is a common coolant, industrial solvent, and antifreeze agent. It is metabolized in the liver to glycoaldehyde by the

alcohol dehydrogenase enzyme. Glycoaldehyde is then oxidized into glycolic and glyoxylic acids and finally to oxalic acid. Accumulation of such toxic metabolites is responsible for the potentially fatal acidosis, disturbed hepatic function (in the form of increased ALT, AST, ALP), and renal failure.

In the current study, exposure to smoke of e-cigarettes resulted in a highly significant elevated serum cholesterol level in a matter could be attributed to the diethylene glycol exposure. Meanwhile, exposure to the smoke of the tobacco cigarettes resulted into a reduced serum cholesterol level as a result of the reduced nutritional status secondary to irritation in the exposed animals. This was not in agreement with Werley et al. (2008), who revealed a similar reduced serum cholesterol level both in e-cigarette and tobacco groups, and the origin of this change could not be explained.

The present study revealed that exposure to smoke of e- cigarettes resulted in a highly significant hperkalemia, hyponatraemia and reduced total Ca level. These results were in agreement with McAuley et al. (2012) who reported a similar results on exposure to e-cigarettes smoke. These changes on electrolytes due to the toxic ethylene glycol component of e- cigarettes and its toxic metabolites mainly (glycolic acid) which may cause acute tubular necrosis, hyperkalemia, and hyponatremia. Low Ca concentration was explained by accumulation of oxalic acid in the body as a final step of glycolic acid metabolism, and binding of oxalic acid to body Ca resulting in formation of Ca oxalate crystals and decreased total Ca level (Caravati et al., 2005).

In the current study, exposure to smoke of e- cigarettes resulted in a highly significant reduction in platelets count, WBCs, Hemoglobin concentration, lymphocytes, MCV, MCH. Shaham et al. (2000) explained these significant changes by the effect of the toxic metabolite of ethylene glycol component of e- cigarette on the bone marrow. Additionally, immunological sensitization to ethylene glycol oxide in the bone marrow over a long period of exposure, could lead to gradual depression of lymphocytes, platelets and hemoglobin concentration and other blood parameters.

A significant related increase in alkaline phosphatase activity, and decreased leucocyte and lymphocyte counts were observed, with similar magnitude of responses, for both e-cigarettes and tobacco smoke exposed groups (Werley et al., 2008). This was inconsistent with the current results which found that such

changes were more evident with e-cigarettes than the tobacco cigarette smoke exposed group.

Other studies revealed a trend towards lower platelets count which was seen in smoke exposed group compared with untreated rats. The total white blood cells (WBCs) were lower in male smoke-exposed rats compared to sham (Vanscheeuwijck et al., 2002). This is coinciding with the present work, with a highly significant change in e-cigarette exposed rats than those exposed to the smoke of the tobacco cigarettes.

In another acute smoke exposure study by Flouris et al. (2012), it was concluded that e-cigarette smoking does not influence the complete blood count (CBC) indices. This is not in agreement with the current results which found that the subchronic smoke exposure to e-cigarette resulted into reduced number of RBCS, platelets, and WBCs. The same study demonstrated that the tobacco cigarette smoke resulted into increased WBCs, lymphocytes, and acute granulocyte count.

In the current study, histopathological examinations revealed significant inflammatory and degenerative changes in trachea, lung, liver, and kidney in e- cigarette when compared to the conventional cigarette. These changes explained by the presence of toxic ethylene glycol metabolites in these tissues as a result of e-cigarette smoke (Kraut and Kurtz, 2008).

The respiratory function data can provide an explanation of the pulmonary histopathological findings related to smoke inhalation, the increased minute volume, approximately 6-9% in e-cigarette smoke exposed groups higher than the corresponding tobacco exposed groups. This increased minute volume, might impact the total smoke exposure and/or deposition at different levels in the respiratory tract (Moennikes et al., 2008).

Inconsistent with the present results, as reported by (Werley et al., 2008; Terpstra et al., 2003), e-cigarette smoke exposure resulted into a reduced severity of histopathological changes in the respiratory tract tissues, at each level in the respiratory tract from the nose to the lungs, histopathological severity and incidence scores were lower in e-cigarette smoke exposed animals compared to tobacco smoke exposed groups. In the recent study, exposure was for a longer period compared with the earlier studies.

Coinciding with Moennikes et al. (2008), in the trachea, minimal reserve-cell hyperplasia and goblet cell hyperplasia were observed in smoke exposed rats. The

lungs showed hyperplasia of the bronchial epithelium and accumulation of pigmented alveolar macrophages in the alveolar lumen.

CONCLUSION & RECOMMENDATIONS

The results of this toxicological evaluation of e-cigarettes compared to conventional cigarettes, suggested that this novel cigarette product is inconsistent with the reduced biological activity.

More researches on e-cigarettes are crucially needed to protect the health of e-cigarette users and even those who do not use e-cigarettes. Justifiably, more information about the potential toxic and health effects of e-cigarette vapors is necessary before the public can have a definitive answer about the safety of e-cigarettes. Hopefully, in the near future, scientists can provide firm evidence for or against the claimed 'safety' of e-cigarettes as a nicotine-delivery tool.

There are very few published studies on e-cigarettes and research is urgently required, particularly on the efficacy and toxicity of these devices.

Given the enormous burden of disease and death caused by tobacco smoking, there is an urgent need for research into the toxicity, efficacy, and public health impact of e-cigarettes. In addition, whether devices that resemble e-cigarettes could be used to deliver medications other than nicotine to the lung and bronchi also warrants investigation. As the manufacturers and distributors of e-cigarettes are relatively small companies that may be unable to afford the research costs, or possess the expertise or manpower to go through the regulatory approval process, support from governments, public health organizations or foundations may be needed to produce evidence on these novel devices. There is an ongoing debate to whether other bases of comparison, such as equal TPM (Total particulate matter) or equal nicotine, might be better suited to provide a link to the human situation.

Table (1): Comparison between the effects of tobacco cigarette and the electronic cigarette smoke exposure on some examined biochemical parameters.

	Normal values	Tobacco cigarettes (X± SD)	Electronic cigarettes (X± SD)	t	p
Serum Ph mg%	2.5 : 4.6	4.1±0.58 (3.1:4.6)	2.1±0.129 (2.0:2.4)	10.64	0.00**
Serum urea mg%	15 : 45	25.1±5.021 (21:35)	44.6±4.58 (37:49)	-9.08	0.00**
Serum creatinine mg%	0.5 : 1.5	0.75±0.143 (0.6:1)	1.63±0.082 (1.5:1.7)	-16.83	0.00**
Serum K mmol/L	3.5 : 5.5	5.68±0.333 (5.4:6.1)	8.14±1.05 (5.8:8.9)	-7.07	0.00**
Serum Na mmol/L	137 : 148	139.8±8.23 (136:148)	114.0±12.52 (102:137)	5.45	0.00**
Serum AST IU/L	up to 45	146.4±6.24 (141:161)	170.2±2.53 (165:173)	-11.18	0.00**
Serum ALT IU/L	up to 37	47.5±6.294 (44:58)	64.9±10.27 (46:74)	-4.57	0.00**
Serum ALP KAU/L	up to 276	270.1±4.725 (261:276)	457.0±2.45 (454:460)	-111.06	0.00**
Serum cholesterol mg%	up to 200	167.8±13.122 (148:185)	220.9±7.522 (222:232)	-13.98	0.02**
Total serum Ca mg%	8.8 : 10.2	9.63±0.48 (8.8:10.2)	6.66±0.477 (6.00:7.4)	13.91	0.00**

P is significant ≤ 0.05 **X:** mean **SD**: standard deviation

Table (2): Comparison between the effects of tobacco and electronic cigarette smoke exposure on the complete blood picture (CBC).

	Normal values	Tobacco cigarettes (X±SD)	Electronic cigarettes (X±SD)	t	p
Platelets Million/Cumm	150.000:450.000	292.9±18.06 (284:310)	255.4±5.582 (246:262)	6.274	0.00**
WBCs Thousand/Cumm	4.000 : 11.000	6.11±0.242 (5.8:6.4)	4.69±0.145 (4.5:4.9)	15.898	0.00**
Hb g/dl	13 : 18	12.6±0.287 (12.1:12.9)	8.76±0.18 (9.4:9.8)	22.578	0.02**
Lymphocytes	25 :45%	41.1±0.88 (40%:42%)	26.7±1.77 (25%:30%)	23.091	0.00**
MCH Pg	27 : 31	29.0±1.05 (27:30)	20.6±0.69 (20:22)	21.0	0.02**
MCV fl.	76 : 96	76.3±1.42 (75:79)	52.8±1.42 (53:56)	31.59	0.03**
RBCs Million/cumm	3.5 : 5.5	5.32±0.18 (5.0:5.5)	3.27±0.164 (3.0:3.5)	27.048	0.00**

P is significant ≤ 0.05 X: mean **SD**: standard deviation

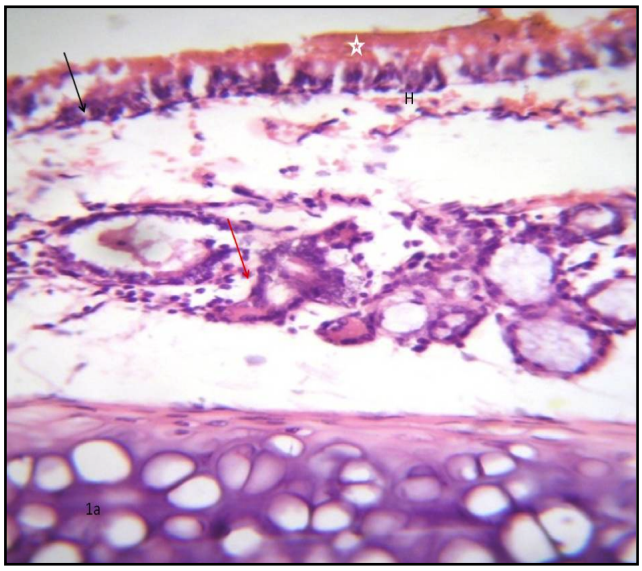

Figure 1a: A photomicrograph of tracheal tissue of tobacco smoke exposed rats, showing areas of disrupted epithelia (black arrow), amalgamated cilia (star), subepithelial hemorrhage (H) and inflammatory cells infiltration (red arrow). X400.

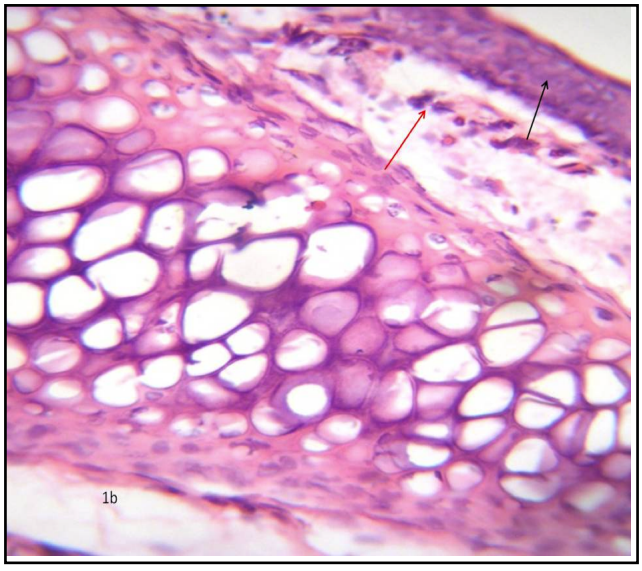

Figure 1b: A photomicrograph of tracheal tissue of electronic cigarette smoke exposed rats showing stratification of the epithelial lining of the trachea (black arrow) and subepithelial inflammatory cells infiltration (red arrow). X400.

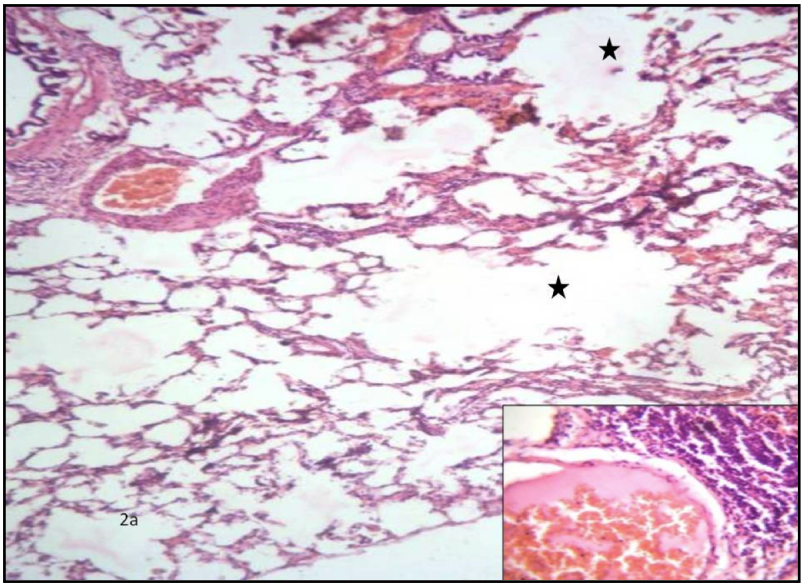

Figure 2a: A photomicrograph of lung sections of tobacco smoke exposed rats showing large area of alveolar space enlargement, thinning of alveolar wall in other areas and extensive destruction of alveolar septa wall (stars) X100 Notice congestion of some blood vessels and perivascular inflammatory cells infiltration (inset)X400.

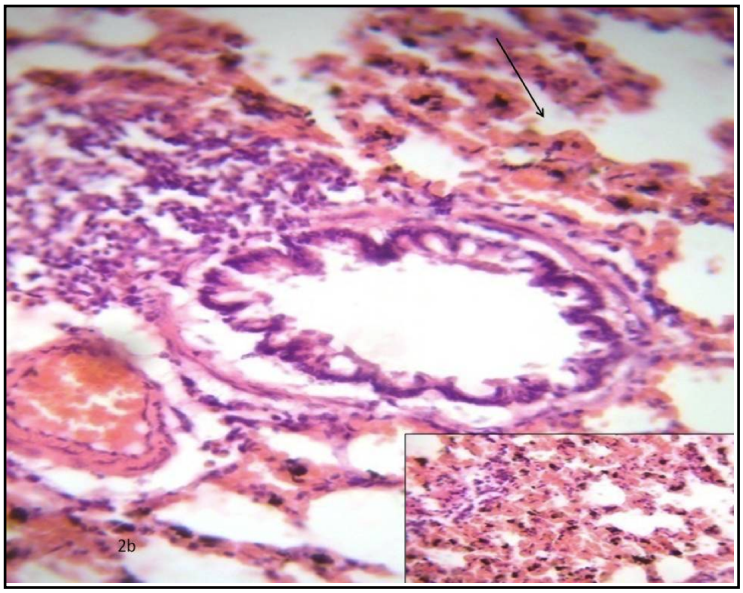

Figure 2b : A photomicrograph of lung sections of electronic cigarette smoke exposed rats showing alveolar septal thickening, septal infiltration by erythrocytes and inflammatory cells (mostly macrophages), with a scattered presence of these cells within the alveolar space (arrows). Notice black carbon particles within the dust cells (inset). X400.

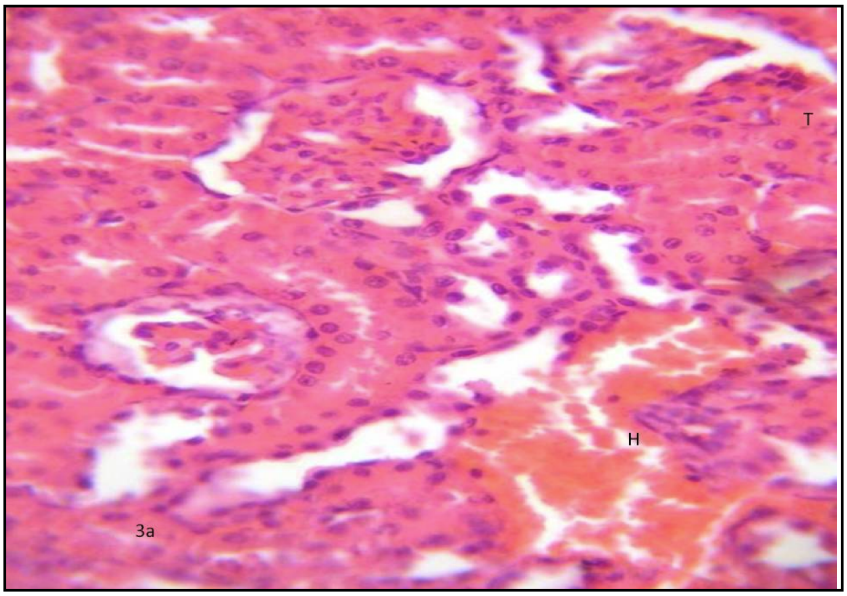

Figure 3a: A photomicrograph of tobacco smoke exposed rats, showing degeneration of some renal tubules. The lumen of some tubules was obliterated (T). Areas of hemorrhage were observed (H). X400.

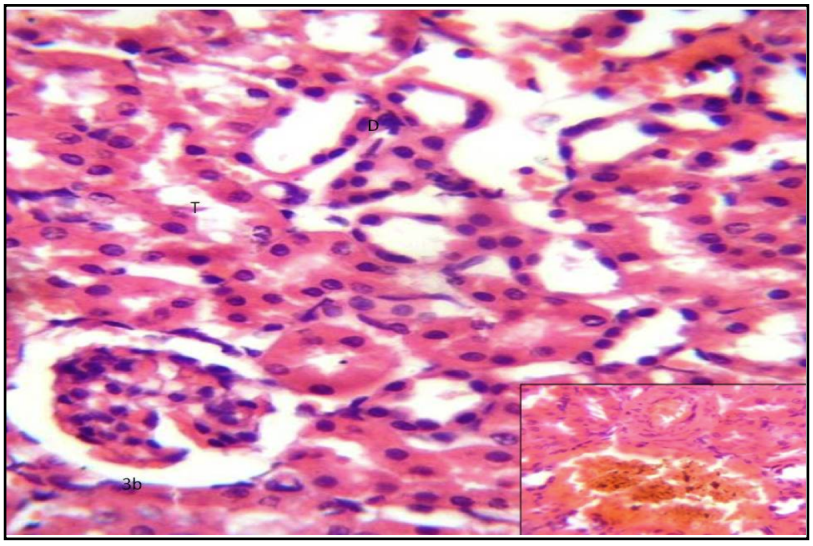

Figure 3b: A photomicrograph of electronic cigarette smoke exposed rats, showing degeneration of some renal tubules (T). Some tubules with cystic luminal dilatation (D). Areas of hemorrhage were noticed (inset). X400.

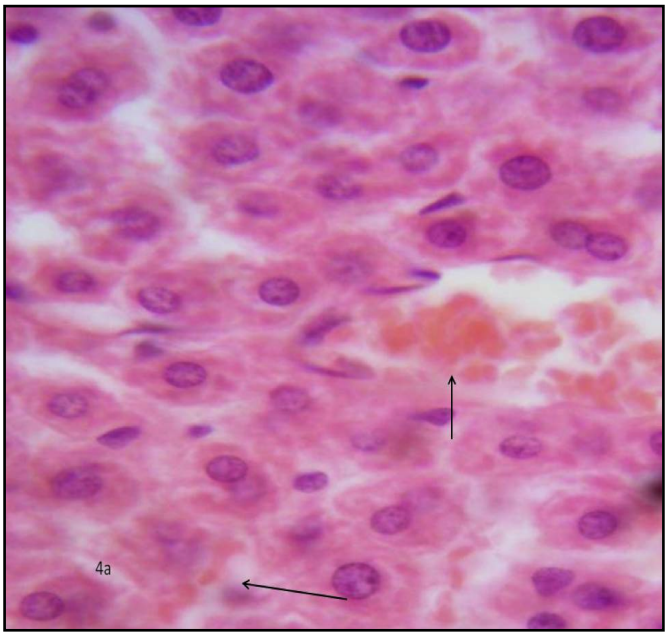

Figure 4a : A photomicrograph of liver tissue of tobacco smoke exposed rats showing congestion in the central vein and some hepatic sinusoids (arrows)

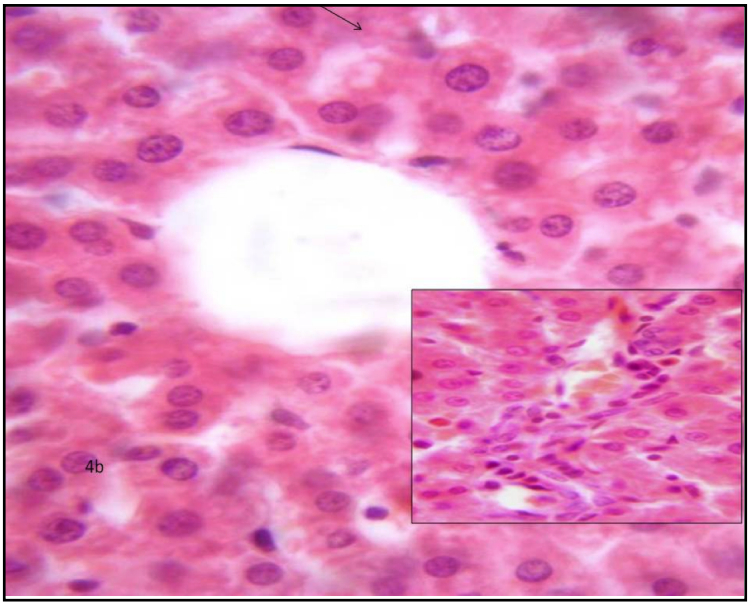

Figure 4b: A photomicrograph of liver tissue of electronic cigarette smoke exposed rats showing some hepatocytes with cytoplasmic vacuolations (arrow).Inset showing inflammatory cellular infiltration around the portal tract.X400.

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دراسة مقارنة بين المخاطر الصحية المحتملة المرتبطة بالتعرض للتدخين شبه المزمن للسجائر الإلكترونية وسجائر التبغ

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يتزايد استخدام السجائر الإلكترونية فى جميع أنحاء العالم وعلى الرغم من ذلك، فالمعلومات المتاحة فى تأثيراتها الصحية نادرة ولهذا فقد تم فحص آثار تدخين السجائر الإلكترونية بالمقارنة مع السجائر التقليدية المرجعية (سجائر التبغ) باستخدام السجائر المتاحة تجاريا (كليوباترا)، عن طريق دراسة التعرض شبه المزمن للدخان فى الجرذان بنظام ثابت النفخ. وأظهرت الدراسة أن تعرض الجرذان لدخان السجائر الإلكترونية لمدة تسعين يوم نتج عنه فقر الدم مع انخفاض عدد كرات الدم الحمراء، كرات الدم البيضاء، والصفائح الدموية. وكشفت الدراسة أيضا عن خلل فى وظائف الكبد والكلى بسبب التعرض للسجائر الإلكترونية. وكذلك إرتفاع نسبة الكولسترول، وزيادة البوتاسيوم وحموضة الدم، بالإضافة إلى نقص الصوديوم وانخفاض مستوى الكالسيوم فى الدم مع السجائر الإلكترونية. وكانت التغيرات النسيجية المرضية أكثر وضوحا فى الجهاز التنفسى السفلى فى الجرذان المعرضين لدخان السجائر الإلكترونية كما بينت التغيرات النسيجية المرضية للكبد والكلى وجود نزف وتحلل لهم مع دخان السجائر الإلكترونية. وبشكل جماعى، كانت التأثيرات البيولوچية لدخان السجائر الإلكترونية مقارنة لتلك التأثيرات الناتجة عن السجائر التقليدية. وكانت المخاطر الصحية السمية شبه المزمنة بعد التعرض لدخان السجائر الإلكترونية أكثر وضوحاً.