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RESEARCH ARTICLE

The Effect of Pepper Gas (OC) on Some Biochemical Parameters in Rats [1]

Ercan SEYHAN * Nihat MERT ** Handan MERT **

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* Jandarma Kriminal Daire Baskanligi, TR-06580 Beytepe, Ankara - TURKEY
** Yüzüncüyıl University, Veterinary Faculty, Biochemistry Department, TR-65080 Van - TURKEY

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Summary

In this dissertation, the effect of the widely used pepper gas (oleoresin capsicum, OC) derived from the cayenne pepper was studied in the blood gases, electrolytes and some biochemical parameters on the rats with different dosages and periods. In the pre-dosage phase, 12 of 47 Wistar albino rats were used as the live material. Commercially available 90 g OC sprays were provided. It was experimentally measured that 6 g of OC was sprayed per second. 6 rats were used as control group. Experimental Group 1 was 9 rats which were kept 5 min in an OC sprayed closed enviroment for 4 sec (24 g); Experimental Group 2 was 10 rats which were kept 8 min in an OC sprayed closed enviroment for 8 sec (48 g); Experimental Group 3 was 10 rats which were kept 15 min in an OC sprayed closed enviroment for 12 sec (72 g). The rats were kept as a group of 5 of each in 50x50x50 cm experiment cube and OC was applied for the abovementioned periods and dosages. The blood samples were taken from the heart after the 1-2 min sedation application. The potential hydrogen (pH), carbon dioxide partial pressure (pCO_2), concentration of total carbon dioxide (ct CO_2), O_2% saturation, HCO_3, base excess (BE), base excess of extracellular fluid (B(ecf)), Na, K, Ca, Cl and glucose levels were measured by Rapidlab 865 System and auto analyser. When the control group values were compared to the other three groups, pH, ct CO_2 and HCO_3 (except the Group 3) were decreased, pCO_2, pO_2, O_2% saturation, K, Cl, glucose, BE and B(ecf) were increased and no significant change was observed in Na and Ca levels. The pH change ($P \leq 0.05$), pO_2 ($P \leq 0.01$), HCO_3 ($P \leq 0.01$); $\%O_2$ saturation ($P \leq 0.001$), K ($P \leq 0.05$), Cl ($P \leq 0.05$); B(ecf) ($P \leq 0.05$) levels were evaulated the changes according to inter-group and control group. As a result, no fatality were encountered in rats which were exposed different dosages and amounts of OC in a closed enviroment except difficulty in breathing and conjuctivity. Despite that supporting biochemical changes for respiratoric asidose were encountered, it was understood that pepper gas could especially be used as a safe riot control agent in open air.

Keywords: *Bicarbonate, Blood gases, Electrolyte, OC, Pepper Gas, Rat*

Ratlarda Biber Gazının (OC) Bazı Biyokimyasal Parametreler Üzerine Etkisi

Özet

Bu çalışmada Cayenne bitkisinden elde edilen ve bu amaçla çok kullanılan biber gazının (oleoresin capsicum, OC), ratlar üzerinde farklı süre ve dozda uygulanması sırasında kan gazları, elektrolitler ve bazı biyokimyasal parametreler üzerine etkisi incelendi. Araştırmada 12 tanesi ön doz çalışmasında kullanılmak üzere toplam 47 adet Wistar albino rat canlı materyal olarak kullanıldı. Ticari olarak satılan 90 g'lık spreyler halinde OC temin edildi. Saniyede 6 g OC püskürtüldüğü denemelerle hesaplandı. 6 adet rat kontrol grubu, 9 adet rat 4 saniye OC sıkılmış (24 g) ortamda 5 dak. bırakılan deneme 1; 10 adet rat 8 saniye (48 g) OC sıkılmış ortamda 10 dakika bırakılan deneme 2; 10 adet rat ise 12 saniye (72 g) OC sıkılmış ortamda 15 dak. bırakılan deneme 3 grubunu oluşturdu. Ratlar 50x50x50 cm'lik bir deney küpüne beşerli gruplar halinde konularak, yukarıda belirtilen doz ve sürede OC uygulandı. Süre sonunda hayvanlar eter ile 1-2 dak. sedasyon işlemine tabii tutulup kalpten kan örnekleri alındı ve hemen pH, parsiyel karbondioksit basıncı (pCO_2), toplam karbondioksit (ct CO_2), $\%O_2$ saturasyonu, bikarbonat (HCO_3), baz fazlalığı (BE), hücre dışı sıvı baz fazlalığı (B(ecf)), Na, K, Ca, Cl ve glukoz düzeyleri Rapidlab 865 cihazı ve otoanalizörle ölçüldü. Kontrollerin değerleri diğer üç grup ile karşılaştırıldığında pH, ct CO_3, üçüncü grup hariç HCO_3 düzeylerinde azalma, pCO_2, pO_2, $\%O_2$ saturasyonu, K, Cl, glukoz, BE ve B(ecf) düzeylerinde artma, Na, Ca düzeylerinde ise dikkati çeken değişim saptanmadı. pH değişimi ($P \leq 0.05$), pO_2 ($P \leq 0.01$), HCO_3 ($P \leq 0.01$), $\%O_2$ saturasyonunda ($P \leq 0.001$), K ($P \leq 0.05$), Cl ($P \leq 0.05$), B(ecf) ($P \leq 0.05$) düzeylerinde önemle deneme grupları arasında veya kontrollere göre değişim hesaplandı. Sonuç olarak kapalı ortamda farklı dozda OC miktarına, farklı sürelerde maruz kalan ratlarda solunum güçlüğü ve konjuktivit görülmesine rağmen hiçbir ölüm olayına rastlanılmadı. Kan gazları değerleri incelendiğinde respiratorik asidoz oluşumuna destek veren biyokimyasal değişimlere rastlanmış olmasına rağmen ve biber gazının özellikle açık alanlarda toplumsal olaylarda güvenli olarak kullanılabilecek gaz olabileceği kanısına varıldı.

Anahtar sözcükler: *Biber gazı, Bikarbonat, Elektrolit, Kan gazları, Rat, OC*

İletişim (Correspondence)
+90 312 4647230
ercnes@yahoo.com

INTRODUCTION

For as long as human existed on earth, there has been an ongoing need for law enforcement and justice. To maintain the continuity of this balance, law enforcement agencies has got the responsibility of force continium. Law enforcement agencies sometimes perform their duties during life treatening situations. In such cases, they only have moments to decide the level of force to be applied. Law enforcement agencies had limited numbers of tools to stop the aggresive behaviors of substance addicted or mentally ill persons for many years. Even the police force or the suspects got injured due to the inadequate means of force continuum means.

For many years, law enforcement agencies have used chloracetophenone (CN) and cholorobenzylidene malononitrile (CS) against the suspects to stop the assaults and control the riot [1]. But these agents could not be used effectively because of their impact dependancy on exposure distance and ambient temperature. Particularly, serious problems were encoutered related with the decontamination procedures.

The police force started to use oleoresin capsicum, commonly known as pepper gas in public. Oleoresin capsicum is an organic substance derived from cayenne pepper which is imflammatory and adhesive because of its oily resin surface [2,3].

The short and long term effects as well as the possible negative effects on the suspects under arrest must be finely evaluated by the law enforcement agencies. The main reason behind is that every technique enables the police force to arrest and cuff the aggressive suspects is highly significant.

OC is commonly accepted as an effective and safe means of tool by law enforcement agencies to control the riot [4,5]. The effectiveness of OC mostly depends on the inflammatory effect rather than the distance sprayed or ambient temperature. This makes OC more efficient for controling the drug addicteds and mentally ills than CN and CS [6]. It is also known that OC provides more effectiveness on aggressive animals while carrying out duties.

OC is basically different from the traditional riot control agents of CS and CN. The tradional chemical riot control agents mostly cause pain and tears but OC generally has inflammatuar effect. Inhaling OC causes an intense inflammatuar effect on trachea and breathing is temporarily restricted to short and shallow breaths. The other side effects include involuntarily closing the eyes, coughing, chocking, lack of upper body strenght and nausea [7].

OC is a substance having the same inflammatuar effect of many commonly known plants. The direct touch to the substance which has capsaicin content causes local irritation, burning and lacrimation. Long or repeated OC exposure dosages can cause dermatitis, adverse nasal and gastrointestinial effects in the lungs [8].

Medical researchers still have difficulty to define the pathological symptoms of OC gas. Despite that OC is stated as a very safe riot control agent in some studies, it is also stated that there is not enough physical data if it does not have long term side effects or cause fatality. This situation can lead to that the long term side effects of OC had not been systematically put forward enough. Today, there is insufficient data about the OC's long term side effects. Except some studies performed on animals, there is not enough data about the mutagenic and carcinogenic long term side effects of OC [9,10]. Even some researchers state that single dose does not have significant long term cancer risk, there is not enough study about it [9]. Besides, not enough studies were found about the biochemical parameter changes in blood of materials exposed in a closed enviroment or in the open air.

In this study, It was aimed to determine the changes occure in the biochemical blood parameters of OC use in a closed enviroment.

MATERIAL and METHODS

As live material, 47 male Wistar albino rats, each between 190-220 g of weight provided from Fırat University Experimental Research Center (FUDAM), were used. Six rats in every cage were kept in an air conditioned room with 23°C controlled room temperature. *Ad libitum* feeding and care were done to the end of trial period. Special rat food and *ad libitum* water were given in the 7 days adaptation period. The cages were cleaned daily.

SR 10 ST Rubber Gas Mask (MKEK, Code No: 214) which is protective for biological and chemical agents was used [11].

A special glass cube with 50x50x50 cm dimentions and 5 mm glass thickness was built. The upper lid was designed as an easy open lid with a rubber isolation stopping the gas leak. A circle with 3 cm diameter was cut on the side window of the experiment cube to spray OC in easily. The gas leak was prohibited by a sticky plastic material closing the circle.

The pepper gas was commercially purchased 90 grams of 5% pepper gas with March 2011 expiration date were used in the experiment. It was experimentally evaluated that OC spray canister releases 6 g of OC per second to enviroment because it emties fully in 15 sec.

Twelve rats were used as preliminary study to get an overwiev of the OC effect on rats. The practicability of experiment cube was tried by different spraying durations and dosages. Then, 35 rats were grouped for different applications.

Group I, 6 rats as Control Group (Control)

Group II, 9 rats kept 5 minin cube with 4 sec OC spraying (24 g) (Experiment 1)

Group III, 10 rats kept 10 min in cube with 8 sec OC Spraying (48 g) (Experiment 2)

Group IV, 10 rats kept 15 min in cube with 12 sec (72 g). (Experiment 3)

Five rats of each group except control group were taken to the experiment cube at every turn. OC was sprayed into the cube as much as determined for each group. Then the upper lid and the secured 3 cm diameter spraying hole were closed firmly. Rats were kept in the cube due to the predetermined durations of 5, 10 and 15 min. The special hygienic clothes, gloves and protective mask was worn.

The rats were sedated by a short preanesthetic application with ether and the blood samples were taken and sent to laborotory for analysis. The blood gases were analysed by Bayer Health Care Lab 865 and K, Cl, Ca and glucose levels were analysed by otoanalyser in biochemistry lab of Yuzuncuyil University Research Hospital [12].

In this study, ethical approval was taken from YYU Ethical Council.

RESULTS

In this study, the effect of pepper gas on blood gases, different electrolites and bicarbonate ions in rats were studied and the results were shown at three different tables *(Table 1-3)*. The statistical importance between control and the other groups means was shown by (*) and the statistical importance of the comparisons made between experiment groups was done by Duncan Test and shown by capital letters. The blood gas and pH values of all the rats were presented at *Table 1*.

Considering the pH values, the 7.208 mean value in the control group was decreased to 7.099-7.084-7.093 at OC exposed rats for 4, 8 and 12 sec. The change with respect to controls showed P≤0.05, P≤0.07 and P≤0.05 statistical importance.

pCO_2 levels with respect to controls showed increase in all three OC exposed groups. The significant physiological

Table 1. *The pH and Blood Gas Changes in the rats of different duration and quantity OC Exposure*
Tablo 1. *Farklı süre ve miktarda OC uygulanan ratlardaki pH ve kan gazlarının değişimi*

Group	n	pH X ± SEM	pCO_2 (mmHg) X ± SEM	pO_2 (mmHg) X ± SEM	$ctCO_2$ (mmol/L) X ± SEM	O_2SAT (mmol/L) X ± SEM
Control	6	7.208±0.015	49.167±3.027	78.500±9.511	21.733±0.837	87.083±5.643
Experiment 1	9	7.099±0.038 *	56.000±3.520	133.556±15.779 [b]	18.733±1.132 [a]	94.267±2.760
Experiment 2	10	7.084±0.027	50.900±2.742	146.400±6.809 [b]	16.300±0.447 [b]	97.930±0.293**
Experiment 3	10	7.093±0.036*	57.200±5.164	187.400±12.151 [a]	14.510±0.796 [b]	98.060±0.833**

** P≤0.05, ** P≤0.01 ,* ***a,b:*** *Different letters in the same column show P≤0.05 importance*

Table 2. *The bicarbonate, BE and Base (ecf) levels change in healthy and OC exposed rats*
Tablo 2. *Bikarbonat, BE ve Baz (ecf) düzeylerinin sağlıklı ve farklı OC uygulanmış ratlardaki değişimi*

Group	n	HCO_3 (mmol/L) X ± SEM	BE (mmol/L) X ± SEM	B(ecf) (mmol/L) X ± SEM
Control	6	19.600±0.694	-9.217±0.894	-8.567±0.695
Experiment 1	9	17.022±1.097	-13.100±1.602	-12.667±1.584*[b]
Experiment 2	10	14.910±0.446	-13.930±0.959	-14.190±0.835[ab]
Experiment 3	10	25.260±12.213**	-16.200±1.009	-16.590±0.914 [a]

** P≤0.05, ** P≤0.01 ,* ***a,b:*** *Different letters in the same column show P≤0.05 importance*

Table 3. *The changes in serum electrolyte and glucose levels during different OC exposure doses and duration*
Tablo 3. *Farklı doz ve sürede OC uygulanması sırasında serum elektrolit ve glukoz düzeylerindeki değişimler*

Gorup	n	Na (mmol/L) X ± SEM	K (mmol/L) X ± SEM	Ca (mg/dL) X ± SEM	Cl (mmol/L) X ± SEM	Glucose (mg/dL) X ± SEM
Control	6	135.500±1.147	4.570±0.097	10.605±0.323	96.167±0.477	142.167±13.489
Experiment 1	9	136.300±0.573	4.898±0.139	10.084±0.164	99.889±0.857	235.889±15.697
Experiment 2	10	136.500±0.500	5.270±0.233*	10.425±0.192	100.500±0.582	244.100±12.885
Experiment 3	10	135.200±1.133	5.688±0.414*	10.107±0.227	99.300±1.713*	248.600±11.211

** P≤0.05*

increase (56-50.9-57.2 mmHg) was not considered as significant. Only the increase at the third group was accepted as P≤0.05 significant.

pO_2 value at control group was 78.5 mmHg while it increased to 133.556-146.4-187.4 mmHg at all other three groups. This increase was not considered as statistically significant with respect to control groups but the comparisons between them made by Duncan test was determined statistically significant as P≤0.05.

The comparison of controls with other three groups mean values showed no statistical importance. But the comparison between other groups showed P≤0.05 meaningful statistical chance.

O_2% saturation was determined as 87.083-98.060%. The comparison between control and the other three groups, this difference in saturation showed P≤0.001 statistical significant change in 2nd and 3rd groups but no significant change was determined in the 1st group (P≥0.05). In the Duncan Test observation, the difference between all three groups except controls was not found meaningful (P>0.05).

When total bicarbonate levels of control group was compared with the other three groups, it was only observed in the 3rd group a statistical importance of P≤0.001. The control group mean value of 19.6 mmol/L increased to 25.260 mmol/L in the 3rd group. At the interpretation between the experiment groups made by Duncan Test, the difference was not found meaningful (P≥0.05) *(Table 2)*.

The BE levels at control and other groups were changed between -9.217-16.200 mmol/L. These observed increases was not found statistically significant at the comparisons made by Duncan Test neither between controls and other groups nor between experiment groups (P≥0.05) *(Table 2)*.

As the Base (ecf) level at the control group was -8.567 mmol/L, increase in other groups were determined as increased -12.667, -14.190 and -16.590 mmol/L and the statistical importance of P≤0.05 between control and the 1st group was found. The comparison made by Duncan Test between groups showed P≤0.05 statistical importance *(Table 2)*.

No statistical importance was determined in Na and Ca value changes *(Table 3)*. The Na level was 135.5 mmol/L in the control group while it was between 135.2-136.5 mmol/L levels in the other groups.

The Ca level at the controls was 10.605 mg/dL and between 10.084-10.425 mg/dL values in other three groups. No importance was determined neither in Na nor Ca levels between controls and the other three groups comparisons. The comparison made in mean values between experiment groups showed no importance (P≥0.05).

The serum K level of controls was lower than the experiment groups means. A significant increase of P≤0.05 was determined in the comparisons of 2nd and 3rd group means but the comparison with Duncan Test between experiment groups showed no importance (P≥0.05).

The Serum Cl level in OC exposed rats was found as changed between 96.167 mmol/L and 100.5 mmol/L. A significant change as P≤0.05 level was found between controls and the 3rd group but the comparison between experiment groups showed no statisitcal importance (P≥0.05).

The glucose level, a significant energy metabolism in organism, was found as 142.167 mg/dL in the control group but it showed increase due to amount of OC exposure and time period. The values of experiment groups were respectively 235.889, 244.1,248.6 mg/dL. The comparison of these values with control groups and the comparison of the three experiment groups by Duncan Test was not considered significant (P≥0.05) *(Table 3)*.

The initial clinical symptoms observed in the OC exposed rats were tendency of dispersing and reunion, sensitivity in the eyes, conjunctivitis and respiratory distress. Due to the increase in exposure quantitiy from 24 g to 72 g, rats were dispersed and tried to put their heads under cage bedplace by the burning and pain feelings *(Fig. 1-4)*.

In the histopathological examination, the organs at the control group were observed as normal histologic appearance *(Fig. 5)*. The most meaningful change was observed in the lungs at the OC exposed groups. The changes in the lungs were more distinctive and broad depending on the OC exposure duration and dose. It was observed in the lungs that there were capillar hyperemia in interalveolar septum, mononuclear cell infiltration and obvious thickenning due to oedema, mostly lymphoid cell as perivascular and peribronchioler, less pneumonia charecterized by cellular exudation formed by leucocyte *(Fig. 6)*.

Fig 1. The 190-220 g weight Wistar albino rats used in experiments
Şekil 1. Araştırmada kullanılan 190-220 g ağırlığına sahip Wistar albino rat

Fig 2. The conjunctivitis and eye sensitivity case at the rats with 8 seconds (48 g) OC exposure

Şekil 2. 8 saniye süre ile 48 g OC uygulanan ratlarda gözde meydana gelen hassasiyet ve konjuktivit olgusu

Fig 3. The case of general condition disorder and effort to put their heads under cage bedplace at the rats with 8 seconds (48 g) OC exposure

Şekil 3. OC spreyi ile 8 saniye (48 g) biber gazı uygulanan ratlarda genel durum bozukluğu ve hayvanın altlık içine kafasını sokma girişimi

Fig 4. The case of putting heads under cage bedplace to ease the pain and disorder at the rats with 12 seconds (72 g) OC exposure

Şekil 4. 12 saniye süre ile biber gazı uygulanan (72 g) ratlarda duyulan rahatsızlık ve acı hafifletmek için altlık içine kafasını sokma işlemi

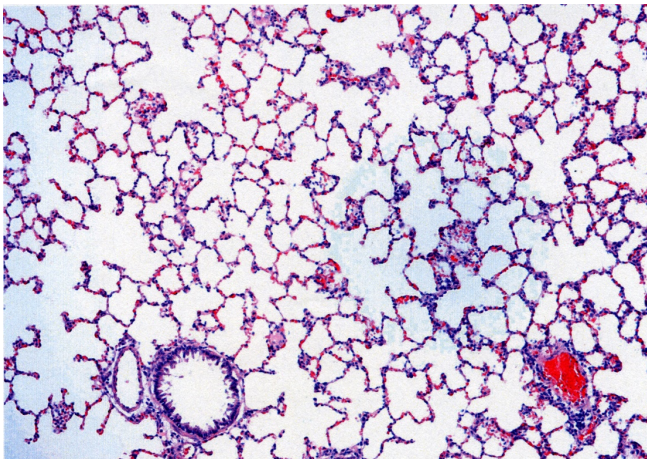

Fig 5. Normal hystologic appearence of lung parenchyma. H.E.X 300

Şekil 5. Akciğer parankiminin normal histolojik görünümü. H.E.X 300

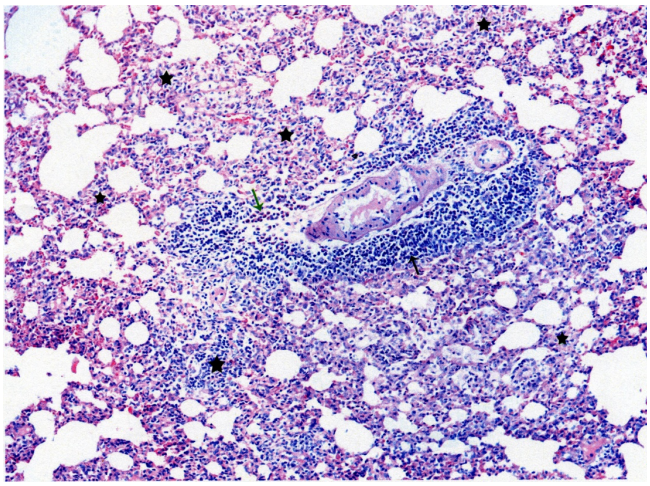

Fig 6. Group VII: Ccapillar hyperemia in interalveolar septum, mononuclear cell infiltration and obvious thickenning due to oedema (star marking), leucocyte as leucocyte perivascular (gren arrow) and lymphoid cell infiltration (black arrow) H.E.X 300

Şekil 6.VII. Grup: İnteralveoler septumda kapilar hiperemi ve mononükleer hücre infilitrasyonu sonucu belirgin kalınlaşma (yıldız işareti), perivasküler olarak eozinofil, lökosit (yeşil ok) ve lenfoid hücre (siyah ok) infilitrasyonu, H.E.X 300

DISCUSSION

During riot control operations, the chemical agents are widely used to incapasitate the crowd without causing any illness or permanent injury. Incapacitating effects are based on unpleasant symptoms involving eyes, skin, mouth, nose and respiratory tract [13].

OC or pepper gas was considered as the main consideration of chemical agents to be used. They contain capsaicin which leads to irritation of the trigeminal cell pain receptors located in the mouth, nose, stomach and the mucous membrana [14].

Many riot control gases were developed with OC using different solvents. But no link with OC has been observed

to result in severe health problems and even death. As a result of public diffusion for personal protection, the use of riot control chemicals were brought to agenda. Various biological screening tests have been experimented. Among the exisitng test involving animals, plethysmography is the most common one to evaluate the effects of active substances on the respiratory tract. Using a nose-only exposure integrated system, minute ventilation, frequency and tidal volume in awake rats were studied.

In a study, the effects of the solutions usually found in tear gas sprays on the respiratory tract of awake rats exposed to aerosols generated with a Collision Nebuliser were studied. The results indicate that the respiratory effects observed during acute exposure to CS (5%) are more significant than those observed during exposure to OC (7%). In addition, for both tear gases the respiratory effects observed during exposure to their solvents alone, are in the same range as those observed during exposure to the product as a whole [15].

The necessity to stop dangerrous and higly agitated persons leads enforcement forces to search for strong incapacitating properties of chemicals. These incapacitating properties are the result of the chemical's direct action on nevre endings [16]. The effects and signs observed concern eyes, skin and respiratory tract [17].

Effects involving the repiratory tract are potentially the most capable of having incapacitating consequences and consist in a burning sensation of the throat, coughing and chest constricting. Persons exposed can involuntarily gasp, come into apnoea shallow [17]. The effects produced by those potent gases strongly dependant on the concetration of the compound and the exposure duration. It was reported in literature that these effects are generally transient and no long term sequelae [13]. However cases of asthma aggravation have been reported and questions on the safety of tear gases used against persons with pre-existing lung disease have been raised [18]. In addition, several fatalities, probably due to respiratory effects, have been reported after exposure to tear gas in confined space [19]. The use of these chemical agents for self defence if their use are no longer well controlled, leads to search for safer agents. The screening of riot control agents for safety includes conventional acute, subacuteand chronic toxicity in order to identify any specificially vulnerable target organs esepially the respiratory organs [20].

In addition main studies are made with solvents which are not clasically used in tear gas sprays. It must be noted that OC was used with several solvents such as dichloromethane, trichlorethylene, tetrachlorethylene, which potentially are highly irritant to the respiratory system. Fatalities have been reported after tear gas bombs containing OC dissolved in one of these solvents. Nevertheless, involvement of OC could not be established [14].

Steffee et al.[21] stated that intense pain in the conjunctiva, systematic physiological changes and intense disorder feeling were observed when OC was sprayed to mucose membrans. The behaviours of putting head under cage bedplace, gathering and dispersing to ease the pain were observed at the rats when they have been exposed to OC with different dosages because of redness in conjunctiva, diffuculty in breathing and burning feeling.

Dicpinigaitis et al.[22] stated in a compiling on capsaicin that they evaluated a total of 4388 subjects undergoing capsaicin cough challenge testing. No serious adverse reaction to capsaicin inhalation challenge was reported. In the small fraction of studies that mentioned any adverse reactions to capsaicin inhalation, these were limited to minor complaints, most commonly transient throat irritation but not any long term side effects.

Any death or extreme abnormality in breathing were not obseved even spraying 72 g of OC into 0.5 m^3 experiment cube. No death were seen in this consentration of OC in 15 min. No serious symptoms were observed even it was a closed enviroment. When subjects with sensory hyper-reactivity undergo capsaicin cough challenge testing, the same syptoms develop as happening from exposure to numerous environmental triggers, such as nasal and ocular irritation, rhinorrhea, hoarseness, phlegm production and dyspnea [22,23]. One study specifically evaluating broncho-constriction after capsaicin inhalation demonstrated a dose-dependant fall that lasted less than 60 seconds [24].

In the present study, a relief was observed at the first few minutes in the rats exposed to OC with high dosage when we take them out to get their blood. In short, it was seen that possible side effects on trachea and lung were no longer existing.

Moreover, 109 of 122 studies, all of whom confirmed that there in fact had been no serious adverse effects associated with capsaicin inhalation [27].

Some previous animal and cell culture studies [4,28] have suggested that capsaicin may be mutagenic an/or tumorigenic. However, subsequent studies [27,28] have failed to demonstrate such capsaicin-induced effects have even demonstrated a chemoprotective effect of capsaicin against vinylcarbamate and N-nitrosodimethylamine induced mutagenesis and tumorigenesis [29].

A study [30] of 81 individuals presenting to an emergeny department after olearesin capsicum aerosol exposure found that none of the patients required hospitalization due to toxicity and pepper spray did not result in abnormal spirometry findings, hypoxemia, or hypoventilation [31].

In a study carried out to examine the potential harmful effects on corneal structure, innervation and sensitivty of a spray containing the capsaicin (OC), it was stated that OC causes immediate changes in mechanical and chemical

sensitivity that may persist for a week, a single exposure of OC appears harmless to corneal tissues [32]. The same study also states that the changes are possibly associated with damage of corneal nevre terminals of mainly unmyelinated polymodal nociceptor fibers and shows that the structural and functional effects of OC spray on conjunctiva and cornea are mild and temporary. This interpretation does not apply to the solvents such as 92% trichloroethylene which can cause severe corneal damage [33]. It was already known that isoprophyl alcohol used in OC does not cause any damage. The damage caused in eye appications of OC is mostly because of alcohol rather than the OC itself [34].

OC is an inflammatory agent that causes pain, erythema and edema. It is safer and more effective than other riot control agents and its effects on the eyes and skin are transient. When sprayed to eyes, it causes a burning sensation and blurring vision. Gasping and couhing are the main symptoms when inhaled. In another study, it was stated that there was no significant change in O_2 and CO_2 levels in vital capacity of lungs [35].

The pH and some other parameters must be in a limited change for the regular survival functions of life. In this study, pH value was 7.21 at the control group. But it was decreased between 7.10-70.84 in the OC exposed rats and showed decreasing tendency.

The pCO_2 levels increased respectively to 56.00, 52.10, 59.00 mmHg in the 1st, 2nd and 3rd experiment group from 49.17 Increase in pCO_2 takes place in hypoventilation and insufficient blood stream to lungs and insufficient clearence of CO_2 from lungs. In this way, CO_2 retention increases respectively pCO_2 level and amount of carbonic acid. At the end pH in blood will decrease. pCO_2 increase and pH decrease will stimulate ventilation and try to stop CO_2 retention.

The increasing ventilation due to high pCO_2 is not enough to normalize pCO_2. If the pCO_2 increases too much, respiration center cannot be stimulated and hypoxia starts to form. If it is not treated, hypoxia can form because acidosis and O_2 will be diffused slowly. When the blood pCO_2 increase is not too high, the respiration center will be sensitive to slightly pCO_2 increase. The respiratoric asidosis answers this with a counter-ventilation. In the present study, respiratoric asidosis in the rats can be decided by looking at the pH and pCO_2 changes. These two parameters differed paralel to controls and compatible with the respiratory acidosis classic literature [36-38].

Increase in bicarbonate level shows alcalosis and decrease shows acidosis. The normal blood bicarbonate levels are stated as 22-26 mEq/L. The actual bicarbonate is the real bicarbonate value in the blood. But the standart bicarbonate is normal pCO_2 value and pO_2 is the bicarbonate existing in blood. In the present study, the actHCO_3 value of control group rats was 19.60 mmol/L. But it was between 17.02-14.91-13.11 mmol/L after exposed to OC. The pCO_2 increase and decrease both in pH and HCO_3 reinforces the acidoses symptoms.

K^+ which is essential for celullar excitability is an important intracelullar cation. Its value in the extracelullar liquid is 3.5-5 mEq/L and 150 mEq/L in intracellular liquid. Majority of potassium dispersed mostly in muscle cells as well as erythrocyte and liver. K goes in cell in alcalosis but goes out of cell in acidosis. In the present study, serum K level was 4.57 mmol/L in control group but it increased in the experiment groups and reached 4.90-5.27 and 5.65 mmol/L levels. Serum K level is followed to monitor the K metabolism. In acidosis, collected H is taken inside the cell and K changes its place toward extracelullar liquid. K accumulates extracellularly parallel to this undesired change. In alcalosis, H ions go out of the cell and extracelullar K goes to intracellular compartment. K level decreases. Increasing extracellular K and decreasing intracelullar K levels incite the hyperkalemia. In hyperkalemia, weak muscle, deep tendon reflex loses and seldomly skeleton muscle paralysis are seen [36].

The blood glucose level controlled by insulin, glucagon and adrenaline can be affected from hunger, stres, fear, excitement and diabetes [39]. In the present study, the blood glucose level in control group was 142 mg/dL but it was 235-244 and 248 mg/dL in the experiment groups due to the OC exposure. However, statistical importance of this could not be determined. It is obvious that the reason of sharp change in glucose was the stimulation of glucose producing mechanism of blood in the course of adrenaline produced by fear and excitement in the rats under OC exposure. The other reason was also sharp increase of the blood glucose level because of the dispersion of muscle glycogen. This shows that pepper gas adversely affected the rats' behaviors and metabolism.

As a result, no fatality was observed in the rats when they were kept inside the 0.5 m^3 glass cube in fives and sprayed OC for 4, 8 and 12 sec durations in which the rats were respectively exposed to OC of 24, 48 and 72 g. All the rats in control group was observed with intensive redness in the eyes, conjunctiva and difficuly in breathing. In the analyses of blood gases, decrease in pH, increase in pCO_2, decrease in HCO_3 and increase in K support the respiratory acidosis formation but no fatality was obseved in any OC exposure group.

The pepper gas used often by police force to control the riot can be a safe agent due to the results obtained if the the person was not subject to asthma or chronic lung disease. It can be also stated that OC does not cause any fatality but sensitivity and burning in the eyes, conjunctivitis and coughing symptoms.

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