

Serum heavy metals in patients with fragments and shells of improvised explosive devices

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ABSTRACT

Background: Iraq is the most affected country by injuries of improvised explosive devices (IED) including bomb car, bomb born on person and roadside bombs. Embedded fragments and shells can release heavy metal. High level of heavy metal in serum carries dangerous long term risk for injured patients.

Objective: The aim of this study is to estimate the serum level of heavy metals (copper, lead, cadmium, nickel, and zinc) in patients with fragments and shells from IED including bomb car, bomb born on person and roadside bombs.

Material and methods: Serum concentrations of heavy metals (copper, lead, cadmium, nickel, and zinc) were assayed using atomic absorption spectrophotometry in 52 patients with fragments and shells from IED. Serum concentrations of heavy metals were measured in 52 healthy adults as control group.

Results: The mean serum level of copper, lead, cadmium, nickel, and zinc in patients were $1304 \pm 258.1 \mu\text{g/L}$, $36.5 \pm 16.7 \mu\text{g/L}$, $6.203 \pm 2.372 \mu\text{g/L}$, $0.387 \pm 0.183 \mu\text{g/L}$, and $1651 \pm 532 \mu\text{g/L}$ respectively, while in control were $824.2 \pm 203.6 \mu\text{g/L}$, $31 \pm 15.1 \mu\text{g/L}$, $1.654 \pm 0.4 \mu\text{g/L}$, $0.239 \pm 0.028 \mu\text{g/L}$, $619 \pm 234 \mu\text{g/L}$ respectively. The differences in serum copper, lead, cadmium, nickel, and zinc between patient and control is highly significant, (P value < 0.0001), while the differences in serum lead between patient and control is not significant (P value > 0.05).

Conclusion: The present study demonstrates that a highly significant increase in serum level of copper, cadmium, nickel, and zinc in patient with fragments and shells from IED in comparison with control group, while the difference in serum lead in patients and control was not significant.

Keywords: Improvised explosive devices, fragment, shell, metal, serum level.

الخلاصة

الخلفية: العراق هو البلد الأكثر تأثراً بإنفجارات السيارات المفخخة والعبوات والأحزمة الناسفة وأن الشظايا الداخلة في أجسام المرضى من الممكن أن تحرر معادن ثقيلة داخل الدم وأن ارتفاع مستوى المعادن الثقيلة في الدم يعد خطراً جدياً في المرضى المصابين.

الأهداف: إن هدف الدراسة هو تحديد مستوى المعادن الثقيلة (النحاس، الرصاص، الكاديوم، النيكل والزنك) في دم المرضى المصابين بشظايا إنفجارات السيارات المفخخة والعبوات والأحزمة الناسفة.

المواد وطريقة العمل: تم قياس مستوى المعادن الثقيلة (النحاس، الرصاص، الكاديوم، النيكل والزنك) بواسطة جهاز امتصاص الطيف الضوئي الذري في دم 52 مريضاً من المصابين بشظايا إنفجارات السيارات المفخخة والعبوات والأحزمة الناسفة. وتم قياس نفس المعادن وبذات الطريقة في دم 52 شخصاً من الأصحاء كمجموعة ضابطة.

النتائج: كان معدل مستوى النحاس، الرصاص، الكاديوم، النيكل والزنك على التوالي في دم المرضى ١٣٠٤ مايكرو غرام /لتر، ٣٦,٥ مايكرو غرام/لتر، ٦,٢ مايكرو غرام/لتر، ٠,٣٨٧ مايكرو غرام/لتر، ١٦٥١ مايكرو غرام/لتر. أما في المجموعة الضابطة فكانت ٨٢٤,٢ مايكرو غرام/لتر، ٣١ مايكرو غرام/لتر، ٠,١٦٥ مايكرو غرام/لتر، ٢,٣٩٦ مايكرو غرام/لتر، ٦١٩ مايكرو غرام/لتر ويعد الفرق معنوي بالنسبة لكل من مستوى النحاس، الكاديوم، النيكل والزنك وغير معنوي بالنسبة للرصاص.

الاستنتاج: كان هناك ارتفاعا في مستوى المعادن الثقيلة وكان الفرق معنويا عند المرضى المصابين بالشظايا في مستوى النحاس والكاديوم والنيكل والزنك عند المقارنة مع المجموعة الضابطة ولم يظهر مستوى الرصاص فرقا معنويا.

The improvised explosive devices (IED) ranged from bombs born on persons and bomb cars to roadside bombs ⁽¹⁾. The explosive weapons in populated areas consistently cause unacceptable level of harm to civilians, this pattern of harm is seen in individual incidents of violence as well as in major conflicts ⁽¹⁾. Explosive weapons produce a common pattern of wounding with variations depending on the force of blast, size of fragments, location of the blast, and susceptibility of the individual victims ⁽¹⁾. The mechanisms of injury from blast have been divided into primary (effect of blast wave on organs and tissues), secondary (injuries caused by propagated flying debris and bomb fragments projection into body), tertiary (effect of blast wind cause propulsion of body into other objects) and quaternary (all other injuries and diseases following blast trauma)^(1,2). Primary Fragmentation can be part of the bomb casing itself or objects intentionally imbedded into the IED designed to cause further wounding like nails, screws, nuts , bolts and many variable materials, and any local material that was made airborne by projectile (secondary fragmentation) ^(1,2).

IED cause complex patterns of wounding and numerous penetrating wounds containing embedded fragments that require greater medical resources than other trauma. For survivors, immediate injuries can result in a range of long term physical condition ⁽¹⁾. Information accumulated in the last 6 years in Iraq shows an increase in oncological, chronic and reproductive diseases and malformations at birth, particularly high in the areas most severely attacked ⁽³⁾. It is well-known that excess of the heavy metals can disrupt body

functions and have pathogenic effects on human respiratory organs, kidney, skin and affect sexual and neurological development and functions ⁽³⁻⁶⁾. Cadmium, and nickel are known to be human toxic, carcinogenic and teratogenic. Lead, copper and zinc are well-known human multi-systemic toxic and fetotoxic ⁽³⁻⁶⁾. Systemic lead toxicity following gunshot, has been reported to occur anywhere from 2 days to 40 years after intra-articular gunshot injury ⁽⁷⁾.

In our community there is an un-estimated large number of injured patients with fragments and shells after explosion. There are no available studies on the level of heavy metals after injuries with fragments and shells of IED. The aim of this study is to estimate the serum level of copper, lead, cadmium, nickel and zinc in patients with fragments and shells from IED including bomb car.

Material and methods

This study was approved by the scientific research committee at the College of Medicine, University of Mosul. A written informed consent was obtained from all patients and controls. The chemical analysis and metal serum level measurement were conducted at laboratories of College of Medicine and College of Sciences, University of Mosul, during the period from September 2009 to September 2010. Fifty two patients with symptoms related to fragments and shell of IED including bomb cars, person born bombs, and road side bombs included in this study. All patients collected from the department of orthopedic surgery, Aljumhori Teaching Hospital, they had either pain at site of foreign body, acute flare up of infection or

chronic discharging sinus. Forty four patients were males and 8 were females. The mean age of patients was 33.9 years \pm 10, ranged 4 to 68 years. Forty six patients were injured in bomb cars while 4 patients injured by road side bombs and 2 by person born bomb. Forty nine patient had multiple shells and only 3 patients had a single shell. The mean duration between injury and samples taking was 14.6 months, ranged between one month to 6 years. Fifty two healthy adults share as a control group, they donated 10 ml of blood for chemical analysis for heavy metals. The control group mean age was 33.1 years \pm 13 ranged 18 to 62 years, 28 of them were males and 24 were females.

All patients and controls were clinically examined. The exclusion criteria for patients and control were: the presence or history of any orthopedic or dental implants, renal insufficiency or chronic renal disease, or chronic medical treatment for systemic or local diseases, to avoid any bias in the serum metal determination.

Preparation of samples

Ten milliliters of venous blood was drawn from each patient and control. Blood samples were taken by blood sampling kit dedicated to trace element determination to avoid metal contamination. Serum samples were lysed for analysis of heavy metals by adding 10ml HNO₃ to one ml of serum and heated at 60-70 C° for 3-4 hours. Then 1 ml perchloric acid was added to the same sample. Digestion process continued until the solution was clear.

Atomic absorption spectrophotometry flameless method was used to determine serum lead, cadmium and nickel by using Shimadzu AA-6650G instrument with electronic double – beam Graphite Furnace Atomic Absorption (GFAA) spectrophotometer. The copper and zinc serum level were measured with the flame atomic absorption spectrophotometer.

Statistical analysis

Results were reported as mean \pm standard deviation. The unpaired two tail student (t) test used to calculate the differences between two means. The P value was considered significant if it was less than 0.05.

Results

The mean age of patients was 33.9 years \pm 10, the mean age of control group were 33.1 years \pm 13. Serum copper mean in patients with fragments and shells of IED was 1304 \pm 258.1 μ g/L, while in control group was 824.2 \pm 203.6. The difference between the two means was highly significant (P value < 0.0001), (table 1). The mean of blood lead in patients with shells and fragments of IED was 36.5 \pm 16.7 μ g/L, while in control group was 31 \pm 15.1. The difference between the two means was not significant (P value was 0.067), (table 1). The mean of blood cadmium in patients with shells and fragments of IED was 6.203 \pm 2.372 μ g/L, while in control group was 1.654 \pm 0.4 . The difference between the two means was highly significant (P value <0.0001), (table 1).

Table (1) : Serum metals in patients with fragments and shells of IED and control.

Serum metals		Serum level		p- value	Significance
		mean	Standard deviation		
copper	Patients	1304.6 μ g / L	258.1	.0001	Highly significant
	Control	824.2 μ g / L	203.6		
lead	Patients	36.5 μ g / L	16.7	.067	Not significant
	Control	31 μ g / L	15.1		
cadmium	Patients	6.20 μ g / L	2.37	.0001	Highly significant
	Control	1.65 μ g / L	0.40		
nickel	Patients	0.387 μ g / L	0.183	.0001	Highly significant
	Control	0.239 μ g / L	0.028		
zinc	Patients	1651 μ g / L	532	.0001	Highly significant
	Control	619 μ g / L	234		

The mean of serum nickel in patients with shells and fragments of IED was 0.387 ± 0.183 $\mu\text{g/L}$, while in control group was 0.239 ± 0.028 . The difference between the two means was highly significant (P value < 0.0001), (table 1). The mean of serum zinc in patients with shells and fragments of IED was 1651 ± 532 $\mu\text{g/L}$, while in control group was 619 ± 234 . The difference between the two means was highly significant (P value < 0.0001), (table 1).

Discussion

In Iraq gunfire remains the most common cause of death, and deaths from car bombing have increased⁽⁸⁾. The expected numbers of injured patients would be much higher⁽⁹⁾. Iraq is the country most affected by injuries of IED weapons⁽¹⁾. Bomb blast injuries are no longer confine to battlefield⁽¹⁰⁾.

Data from Iraq suggest that explosive weapons, by comparison with other weapons types, have higher proportion of child and female deaths and injuries⁽¹⁾. Explosive weapons injuries represent a demanding surgical emergency⁽¹¹⁾. Heavy metal high level in serum carries dangerous long term risk for injured patients of IED⁽¹⁾. It is recommended to evaluate serum heavy metals in all patients with retained bullet and fragments⁽¹²⁾.

In our study, there was highly significant difference in the level of serum copper between patients and control, (table 1). This might be explained by the intended use of copper containing covers of bullet and missiles to increase the fragmentation in explosion. Copper is an essential nutrient that is incorporated into a number of metalloenzymes, exposure to excessive levels of copper can result in a number of adverse health effects including liver and kidney damage, anemia, immunotoxicity, developmental toxicity, and carcinogenic⁽¹³⁻¹⁵⁾. Copper serum level varied between 782-1690 $\mu\text{g/L}$ ^(4, 13-16), the reference value of serum copper in normal healthy human is 830 – 1530 $\mu\text{g/L}$ ⁽¹⁷⁾.

There was no significant difference in the level of serum lead between patients with fragment and shells of IED and control, (table 1). Lead poisoning from retained bullet or missile is rare⁽¹²⁾. Lead is a dangerous highly toxic substance, exposure to which can

produce a wide range of adverse health effects, it is harmful even in small amount. Humans get exposed to lead through their environment and diet^(4,18,19). Lead is a multitargeted toxicant, usually affect kidney and nervous system^(4,18). Lead toxicity remains one of the most important problems in terms of prevalence of exposure and public health impact⁽²⁰⁾. Mean lead concentrations in blood, tibia, and patella were 3.5 $\mu\text{g/dl}$, 18.9 $\mu\text{g/g}$ and 6.8 $\mu\text{g/g}$ respectively⁽²¹⁾. There is variation in gender and race, normal level was < 5 $\mu\text{g/dl}$ ^(20, 21).

The level of serum cadmium shows a highly significant difference between patients and control, (table 1). This might be explained by the cadmium containing alloys used in cars and batteries used in explosion. Cadmium, a heavy metal is well known to be highly toxic to both human and animals. Cadmium exposure leads to long-term effects on human health even at low concentrations and it affect many systems, because cadmium confounds many physiological processes⁽²²⁾. Cadmium serum level is variable in literatures^(4, 18, 22). Cadmium is toxic, carcinogenic and fetotoxic^(4, 18).

There was highly significant difference in serum nickel between patients and control, (table 1). This might be explained by the wide use of nickel in cars bodies and parts, which produce many fragments and shells that contain nickel. Nickel is one of the heavy metals widely used in modern industry has been recognized as highly toxic to skin, respiratory system and reproductive system, and carcinogens^(23, 24, 25). Reference value for nickel in healthy adults is 0.2 $\mu\text{g/L}$ in serum and 1-3 $\mu\text{g/L}$ in urine, it reaches 2-6.5 $\mu\text{g/L}$ in serum of nickel industry workers^(24, 25). The essentiality of nickel in humans has not been established, the nickel dietary recommendations has not been established for human^(24,25). Stainless steel endoprostheses may release nickel, also administration of nickel contaminated medications lead to significant exposure⁽²⁵⁾.

Serum zinc in our study shows a highly significant difference between patients and control, (table 1). This might be explained by the wide use of zinc containing metallic parts

in cars and in bomb designs. Zinc is an essential nutrient that is incorporated into a number of metalloenzymes, chronic zinc toxicity can impair cellular immunity and can cause hypochromic anemia^(5, 18). The normal value of serum zinc varied in different studies, its ranged between 700- 1348 µg/L^(4, 5,13-16, 26).

It is wise to follow up patients with shells and fragments of IED for metals toxicity. More studies should be done in this field since this is very common medical problem in our country which subjected to the most heroic explosions and violence. In conclusion, the present study demonstrates that embedded fragments and shells form IED including bomb car causes a highly significant elevation in metals (copper, cadmium, nickel, and zinc) concentration in serum, while serum lead shows no significant differences in patient in comparison with control.

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