Wide Spectrum of Traumatic Rhabdomyolysis in Earthquake Victims

Mostafa Hosseini[1], Saeed Safari[2,3], Ali Sharifi[2], Manuchehr Amini[2], Farin Rashid Farokhi[4], Houshang Sanadgol[5], Shiva Seirafian[6], Ahmad Mooraki[7], Hamidreza Samimagham[8], Vahid Pourfarziani[9], Shahnaz Atabak[10], Shahrzad Osareh[11], Behrouz Boroumand[7], and Iraj Najafi[*2,12]

[1] Department of Epidemiology and Biostatistics, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

[2] Department of Nephrology, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran

[3] Department of Emergency medicine, Imam Hossein Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[4] Department of Nephrology, Kerman University of Medical Sciences, Kerman, Iran

[5] Department of Nephrology, Zahedan University of Medical Sciences, Zahedan, Iran

[6] Department of Nephrology, Isfahan University of Medical Sciences, Isfahan, Iran

[7] Department of Nephrology, Rasool Akram Hospital, Iran University of Medical Sciences, Tehran, Iran

[8] Department of Nephrology, Bandarabbas University of Medical Sciences, Bandarabbas, Iran

[9] Department of Nephrology, Milad hospital, Tehran, Iran

[10] Department of Nephrology, Imam Hossein Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[11] Department of Nephrology, Hasheminejad Hospital, Iran University of Medical Sciences, Tehran, Iran

[12] Urology Research Center, Tehran, Iran

Received: 28 May 2008; Received in revised form: 14 Jan. 2009; Accepted: 10 Mar. 2009

Abstract- In the natural disasters such as earthquake, based on severity of trauma, time under the rubble and quality/quantity of hydratation we will confront with a spectrum of traumatic rhabdomyolysis. In present study we evaluate victims of Bam earthquake to show different stage of muscle trauma, from minor trauma with almost normal level of muscle enzyme to those with moderate trauma leading to crush injury and finally to advanced crush syndrome. Questionnaire consisted of clinical, biochemical and demographic items was designed and completed by our research team retrospectively. We divided the patients to crush and non-crush and also crush injury and crush syndrome, and then compared aforementioned items between them. Clinical and laboratory data of 2962 hospitalized victims, with an average age of 28.4(SD14.2) years (range 1-90) were collected (40% female). 611 patients were affected with crush injury (20%). These were entrapped 2.2 hours longer than the others (P<0.001). Mean IV intake in first 5 days was 3.6(SD2.6) liters for these patients in compare with 2.5(SD1.4) liters for others (P<0.001). 200 cases showed complete feature of crush syndrome. Electrolyte imbalance and systemic complications were drastically increased in the worst patients with crush syndrome. In approach to crushed patients of natural disasters by attention to the wide spectrum of muscle damage and systemic problems, the stepwise management protocol based on severity of traumatic rhabdomyolysis is inevitable and warranted.

Acta Medica Iranica 2009; 47(6): 459-464.

Key words: Rhabdomyolysis; crush syndrome; earthquakes

Introduction

Crush injury is a form of traumatic rhabdomyolysis, and it is defined as crush syndrome when followed by systemic manifestation (1). The symptoms and signs that result from muscle damage are not confined to the local area sustaining the crush. The pressure causes necrosis of myocites; during revascularization, diffusion of calcium, sodium and water into the damaged muscle cells together with loss of potassium, phosphate, lactic acid, myoglobin and creatine phosphokinase to the systemic circulation triggers many clinical and biochemical abnormalities such as hyperkalemia, acidosis, acute renal failure, compartment syndrome and hypovolemic shock (2-6). But in fact, not every muscular trauma results in rhabdomyolysis, and crush syndrome not necessarily develops in all cases of crush injury (7-9). Base on severity of trauma, time under the rubble and quali-

***Corresponding Author:** Iraj Najafi
Department of Internal Medicine, Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran
Tel: +98 912 1098995, Fax: +98 21 88026010, E-mail: najafi63800@gmail.com

ty/quantity of hydratation we will confront with a spectrum of traumatic rhabdomyolysis, from almost normal, crush injury to crush syndrome patients (10). The most commonly described crush syndrome is that which affects victims of natural disasters such as earthquake. On Friday December 26th 2003 a devastating earthquake (6.7 on the Richter scale) struck BAM in Kerman province (southeastern Iran). In present study, we are going to evaluate victims of this earthquake, with different stage of muscle trauma, to show the stepwise management protocols are inevitable and warranted.

Patients and Methods

On the first day of the Bam earthquake, the Iranian Society of Nephrology, in collaboration with the International Society of Nephrology (ISN), developed a questionnaire and sent it to all hospitals expected to treat crush patients (15 centers in 7 cities; Kerman, Tehran, Esfahan, Zahedan, Bandarabbas, Bushehr, Shiraz). The questionnaires were designed to register the basic demographic data and the key clinical and biological parameters of all rescued victims arriving in those hospitals. In each hospital, a local key person was identified to assure the completeness and accuracy of the responses to the questionnaires, and the first author had regular contact by e-mail and telephone with all these key persons to cross-check accuracy of the data. We had access to 4552 charts; among them 2962 cases had minimum relevant data to enter our study. All patients who were hospitalized and had a documented renal status (AKI and Dialysis) and muscle enzymes level were included in the analyses. Non-crushed victims were defined to hospitalized patients with no or mild rhabdomyolysis as CPK<1000 (n=2351). Crushed victims (n=611) were divided to:

1- Crush injured as CPK>1000 IU/L, moderate rhabdomyolysis (n=411).

2- Crush Syndrome as crush injured with acute renal failure or other systemic manifestations, severe rhabdomyolysis. (n=200).

Finally we compared clinical and biochemical factors between two groups.

Statistical analysis

All data were entered into the computer and rechecked later. The database then was converted to one worksheet and analyzed using STATA (8) statistical software. Descriptive analyses were performed and mean ± standard deviation values were calculated. Two-sample t-test was performed to compare the mean of 2 independent groups and Chi-square or Fisher Exact test was applied to compare proportions of categorical variables, when appropriate.

Results

Clinical and laboratory data of 2962 hospitalized victims, with an average age of 28.4(SD14.2) years (range 1-90) were collected (40% female). Figure 1 shows frequency of trauma in different site of the body. Lower extremities were injured higher than trunk and upper extremities. Acute respiratory distress syndrome (ARDS) in 18 cases, disseminated intravascular coagulopathy (DIC) in 13 and sepsis in 21 cases were developed.

Crushed versus non-crushed

611 patients were affected with moderate to severe rhabdomyolysis (20%). Table 1 compares different factors between crushed and non-crushed. Crushed victims were entrapped under the rubbles 2.2 hours longer than the others (P<0.001).

Table 1. Comparison of mean of different parameters between crushed and non-crushed

Parameters[#]	Crushed (n=611)	SD	Non crushed (n=2351)	SD	P value
Bun(mg/dl)	36.6	35.4	21.7	13.8	<0.001
Creatinine(mg/dl)	1.6	1.6	0.8	0.3	<0.001
Calcium (mg%)	7.2	1.8	7.7	1.8	=0.9
Phosphorous (mg %)	3.6	1.7	3.4	1.08	<0.05
Potassium(meq/l)	4.6	1	4.1	0.5	<0.001
Sodium(meq/l)	138	5.2	139	4.2	=0.9
Uric acid(mg/dl)	4.8	2.7	3.4	1.2	<0.001
CPK(IU/L)	7000	1345	473	268	<0.001
LDH(IU/L)	1541	2092	652	512	<0.001
TUR(h)	4.8	4.1	2.6	2.1	<0.001
IV intake*(L)	3.6	2.6	2.5	**SD**	<0.001

CPK, Creatine phosphokinase; LDH, Lactate Dehydrogenize; TUR, time of being under the rubble

#Mean of first 3 days of admission for biochemical parameters is used *Mean IV intake in first 5 days of admission

Table 2. Comparison of complications between crushed and non-crushed

Complication	Non crushed (n=2351)	Crushed (n=611)	P value
Sepsis	9(30%)	21(70%)	*P*<0.001
DIC	1(7%)	13(93%)	*P*<0.001
ARDS	13(41%)	18(59%)	*P*<0.001
Death	19(39%)	29(61%)	*P*<0.001

Mean IV intake in first 5 days was 3.6(SD2.6) liters for these patients in compare with 2.5(SD1.4) liters for non-crushed (*P*<0.001). Table 2 compares complications between crushed and non-crushed.

Crush injury versus crush syndrome

200 cases with complete feature of crush syndrome were detected. Table 3 compares the aforementioned factors between them and crush injured. These patients entrapped under the rubble 4 hours longer and received IV intake 1.2 liters lower than the other crushed victims (*P*<0.001). Electrolyte imbalance is drastically increased in the worst patients with crush syndrome. Table 4 compares complications between crush injured and crush syndrome victims.

Table 3. Comparison of different parameters between patients with crush injury and crush syndrome

#Parameters	Crush injury (n=411)	SD	Crush syndrome (n=200)	SD	P value
Bun(mg/dl)	23.8	15.4	88.8	45.1	<0.001
Creatinine(mg/dl)	0.9	0.3	4.5	4.1	<0.001
Calcium (mg %)	7.6	1.7	6.05	1.7	<0.001
Phosphorous (mg %)	3.1	1.2	5.6	1.7	<0.001
Potassium(meq/l)	4.2	0.6	6.09	1.1	<0.001
Sodium(meq/l)	139	4.1	134	7.2	<0.001
Uric acid(mg/dl)	3.7	1.4	8.7	2.9	<0.001
CPK(IU/l)	4348	5978	25561	28569	<0.001
LDH(IU/l)	968	851	4929	3565	<0.001
TUR(h)	2.7	2.4	6.6	4.4	<0.001
IV intake*	3.9	2.7	2.7	2.3	<0.001

CPK, Creatine phosphokinase; LDH, lactate dehydrogenize; TUR, time of being under the rubble.

#Mean of first 3 days of admission for biochemical parameters is used

*Mean IV intake in first 5 days of admission

Table 4. Comparison of complications between crush injured and crush syndrome patients

Complication	Crush injury (n=411)	Crush syndrome (n=200)	P value
Sepsis	1(4%)	20(96%)	*P*<0.001
DIC	1(7%)	12(93%)	*P*<0.001
ARDS	1(5%)	17(95%)	*P*<0.001
Death	6(20%)	23(80%)	*P*<0.001

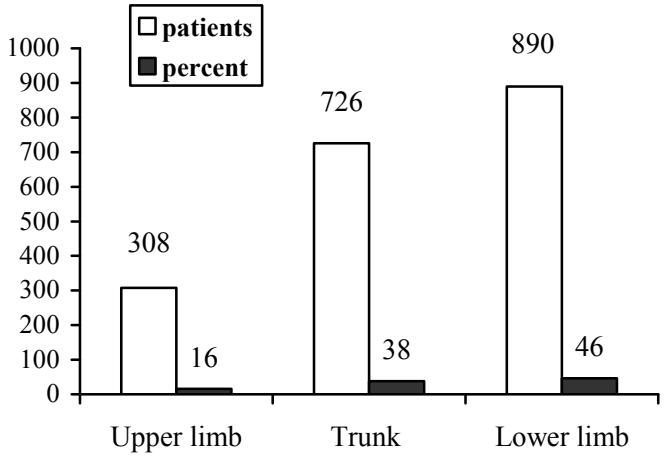

Figure 1. Distribution of trauma in different site of the body

Discussion

Although crush syndrome is recognized after Messina earthquake of 1909 and during the First World War by German physicians, a lot of questions about treatment and diagnose of this syndrome are without answer. In spite of the fact that Intravenous (IV) solution is an important prophylactic strategy to decrease medical complications, but we don't know how much? or what kind of solution?

When estimating the incidence of crush syndrome after earthquakes, the following issues should be considered: 1, not all injured victims suffer from muscle trauma; whereas not every muscular trauma results in rhabdomyolysis, 2, the crush syndrome not necessarily develops in all cases of rhabdomyolysis (7-9), 3, acute kidney injury (AKI) is not necessarily observed in all crush syndrome victims (11-13). In fact we will confront with a spectrum of traumatic rhabdomyolysis, from normal muscular enzyme to crush injury and finally crush syndrome. The most important factor involved in pathogenesis of rhabdomyolysis is entrapment of the muscles for certain period of time. In previous study at least 1h (13), 1.5h (14) and 4h (15) has been proposed for development of this pathology. In our study the mean time of being under the rubbles (TUR) was decreased from crush syndrome to crush injured and finally other patients. Sepsis, DIC, ARDS significantly increase in crush syndrome and mortality rate in these patients was higher than the others ($P<0.001$). Volume resuscitation as a most important prophylactic strategy have vital role in decrease of complications of crush. Mean daily IV intake in first 5 days after quake in patient with crush syndrome was lower than other rhabdomyolized ($P<0.001$).The mean serum level of Na, K, Ca, P and uric acid is drastically different in the worst patients with crush syndrome.

For decreasing morbidity and mortality of these victims the main attention of rescue team should be prevention of crush syndrome and its consequences such as Compartment Syndrome and AKI. As we have schematized in figure 2, this prevention can be done in 3 steps:

Step 1. Extrication of these patients and urgent initiation of early hydration therapy, while checking the most essential clinical and paraclinical factors such as; muscle enzymes, Bun, Creatinine, electrolytes and urine analysis

Step 2. Assessment the level of muscular trauma and utilization of appropriate management strategies accordingly, using high dose prophylactic hydration therapy (more than 10 liters/day) only in those whom are at risk of AKI and dialysis. The majority of victims (80%) with minor trauma and mild rhabdomyolysis do not need such enormous volumes of fluid. Through this kind of triage, we would be able to prioritized our treatment to the most severe and needed patients which would finally decrease morbidity and mortality of these patients. Our unpublished data in Bam earthquake is strongly in favor of this policy.

Step 3. Fasciotomy or amputation, initiation of dialysis, ventilator support and ICU care if indicated to reduce mortality.

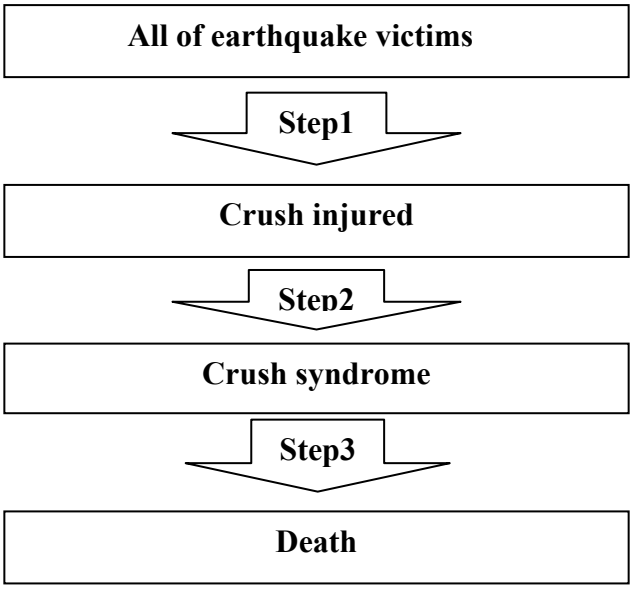

Figure 2. The schematic algorithm of medical managements for decreasing of mobidity and mortality of erthquake's victims

As it is postulated in aforementioned schema, a crucial step in prevention of morbidity and mortality in earthquake victims is classification of the victims based on severity of muscular trauma, and tailoring management and therapy on its basis. We have learned through our experience with different earthquakes in Iran and also here in Bam that almost 80% of victims are among those with only minor superficial injuries, and bruise, not in need of any peculiar management except psychological consultations. In addition to the academic interest, such data can be of importance to civil defense planners, who have to deal with the aftermaths of the disaster, and to health professionals, who are responsible for the care of these patients and often have to prioritize the restricted available resources. Classification itself as a whole is a kind of triage which would help us in saving lives more efficiently. In conclusion, in approach to crushed patients of natural disasters by attention to the wide spectrum of muscle damage and systemic problems, the stepwise management protocol based on severity of traumatic rhabdomyolysis is inevitable and warranted.

This paper was funded based on grant number: 1983 provided by Urology Research Center, Tehran University of Medical Sciences. The authors declare no conflict of interest in this paper**.**

Acknowledgments

We would like to thank all the participants in this study for their cooperation and contribution: Babaei R, Mehrani M, Ganjeui K, Hakemi M, Rajabi M, Jenabi A, Taheri SH.

References

1. Hiraide A, Ohnishi M, Tanaka H, Simadzu T, Yoshioka T, Sugimoto H. Abdominal and lower extremity crush syndrome. Injury 1997;28(9-10):685-6.
2. MacLean JG, Barrett DS. Rhabdomyolysis: a neglected priority in the early management of severe limb trauma. Injury 1993;24(3):205-7.
3. Zager RA. Rhabdomyolysis and myohemoglobinuric acute renal failure. Kidney Int. 1996 Feb;49(2):314-26.
4. Better OS. Post-traumatic acute renal failure: pathogenesis and prophylaxis. Nephrol Dial Transplant. 1992;7(3):260-4.
5. Better OS. Early management of shock and prophylaxis of acute renal failure in traumatic rhabdomyolysis. N Engl J Med 1990;322(12):825-9.
6. Nadjafi I, Atef MR, Broumand B, Rastegar A. Suggested guidelines for treatment of acute renal failure in earthquake victims. Ren Fail 1997;19(5):655-64.
7. Holt S, Moore K. Pathogenesis of renal failure in rhabdomyolysis: the role of myoglobin. Exp Nephrol 2000;8(2):72-6.
8. Slater MS, Mullins RJ. Rhabdomyolysis and myoglobinuric renal failure in trauma and surgical patients: a review. J Am Coll Surg 1998;186(6):693-716.
9. Ward MM. Factors predictive of acute renal failure in rhabdomyolysis. Arch Intern Med 1988;148(7):1553-7.
10. Gabow PA, Kaehny WD, Kelleher SP. The spectrum of rhabdomyolysis. Medicine (Baltimore) 1982;61(3):141-52.

11. Santangelo ML, Usberti M, Di Salvo E, Belli G, Romano G, Sassaroli C, Zotti G. A study of the pathology of the crush syndrome. Surg Gynecol Obstet 1982;154(3):372-4.
12. Richards NT, Tattersall J, McCann M, Samson A, Mathias T, Johnson A. Dialysis for acute renal failure due to crush injuries after the Armenian earthquake. BMJ 1989;298(6671):443-5.
13. Oda Y, Shindoh M, Yukioka H, Nishi S, Fujimori M, Asada A. Crush syndrome sustained in the 1995 Kobe, Japan, earthquake; treatment and outcome. Ann Emerg Med 1997;30(4):507-12.
14. Sever MS, Erek E, Vanholder R, Ozener C, Yavuz M, Kayacan SM, et al. Lessons learned from the Marmara disaster: Time period under the rubble. Crit Care Med 2002;30(11):2443-9.
15. Michaelson M. Crush injury and crush syndrome. World J Surg 1992;16(5):899-903.