ORIGINAL ARTICLE

Improvised explosive device bombing police bus: Pattern of injuries, patho-physiology and early management

Muhammad Saeed Minhas,[1] Kashif Mahmood Khan,[2] Jahanzeb Effendi,[3] Anisuddin Bhatti,[4] Seemi Jamali[5]

Abstract

Objective: To understand the different types of blast injuries, their mechanisms, patho-physiology of wounds and clinical consequences caused by improvised explosive device detonation, and their early management.

Methods: The retrospective study related to 70 Special Security Unit personnel of police travelling on duty in a bus that was struck with an Improvised Explosive Device on February 13, 2014, at 7:48am.The data of triage, primary survey and resuscitation and secondary survey on arrival at the Accident and Emergency section of Jinnah Postgraduate Medical Centre, Karachi, were noted and later analysed.

Results: Police commandos aged 20-32 years were brought to hospital within 35-55 minutes of blast by ambulances. Triage at Emergency labelled 11(15.7%) Black, 15(21.4%) Red, 19(27.2%) Yellow and 25(35.7%) Green. Primary blast waves led to 11 closed blast lung presenting as pneumothorax in 9(12.8%) patients; 11(15.7%) chest tube thoracotomies were performed. Primary blast waves also produced ear drum and eyeball perforation. Seven (10%) patients received calcaneal fractures; 2(2.8%) with bilateral calcaneal fractures. Tertiary blast waves also caused amputations, and lower leg open fractures. Patients who died had received multi-system involvement injuries due to combined primary and secondary blast waves.

Conclusions: Improvised explosive devices produce a variety of serious and uncommon injuries requiring special care and early multi-disciplinary response. Repeated primary and secondary survey in Accident and Emergency are very important.

Keywords: Improvised explosive device, Injury pattern, Path physiology, Repeated survey. (JPMA 64: S-49 (Suppl. 2); 2014)

Introduction

Incidents of bombing and other bomb blast related injuries, which were initially confined to certain conflict and war zones, can occur anywhere now, especially targeted at crowded places in civilian and/or military installations and convoys. These events place severe demands on pre-hospital and hospital emergency systems.[1] These bombs are mostly called improvised explosive devices (IEDs), as they tend to produce a number of different types of injuries, affecting different organs from head to toe. Clinicians working in major hospital emergencies who may face the requirement to manage causalities from IEDs and bomb blasts are now required to know the mechanics and injuries caused by such incidents, and their management.[2] Injuries depend on the type of blast material used and its ingredients, magnitude or quantity of explosive material, whether in closed confined space or open place, and victims' distance from the blast site and barrier in between.[3]

IEDs are defined as "devices placed or fabricated in an improvised manner incorporating destructive, lethal, noxious, pyrotechnic or incendiary chemicals, designed to destroy, disfigure, distract or harass and often incorporate military stores..."[4] An IED is specifically designed for use against armoured targets such as personnel carriers or tanks.

Terrorist networks stay in shadows and work on the twin strategy of invisibility and ambiguity. They produce a surprise element and want to give shock to the state on physical, psychological and ideological levels. They change their strategy using different sources of transport to carry IEDs from human carriers to animals, dumper trucks, vehicles and hijacked airplanes.[5,6] IEDs can be classified as roadside explosives and blast mines and as suicide bombing.[7] These devices range from homemade explosives with precursors, including ammonium nitrate, urea, nitric acid, aluminium powder, potassium chlorate, peroxides etc. to sophisticated weapon systems containing high-grade explosives like C4. They may produce big noise and cause damage due to pressure waves, penetration and burns.[8] Potassium chlorate can be made from common household bleach and salt substitutes. It is also present in fertilizers, safety matches and fireworks. They are also loaded with metallic objects like nails, screws and ball bearings that work as a

[1,2,4]Jinnah Postgraduate Medical Centre (JPMC), [3]Demonstrator Professional Development Center JSMU, Karachi.

Correspondence: Muhammad Saeed Minhas. Email: drminhas@hotmail.com

secondary projectile to inflict penetrating injuries and to cause maximum damage to maximum number of victims.[9]

The behaviour and characteristics of these blast incidents and the spectrum of injuries have been difficult to predict. These depend on explosive weight and material and method of delivery. Injuries may involve multi-system, including lung injuries, brain injuries, burns, amputations, compartment andcrush syndromes and penetrating injuries to viscera.[10]

Types of blast injuries can be classified into four types. Primary blast injuries occur as a direct effect of changes in atmospheric pressure caused by blast wave's effects at hollow organs like lung, abdominal viscera and ear drum perforation. Secondary blast injuries are caused by projectile effects of ingredients present in IED and cause penetrating injuries to the affected area. Tertiary blast injuries are caused by effects of blast waves, as victims can be thrown off and may collide with nearby objects. Injuries can be by axial loading like calcaneal fractures, lower leg injuries, spinal and head injuries from collision with vehicle roof. Quaternary blast injuries are all others related to blasts like burns, psychological, toxic inhalation and exposure to radiation etc.[10,11]

The current paper analyses the mechanism and describe the clinical consequences of blast injuries and outline guidelines for the early management of wounds and specific injuries after a blast.

Material and Methods

The intervention was done and noted at the Jinnah Post Graduate Medical Centre (JPMC), Karachi, on February 13, 2014, when emergency was declared at the Accident and Emergency (A&E) section after 70 Special Security Unit (SSU) personnel of police traveling in a bus from the Police-Commando Training Centre were targeted by a vehicle packed with explosives which was parked on the route. As the police bus passed the parked vehicle, the device was detonated by remote control and it ripped the bus apart. The attack took place in the early hours of the morning, at 0748 hours, when there was little traffic in that part of the city. Rescue workers were quick to reach the scene, and sent all the dead and injured to JPMC, which was 29.2 kilometres from the scene. The driving time at that time of the day was about 30 minutes. As soon as the news broke, A&E was geared up to receive the victims.

For the purpose of this study, data like data on arrival at A&E, triage, primary survey, resuscitation, and secondary survey, was obtained from A&E records and medico-legal office. Initial and definite treatment record was obtained from departments of Orthopaedics, General Surgery, Neurosurgery, Chest Surgery, Era, Nose and Throat (ENT) and Intensive Care Unit (ICU).

All victims' wounds and injury patterns were analysed in relation to the type of blast injuries in the patient. We interviewed survivors later and analysed those brought dead, with serious and with minor injuries in relation to their position of sitting/standing in the bus and how far they were from the epicentre of the blast. Injury patterns, their management at different stages in A&E, and specialty management were recorded. Analysis of trauma Awakening-Breathing Coordination, Delirium Monitoring/Management and Early Mobility (ABCDE) Protocol, baseline wound assessment with associated fractures, distal neuro-vascular status were noted. Wound recorded and Initial pictures taken, contamination control and record of essential medicines given were also noted. Then specialty help in open fractures management, amputations and fasciotomy for compartment syndrome were noted down. Early detection of pneumothorax, eyeball rupture and perforation of ear drum were noted and so were early life-saving and limb-saving procedures performed. This all happened due to repeated primary, secondary and tertiary survey of patients so that no injury was missed (Table).

Data was recorded on a predesigned proforma, guidelines for the wounds in disaster were filled for each individual victim of the incident separately, then presented in the form of tables and statistically analysed.

Results

The Police Commandos' bus was hit by the IED-laden vehicle from the left side, in between passengers' front and rear doors (Figure-1). There were around seven seats with 14 policemen sitting on them between the two doors on the left side. These victims were the most affected and died on the spot or during transportation to hospital or in the A&E. As a result, 11(15.7%)victims were brought dead, who were labelled Black on triage, and 2(2.8%) died in the A&E within one hour, bringing the total death count to 13(18.6%).Victims standing in between the rows were mostly the victims of primary blast injuries. There were around 18-20 (25.7-28.6%) policemen standing in between two rows of the bus. They felt the brunt of blast waves and sustained life-threatening injuries. Accordingly, 15(21.4%) were labelled Red and 19(27.1%) Yellow on triage. The remaining 25(35.7%) patients with minor soft tissues injuries, who were walking wounded, were labelled Green. Overall, 50(71.4%) patients were admitted after performing surgeries and procedures.

Figure-1: Police bus hit by improvised explosive device.

Damage control surgery was performed in 34(48.6%) critically injured patients within two hours of arrival at the A&E. Two (2.8%) urgent craniotomies were performed for depressed fractures, 1(1.4%) patient with massive brain damage died within two hours of arrival. Nine (12.8%) patients were diagnosed with pneumothorax in emergency; 2(2.8%) with bilateral pneumothorax (Figure-2). Besides, 11(15.7%) urgent chest tube thoracostomy were done. One (1.4%) patient of pneumothorax also presented with an enucleated eyeball and was subsequently dealt by Ophthalmology. Six (8.6%) patients were admitted under the care of General Surgery for tense abdomen. However, no urgent abdominal surgeries were performed. One (1.4%) patient with multi-system involvement died in ICU after 4 hours. Other victims presented with following complications: 2(2.8%)with maxilla fracture, 2(2.8%) with neck injuries with expanding hematoma, and 3(4.3%) with deafness without ear bleed. No neuro-vascular injury was detected.

Figure-2: Blast lungs.

A total of 13(18.6%) patients were admitted in the Orthopaedic Surgery department, 7(10%) with nine calcaneal fractures, and 2(2.8%) with bilateral calcaneal fractures (Figure-3). There was 1(1.4%) patient with amputated mid leg, 1(1.4%) with clavicle fracture, and 2(2.8%) with open Gustillo type 3 fractures of distal tibia. Soft tissue injuries, multiple laceration and bruises were present in all. External fixator was applied

Table: Categories of Blast injuries, Pathophysiology, Injuries sustained and number of patients.

Category	Characteristics	Types of Injuries	No of cases
Primary	Impact of over pressurized waves with the body.	1. Blast Lungs	1. 11 in 9 patients
		2. Ear Drum Perforation.	2. 03
		3. Globe Rupture	
		4. Concussion	3. 01
		5. Blunt Tense Abdomen	4. 02
			5. 01
Secondary	Flying debris & Bomb Fragments	Multiple system involvement	13 deaths
Tertiary	Blast winds, Vertical shear force in vehicle, closed space.	1. Calcaneal fractures	1. 09 closed fractures in 7 patients
		2. Amputation	2. 01
		3. Open fracture leg.	3. 02
		4. Head Injury	4. 03 Patients.
Quaternary	All other explosion related injuries	Compartment Syndrome	One leg

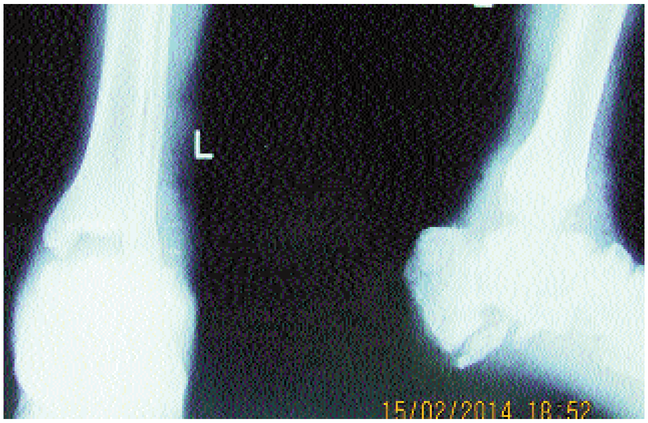

Figure-3: Blast Calcaneus.

in 2(2.8%) patients.

Discussions

During the 20thcentury, anti-vehicle (AV) landmines dominated the attacks on vehicles and their occupants after its introduction during World War I.[12] The use of roadside bombs and IED became significantly high during the conflicts in Afghanistan and Iraq.[13] More than 50,000 coalition force personnel were injured or killed in the US-led war against terrorism.[9,10,14]

More than 51,000 people have lost their lives as a result of IED blasts since the war against terrorism began in Pakistan.[15] It is the perfect weapon for asymmetric warfare and urban militant groups. The IED is a crude homemade bomb used by insurgents due to its easily available ingredients. It is cheap and easy to make, and it causes significant sound, blast waves and injuries due to the presence of dirty ingredients in it, which is why they are also called 'dirty bombs'. The common chemical precursors of the explosive and electronic precursors — used to detonate the main charge — are also readily available in local markets of Pakistan.[15]

Katz et al identified the high morbidity and mortality rates in explosives that are detonated in closed spaces as compared to the same explosive set off in an open space. In an enclosed space blast waves deflect, reflect and coalesce and can magnify the destructive powers to 8-9 times and cause lethal injuries.[16] This mechanism also explains the high incidence of blast lungs, and lung contusion in explosions in confined spaces like buses, and it can be bilateral. The proximity of the victims to the blast and the intense overpressure cause immediate deaths of the victims. As in our cases, 9 survivors were diagnosed with pneumothorax in emergency, two with bilateral blast lung. Blast lung is a primary blast injury and due to sheering force may result in damaging the peripheral alveoli, resulting in pneumothorax, or the pulmonary vessels, causing hemothorax depending on the magnitude of blast explosion. Our findings were also consistent with clinical data from military hospitals in the conflict zones that was evaluated by a study to determine the incidence of blast lungs by IED detonations.[17]

An IED hit to a vehicle blows the floor, generating waves, and causes particular injuries called Tertiary Blast injuries. Local deformation of the floor produces an axial load to the bus passengers that is transferred to the victim's heels, lower legs, pelvis and spine. This results in lower-limb injuries, spinal fractures, and the head hitting the roof of the bus leads to brain injury.[18] Our findings were consistent with a report published in 2002 in Karachi, describing injuries to lower limbs with bilateral calcaneal fractures with adequate soft tissue coverage over the fracture.[19] We recorded 9 calcaneal fractures which were detected in seven patients, an amputation at mid leg level and open fractures at distal 1/3rd tibia. Head injuries were also detected in those standing in bus as axial pressure waves pushed their heads against the roof and lead to the brain injury. Out of the total 70 SSU personnel, 13(18.6%) died out of whom 11 were brought dead, and two died within one hour of reaching A&E. This number is more than double when compared to mass civilian terrorist bombings in buses and trains such as the London Subway bombing in 2005 when the total proportion of dead were 56(7.2%) out of 775 injured in 4 separate bombings with one bomb detonating inside a double-decker bus of London.[20] This figure was consistent with the bombings in Madrid in March 2004 where a similar proportion of civilian casualties 191 (8.5%) out of the 2253 victims died.[21]

The higher mortality (18.6%) in the Karachi SSU Police Bus bombing may have resulted from the over-loading of the bus with police personnel that caused many of them to stand in the aisle. The primary blast effect caused the death of personnel sitting on the left side of the bus where the IED-laden vehicle was detonated. Another reason may be the type of fragments and foreign bodies used by the terrorist in the IED that resulted in a deadly outcome. This higher death toll can also be explained by the lack of on-site triage and pre-hospital emergency management during the transport of victims to the A&E in unequipped ambulances via 'scoop and run' method. When compared to an earlier report, the victims of the IED explosion in the double-decker bus in London on July 7, 2005, at 0947 were immediately treated on site by a team of 14 doctors from the nearby British Medical Association (BMA). As a result, only 13 persons died on the scene.[22] The distance to JPMC A&E was approximately 29.2

kilometres (18.1 miles) which took 30 minutes for the victim to receive emergency medical care.

According to a study, prognostic factors that affect the outcome of victims of bombings are the magnitude of the blast, confined versus open space and the event of a building collapse.[3]

Factors that result in a favourable outcome are availability of immediate medical care and trained medical personnel. This is the only factor that can be changed by training medical personnel in disaster management and primary trauma care, and also emphasis on the in-hospital handling of victims of bomb blast by repeated survey and keeping the record of wounds and managing specific injuries.

Conclusion

New trends and technology used by terrorists now mandate every trauma surgeon and A&E doctor to broaden the existing knowledge of blast physics, mechanism and natures of injuries. Pre-hospital management of bomb blast victims may play a significant role in the reduction of mortality. Emergency medical personnel should be trained, especially in mass bombing and trauma related to disasters, and regular drills should be conducted. Rapid initial and thorough repeated assessments from head to toe and documentation of injuries are very important. Damage control surgery should be performed urgently.

References

1. Zafar H, Jawad A, Shamim MS, Memon AA, Hameed A, Effindi MS, et al. Terrorist bombings: medical response in a developing country. J Pak Med Assoc 2011; 61: 561-6
2. Siddiqui MA, Jawad A, Minhas S, Ansari A, Siddiqui A, Mehtab S. Pakistan: The new target of terrorism. Are Karachi's emergency medical response systems adequately prepared? J Pak Med Assoc 2009; 59: 441-5.
3. Frykberg ER. Medical management of disasters and mass casualties from terrorist bombings: how can we cope? J Trauma 2002; 53: 201-12
4. Katz E, Ofek B, Adler J. Primary injury after a bomb explosion in a civilian bus. Ann Surg 1989; 209: 484-8
5. Zafar H, Rehmani R, Chawla T, Umer M, Mohsin-e-Azam. Suicide bus bombing of French Nationals in Pakistan: physical injuries and management of survivors. Eur J Emerg Med 2005; 12: 163-7
6. DePalma RG, Burris DG, Champion HR, Hodgson MJ. Blast injuries. N Engl J Med 2005; 352:1335-42
7. Ramasamy A, Harrisson SE, Clasper JC, Stewart MP. Injuries from roadside improvised explosive devices. J Trauma 2008; 65: 910-4.
8. Owens BD, Kragh Jr JF, Macaitis J. Svoboda SJ, Wenke JC. Characterization of extremity wounds in operation Iraqi freedom and operation enduring freedom. J Orthop Trauma 2007; 21: 254-7
9. Kang DG, Lehman RA Jr, Carragee EJ. Wartime spine injuries: understanding the improvised explosive device and biophysics of blast trauma. Spine J 2012; 9: 849-85
10. Champion HR, Holcomb JB, Young LA. Injuries from explosions: physics, biophysics, pathology, and required research focus. J Trauma 2009; 66: 1468-77
11. Commandeur J, Derksen RJ, MacDonald D, Breederveld R. Identical fracture patters in combat vehicle blast injuries due to improvised explosive devices; a case series. BMC Emerg Med 2012; 12: 12
12. Ramasamy A, Hill AM, Hepper AE, Bull AMJ, Clasper JC. Blast mines: a background for clinicians on physics, injury mechanism and vehicle protection. J R Army Med Corps 2009; 155: 258-64
13. Ramasamy A, Harrisson S, Lasrado I, Stewart MP. A review of casualties during the Iraqi insurgency 2006--a British field hospital experience. Injury 2009; 40: 493-7
14. Belmont PJ, Schoenfeld AJ, Goodman G. Epidemiology of combat wounds in operation Iraqi freedom and operation enduring freedom: Orthopaedic burden of disease. J Surg Orthop Adv 2010; 19:2-7
15. Improvised Explosive Device: Terrorists' weapon of choice . [online] [cited 2013 Oct 20]. Available from: URL: http://tribune.com.pk/story/619899/terrorists-weapon-of-choice/
16. Katz E, Ofek B, Adler J, Abramowitz HB, Krausz MM. Primary blast injury after a bomb explosion in a civilian bus. Ann Surg 1989; 209: 484-8
17. Smith JE. The epidemiology of blast lung injury during recent military conflicts: a retrospective database review of cases presenting to deployed military hospitals, 2003-2009. Philos Trans R Soc Lond B Biol Sci 2011; 366: 291-4
18. Ramasamy A, Hill AM, Clasper JC. Improvised explosive Devices: Pathophysiolgy, Injury Profiles and current Medical management. JR Army Med Corps 1999; 155: 265-72
19. Malik ZU, Hanif MS, Tariq M, Aslam R, Munir AJ, Zaidi H, et al. Mass casualty management after a suicidal terrorist attack on a religious procession in Quetta Pakistan. J Coll Physicans Surg Pak 2006; 16:253-6
20. Aylwin CJ, König TC, Brennan NW, Shirley PJ, Davies G, Walsh MS, et al. Reduction in critical mortality in urban mass casualty incidents: analysis of triage, surge, and resource use after the London bombings on July 7, 2005. Lancet 2006; 368: 2219-25.
21. Gutierrez de Ceballos JP, Turegano Fuentes F, Perez Diaz D, Sanz Sanchez M, Martin Llorente C, Guerrero Sanz JE. Casualties treated at the closest hospital in the Madrid, March 11, terrorist bombings. Crit Care Med 2005; 33 Suppl 1: S107-12.
22. Ryan J. Montgomery H. The London attacks-preparedness: terrorism and the medical response. N Engl J Med 2005; 353: 543-5.