ORIGINAL ARTICLES

PREDICTIVE VALUE OF TYMPANIC MEMBRANE INJURY IN DETERMINING MORTALITY/MORBIDITY ASSOCIATED WITH TERRORIST BOMB BLASTS

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ABSTRACT

Objective: To analyze the predictive value of drumhead perforation to overall visceral damage by the blast waves.

Study Design: Retrospective observational study.

Place and Duration of Study: It was a multi-centric study extending from Jul 2005 to Jun 2009. Blast victims in Wana (Pak Afghan border area, a hot center of war against terrorism in Pakistan), Lahore (provincial capital of Punjab, Pakistan) and Quetta (provincial capital of Baluchistan, Pakistan) were included in the study.

Methodology: A total of 354 patients were included in the study. A preliminary examination by surgeon and ENT specialist was carried out to evaluate patient's general condition and state of tympanic membranes. Sonographic examination, computerized tomography (CT) scan and other relevant investigations were subsequently carried out to further ascertain the patient's condition and visceral damage. The data were then analyzed to correlate visceral damage as a result of blast injury to the laterality and size of tympanic membrane perforation.

Results: The extent of visceral damage was less in cases with intact drumheads, more in cases with unilateral perforation and maximum in cases with bilateral subtotal perforation.

Conclusion: The size and laterality of drumhead perforation as a result of blast injury is a rough predictor of visceral damage sustained as a result of blast injury.

Keywords: Terrorist bomb blasts, Traumatic drumhead perforation, Visceral damage.

INTRODUCTION

Tympanic membrane rupture is a well-recognized consequence of exposure to the shock-waves originating from suicidal and remote controlled bomb blasts[1,2].

Following the terrorist activities, suicide bomb blasts and other explosions, scores of victims suffer from a combination of blast, penetrating and burn injuries. They are brought to the local hospitals with varying degrees of these combinations. Besides the external wounds sustained by victims, the possibility of blast injury to the abdominal and thoracic viscera should be taken into account. The intensity of same blast waves usually cause simultaneous rupture of one or both eardrums. The size and laterality (Unilateral or bilateral) of drumhead perforation may thus be a rough index as to the intensity of blast waves to which the patient had been exposed and thus have a predictive value in the visceral damage that this blast waves might have caused.

Blast induced ear drum perforation seems weird at the moment but can develop one parameter of scale to predict the morbidity and mortality, just as Glasgow Coma' Scale (GCS) can predict the chances of comatose patient's recovery. This study aims to study the predictive value of tympanic membrane injury of overall visceral damage by bomb blasts.

METHODOLOGY

It was a multicentric retrospective observational study extending from July 2005 to June 2009. Blast victims in Wana (Pak Afghan border area, a hot center of war against terrorism in Pakistan), Lahore (provincial capital of Punjab, Pakistan) and Quetta (provincial capital of Baluchistan, Pakistan) were included in the study.

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Total 354 patients were included in the study. We took all the patients during our study duration using universal sampling method. A preliminary examination by surgeon and ENT Specialist was carried out to evaluate patient's general condition and state of tympanic membranes. Sonographic Examination, CT scan and other relevant investigations were subsequently carried out to further ascertain the patient's condition and visceral damage. The data was then analyzed to correlate visceral damage as a result of blast injury to the laterality and size of tympanic membrane perforation.

Inclusion criteria was, terrorist suicidal attack victims, remote controlled bomb blast victims, and victims of locally made improvised explosion devices by the terrorists. Exclusion criteria was drumhead perforation due to blast wave was to be compared with other variable i.e. visceral damage due to blast waves, therefore the patients whose mortality and morbidity and visceral damage was likely to be effected by other variables like splinter injury or penetrating injury were excluded from study. Also patients with history of previous drumhead perforation or Chronic Suppurative Otitis Media (CSOM) were excluded.

Once the patient had been shifted from emergency department to the Ward/Operation Theater, immediate eardrum examination by ENT specialist was carried out. Diagrams of both eardrums were documented pin pointing the site and size of perforation. A unilateral perforation involving less than one third of total tympanic membrane area was labeled as small, between one third to two third was labeled as medium and more than two third as large perforation. Bilateral perforation irrespective of its size was taken as a separate entity. At the same time trauma surgeon examined the patient in the light of type of blast, evaluation by emergency department, laboratory/radiological investigations and general physical condition of the patient. The same surgeon documented provisional assessment of internal damage before any surgical intervention or otherwise. Patient's progress till final outcome was closely monitored.

All the data were collected on the pre-designed profoma and entered in the Statistical Package for the Social Sciences (SPSS). Frequency along with percentage were calculated. Study was carried out after the ethics review board approval.

RESULTS

A total of 354 patients were included in the study. The results of study showing a relation of ear drum perforation with morbidity and mortality of blast victim was tabulated in table-I. Complete Recovery was found in 198 (54.9%), out of which small unilateral perforation was found in 7 (1.9%) patients. Recovery with minor disability was in 96 (27.1%) patients, recovery with major disability was found in 44 (12.4%) patients while fatal outcome were found in 16 (4.5%) patients. Comparison of visceral damage and varying degree of drumhead perforation was shown in table-II. Liver damage was seen in 27 (7.6%) patients while pulmonary damage was seen in

Table-I: Relation of size of perforation with recovery from blast injury (n=354).

	Unilateral perforation			Bilateral perforation
	Small	Medium	Large	
Complete recovery 198 (55.9 %)	7 (1.9%)	-	-	2 (0.5%)
Recovery with minor disability 96 (27.1 %)	9 (2.5%)	13 (3.6%)	6 (1.6%)	1 (0.2%)
Recovery with major disability 44 (12.4 %)	5 (1.4%)	11 (3.1%)	8 (2.2%)	2 (0.5%)
Fatal outcome 16 (4.5 %)	2 (0.5%)	5 (1.4%)	4 (1.1%)	2 (0.5%)

8 (2.2%) patients. If we compare the visceral damage with tympanic membrane perforation, liver damage was associated with all three sized perforation, while pulmonary and spleenic rupture was seen in medium and large sized perforations only.

DISCUSSION

Following the blasts of varying degrees caused by various explosive devices, external signs of trauma are an index of severity of other concealed or revealed injuries. Different studies show that most traumatic perforations of tympanic membrane have irregular margins and located in inferior quadrant[3,4]. The chances of getting tympanic membrane perforation is more with projectile missiles as compared to improvised explosive device[5]. The resulting hearing loss can be of conductive or a mixed variety[6]. These tympanic membrane perforation can be one important index of assessing the severity of concealed injury.

In primary blast injuries, the ear is the most susceptible organ[7]. Cadaveric models show that the pressure required to rupture the tympanic membrane ranges between. 5-2.1 kp/cm^2 with a median of 1.2 kp/cm^2. Rupture pressures were shown to correlate to age with older individuals requiring lower rupture pressures[8]. As such this inverse relation may be suggestive of greater exposure to the concussion effects of a shockwave when a tympanic membrane perforation is encountered in a younger individual as compared to an older one. This may have obvious implications in management protocols for blast victims. Pressures required to induce pulmonary injuries are higher than those required rupturing the tympanic membrane[9], and as such this may account for the disparity encountered when comparing the frequency of tympanic membrane ruptures against that of pulmonary injuries[10]. Ephysics of blast wave gives supra and sub atmospheric components, which are separate phases but intricately related. Exact mechanism of injury exerted by either phase is debatable due to an obvious dearth of data existing on isolated positive or negative pressure wave induced injuries in uncontrolled scenarios outside the laboratory. Yet none of two can be excluded when attempting to understand the kinetics of blast pressure at the site of blast. Otologic, pulmonary and intraabdominal damages are encountered.

Table-II: A comparison of visceral damage and varying degree of drumhead perforation (n=46).

	Unilateral perforation			Bilateral perforation
	Small	Medium	Large	
Liver damage 27 (7.6%)	3 (0.8 %)	3 (0.8 %)	5 (1.4%)	4 (1.1%)
Pulmonary damage 8 (2.2%)	-	2 (0.5%)	2 (0.5%)	3 (0.8 %)
Spleen rupture 4 (1.1%)	-	1 (0.2%)	1 (0.2%)	1 (0.2%)
Kidney damage 3 (0.8%)	-	-	1 (0.2%)	1 (0.2%)
Laryngeal damage 4 (1.1%)	1 (0.2%)	-	1 (0.2%)	2 (0.5%)

Pressure needed to induce injury in closed compartments differs, but eardrum is the most vulnerable structure in any environment. Predic-

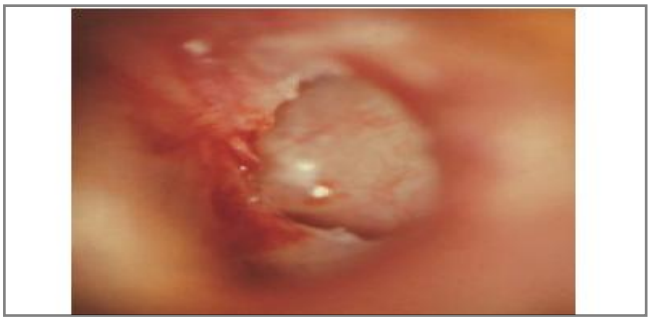

Figure: Traumatic perforation of left eardrum as a result of blast wave pressure between. 5-2.1 kp/ cm^2 with a median of 1.2 kp/cm^2. Note the typi-cally jagged perforation margins.

tive value of blast induced ear drum rupture to diagnose concealed chest and abdominal injury is debatable but it's utility to timely plan and manage an anticipated concealed thoraco abdominal injury cannot be ignored. Many investigators have focused on the acute and chronic otological complications of such injuries[11-15], and there are studies focusing on the value of diagnosing tympanic membrane ruptures in context to their implications on trauma management[16-18]. The conventional model was to look, diagnose and then use post blast tympanic membrane ruptures as a guiding tool to search for other primary blast injuries, such as blast lung injuries. Though theoretically sound in the approach is that one primary blast injury would be indicative of other primary blast injuries, the problem is that there are numerous other parameters which can heavily influence the possibility of suffering from pulmonary or intestinal injuries. The factors affecting injury pattern and severity include distance from the explosion, type of explosives used and explosion confinement. The mortality and morbidity is more in bomb blast victims of confined space as compare to open space[19-24]. However, obtaining accurate information pertaining to all these factors in time to influence initial trauma management is exceedingly difficult and as such they currently don't seem to play over-whelmingly influential roles in primary trauma management protocols.

Israeli experience of managing the victims of suicidal and terrorist bomb blasts is a diverse and difficult set of challenges[11,25]. There is a strong wave of suicidal terrorist blasts in poverty-hit Pakistan and managing the victims is even more diverse and difficult a challenge. Our objective was to assess what the impact of diagnosing tympanic membrane rupture was when managing suicide bombing victims in the Pakistani setting. Seeing that, explosive type and kinetics seem to play a role in injury development, we theorized that the modus operandi of bombings in Pakistan may reveal a different predictive value for tympanic membrane ruptures as an indicator for other primary blast injuries or that they may be a useful indicator of eventual mortality/morbidity.

Isolated ear perforation in mass casualty evacuation and explosion survivors does not appear to be a matter of concealed blast injuries or a matter of poor prognosis. A sizeable number of these isolated eardrum perforations undergo complete spontaneous recovery particularly in children and young age, although many of these cases may develop a permanent long term audiological damage. In a mass casualty event, persons who have sustained isolated eardrum perforation from explosions may safely be discharged from emergency department after Chest X ray and initial observation period.

CONCLUSION

The size and laterality of drumhead perforation as a result of blast injury is a rough predictor of visceral damage sustained as a result of blast injury.

CONFLICT OF INTEREST

This study has no conflict of interest to be declared by any author.

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