



BLAST INJURY TO THE EARS: OUR EXPERIENCE IN A CONFLICT RIDDEN AREA

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ABSTRACT

Background: The ear is commonly affected in persons who sustain blast injuries as it is one of the most sensitive pressure transducers in humans. **Methods:** In this study 146 ears of 73 victims of blast injury were evaluated and followed up for 2 years.

Results: In our study we encountered 120 tympanic membrane perforations out of 146 ears examined. Out of which 62.5% cases of tympanic membrane perforation healed spontaneously while 37.5% required tympanoplasty and 2.5% had to undergo revision tympanoplasty. Ossiculoplasty was required in 29.8% cases. 13.0% had mixed hearing loss, none cases of pure SNHL and 1.6% cases developed cholesteatoma. These results were in congruence to the earlier studies.

Conclusion: An observation period of at least 3 months is recommended in tympanic membrane perforation due to blast injury and the results of tympanoplasty are also generally good.

KEYWORDS

Blast injury, tympanic membrane perforation, spontaneous healing, tympanoplasty

DEFINITION

Blast-produced injury implies those detrimental changes occurring in an organism while it is being subjected to the pressure field (effects of changes in air pressure—blast wave) produced by an explosion, whether such changes are produced directly or indirectly by the explosive phenomena.^{1,2}

INTRODUCTION

In today's world blast resulting from use of various types of explosives is causing mortality and morbidity not only in the battle field but also in civil set ups in conflict ridden areas all over the world. The ear is commonly affected in persons who sustain blast injuries as it is one of the most sensitive pressure transducers in humans,³ but is most often overlooked due to the presence of more ghastly looking and life threatening injuries. Patients are often referred late to the otolaryngologist after the initial focus from other injuries is shifted to injury to one of our special senses, which is, hearing.

Blast injury to the ear is different from noise induced hearing loss as impulse noise generates 2 kPa peak overpressures whereas blast produces peak overpressures in the range of tens of kPa. Considerable movements of air and combustion products are produced in blast and not in noise impulse. Lastly in impulse noise there is low frequency mechanical clutter.^{3,4,5}

Damage to the auditory system includes hearing and balance disorders, like tympanic membrane (TM) perforations, hearing loss, dizziness, vertigo, postural deficits, gaze instability and spatial disorientation.⁶⁻¹²

Objective

The objective of this study is to document the types of auditory damage, the natural course of disease and determine the requirement and timing of intervention

Methods

Study Design: Descriptive prospective study

Study Period: Two years from March 2017 to March 2019.

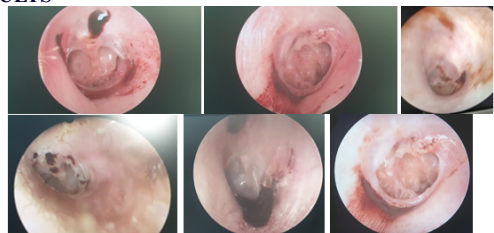
Study Population: Military personnel, who were referred to a tertiary care military hospital in a counter insurgency, counter terrorism and cross border cease fire violation inflicted areas in Northern India were treated, followed up and rehabilitated.

Inclusion Criteria: All military personnel who suffered blast injury to the ears. Usually all military personnel deployed are otherwise fit being subjected to annual medical examinations where any disease detected is documented in their health record cards.

Exclusion criteria: Fatalities and personnel with pre existing ear disease and hearing loss as per their health record cards were excluded from the study.

All patients once they entered the study group were initially evaluated within 3 days with otoscopy using a 3mm 0 degree Hopkins rigid portable battery operated endoscope and the findings were photographed and a file was maintained for each patient. Perforation size was documented as a percentage of the entire drum, as assessed by the treating physician. The reported perforation size was converted into 4 grades of injury (grade 1, <25%; grade 2, 25%-50%; grade 3, 51%- 75%; grade 4, >75%), as previously standardized.^{13,14} Pure tone audiometry was done for each patient and the records were maintained. Those patients with tympanic membrane perforation and pure conductive hearing loss were followed up for 3 months and if the perforation of the tympanic membrane persisted they were taken up for tympanoplasty. Any ossicular discontinuity was managed with ossiculoplasty during the primary surgery. Patients were then reassessed after 3 months of surgery for the success which entails intact tympanic membrane and bridging of air bone gap in pure tone audiometry. Cases of failure underwent revision tympanoplasty 6 months after the primary surgery. Patients were followed up for a total period of 2 years. Patients with sensorineural damage were also treated with oral steroids and vasodilators as indicated but the outcomes are not included in the results for the purpose of the study.

RESULTS



Few representative pictures

Relevant case details are listed in Table I. A total of 73 patients (146 ears) were included in the study. Out of 146 ears 120 had tympanic membrane perforation (82.2%) and pure conductive hearing loss in 101 ears (84.1%) and 19 ears (13.0%) had mixed hearing loss. 26 ears (17.8%) were unaffected by the blast injury in any form.

Table I

S.No.	Data	Numbers	Percentage
1.	Total number of patients seen	73	
2.	Total number of ears seen	146	
3.	Total number of ears with TM perforation	120	82.2%
4.	Total number of ears with conductive hearing loss	101	84.1%
5.	Total number of ears with mixed hearing loss	19	13%

6.	Total number of ears with pure SNHL	NIL	
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All the patients were male and the average age of the patients was 32 years. Tympanic membrane perforation was unilateral in 26 cases (35.6%) and bilateral in 47 cases (64.4%). As per the surface area of pars tensa involved there were 9 ears with grade 1, <25%, 37 ears with grade 2, 25-50%, 57 ears with grade 3, 51-75% and 17 ears with grade 4, > 75% size of the perforation (Table II). Surface area of multiple perforations was added and taken as one.

Table II: Distribution as per size

S.No.	Size of perforation	Numbers	Percentage
1.	Grade 1	9	7.5%
2.	Grade 2	37	30.8%
3.	Grade 3	57	47.5%
4.	Grade 4	17	14.1%

Out of 120 ears with tympanic membrane perforation 75 ears (62.5%) healed spontaneously and 45 ears (37.5%) underwent tympanoplasty. Detailed outcomes are tabulated in Table III and Table IV.

Table III: Size wise spontaneous healing

S.No.	Size of perforation	Numbers	Healed	Percentage
1.	Grade 1	9	7	77.7%
2.	Grade 2	37	26	70.2%
3.	Grade 3	57	34	59.6%
4.	Grade 4	17	8	47.1%

Table IV: Size wise requirement of tympanoplasty

S.No.	Size of perforation	Numbers	Tympanoplasty	Percentage
1.	Grade 1	9	2	22.2%
2.	Grade 2	37	11	29.7%
3.	Grade 3	57	23	40.3%
4.	Grade 4	17	9	52.9%

Out of these 45 ears 3 ears (2.5%) were operated again for residual perforation with tympanoplasty (Table V).

Table V: Size wise requirement of revision tympanoplasty

S.No.	Size of perforation	Numbers	Revision tympanoplasty	Percentage
1.	Grade 1	9	NIL	
2.	Grade 2	37	NIL	
3.	Grade 3	57	1	1.75%
4.	Grade 4	17	2	11.7%

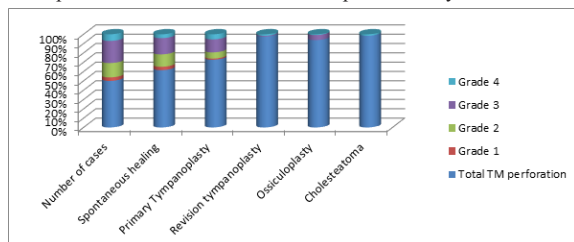
8 (6.6%) among the ears undergoing primary tympanoplasty were found to have ossicular discontinuity and ossiculoplasty was done during the primary surgery (Table VI).

Table VI: Size wise requirement of ossiculoplasty

S.No.	Size of perforation	Numbers	Ossiculoplasty	Percentage
1.	Grade 1	9	NIL	
2.	Grade 2	37	NIL	
3.	Grade 3	57	7	12.2%
4.	Grade 4	17	3	17.6%

Cholesteatoma developed in unilateral ears of 2 patients (1.6%) who had spontaneous healing of their perforations.

Note: 2 patients (2 ears) (1.6%) out of 13 ears of marginal perforations developed Cholesteatoma which healed spontaneously



Graphical representation of the results

DISCUSSION

Earlier studies show up to 70-80% spontaneous healing of TM in blast injury cases with almost complete healing in 40% to 50% of cases in the first month after injury.^{15,16}

It was found by Kronenberg et al in a military review of blast induced perforations that large and central kidney shaped perforations had the lowest propensity to heal spontaneously, while perforations of grade 1 had the best chance of healing spontaneously. While Pahor found that there is an inverse relation between the size of the perforation and the chances of spontaneous healing.¹⁷

Although there exist a debate regarding the optimal timing of repair small to moderate size perforations have a good prognosis for spontaneous healing. Different studies quote different timing of observation and there are arguments regarding delayed versus immediate tympanoplasty.¹⁸⁻²⁰ Blast injuries are related with inoculations of debris and epithelial fragments in the middle ear. Proponents of immediate tympanoplasty quote the ability to perform meticulous debridement of middle ear as one the advantages of immediate tympanoplasty, theoretically which promotes rapid healing and prevents future complications.²⁰

While Kerr and Byrne concluded that if a perforation fails to heal spontaneously even up to 6 months then surgical repair should be undertaken.¹⁹

According to a study by Kronenberg et al they noted spontaneous healing occurring in about 73.8% with almost 62% of them healing within 3 months and this figure reached to 69% in 10 months. Based on these results they recommended a waiting period of 10 to 12 months blast injury related tympanic membrane perforations to maximize chances of spontaneous healing.¹⁸ In a study by Keller et al there was no significant difference in outcomes between immediate and delayed surgery.

Several studies have reported lower success rates than for other common injury mechanisms with regard to the success of tympanoplasty following blast injury.

In a study of 549 blast-induced TM perforations from the Croatia War, 172 individuals underwent tympanoplasty.²⁰ In our study 62.5% tympanic membrane perforations healed spontaneously. The chances of spontaneous healing corroborated with the size of perforation, with maximum spontaneous healing occurring in grade 1 size perforation and the percentage decreased as the size increased from grade 1 to grade 4. In our study out of the 146 ears only one ear developed infection which required early surgery otherwise rest of the cases were operated only after an observant period of 3 months

Reported rates of disruption of ossicles following blast injury was variable ranging from 0% to 36%.^{21,22} Breeze et al reported 11% rate of ossicular disruption in blast related trauma.²³ Kerr and Byrne reported 0% cases of ossicular disruption while Kronenberg et al reported 36.4% cases of ossicular disruption in their study. Keller et al reported 9.1% cases of blast related injuries requiring ossiculoplasty for ossicular disruption.¹⁹ In a study by Kronenberg et al ossiculoplasty was required in 12 of the 33 ears (36.4%) that underwent tympanoplasty following blast-related injury.¹⁸ In a study by Keller ossiculoplasty was required in 9.1% patients.²¹ The ossicular damages range from no cases to 34% of the ears undergoing tympanoplasty in a study by Singh et al.²⁴ In our study out of the total 45 ears undergoing tympanoplasty only 10 ears (29.8%) had ossicular disruption which required ossiculoplasty.

A recent military report from Walter Reed involving 34 blast-induced TM perforations demonstrated an 82% closure rate following tympanoplasty.²⁵ Following the Boston bombing, patients undergoing tympanoplasty had an overall closure rate of 86%.²⁶ The outcome of surgery to repair tympanic membrane perforations caused by blast is excellent; 90% of grafted tympanic membranes will heal completely.^{27, 28, 29, 30} In our study out of the 45 ears undergoing tympanoplasty the graft was well taken up and air bone gap was bridged in 42 ears (93.3%) while 3 ears (2.5%) required revision surgery

As far as development of cholesteatoma is concerned blast related tympanic membrane perforations are associated with higher risk of cholesteatoma development as particulate matter and skin debris may get implanted into the middle ear. Seamon and Newell noted 12% incidence of squamous epithelium identified in the middle ear.³¹ Kronenberg et al reported a 7.6% incidence in their series involving 210 ears³², and Song et al reported an 8% incidence.³³ In our study 2

ears out of total 146 ears (1.6%) examined developed cholesteatoma

The prevalence of permanent sensorineural hearing loss varies between 30 and 55%. Age cannot account for the change in hearing from before to after deployment.^{34,35,36} Sensorineural hearing loss has been treated in the past with vasodilating drugs, corticosteroids, and intravenous administration of low molecular weight dextran, but there is no evidence to show that these improve hearing.³⁷

In our study 19 ears out of 146 ears (13.0%) had element of sensorineural hearing loss

CONCLUSION

Victims of blast injuries usually presents with multiple trauma affecting various body organs. Initially the life threatening injuries are taken care of and then the auditory system injuries come into light. As per other studies reviewed and according to this study also, tympanic membrane perforation with conductive hearing loss is the most common injury. Other injuries include sensorineural hearing loss and damage to the vestibular system presenting in various forms. This knowledge of various forms of possible damage to the auditory system and the high chances of spontaneous recovery can be communicated to the patients who are already fighting with other injuries and will help them to better handle with the stress of injuries and motivate them to fight back.

Conflict of Interest

Nil

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