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Effects of bomb blast injury on the ears: The Aga Khan University Hospital experience

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ORIGINAL ARTICLE

Effects of bomb blast injury on the ears: The Aga Khan University Hospital experience

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Abstract

Objective: To evaluate the frequency and effects of blast-related otologic injuries.

Methods: This retrospective study was conducted at the Aga Khan University Hospital, Karachi, and comprised charts of patients who were victims of bomb explosions between January 2011 and July 2013.

Frequency and percentages were reported using cross tabulation with size of bomb, distance of person from blast and the presence of victim in open or closed space. Association of associated variables were also analysed.

Results: Of the 100 patients, 81(81%) were men and 19(19%) were women. Besides, 68(68%) patients were aged ≤30 years. Also, 78(78%) subjects were exposed to ≤ 80kg of explosives and 68(68%) were at a distance of>10m. Furthermore, 61(61%) patients were exposed to explosion in openspace. The prevalence of ear injuries was 21(21%). The odds of experiencing various symptoms of ears was high in those who were exposed to >80 kg of explosives (odds ratio: 3.38; 95% confidence interval, 1.16, 9.91). The odds of hearing loss in those who were within 10m was 8.62 (95% confidence interval: 2.72, 27.28) times than those who were >10 m from the site of explosion.

Conclusion: Otologic injuries were frequently associated with large blasts.

Keywords: TM perforation, bomb blast, open/closed spaces, barrier, deafness, hearing loss, tympanic membrane perforation. (JPMA 67: 1313; 2017)

Introduction

Bombs and explosions can cause unique patterns of injury, which potentially and simultaneously causes multi-system life-threatening injuries to many people. Based on the mechanisms of blast injury, it is classified as primary, secondary, tertiary or quaternary. Detonation of high order explosives creates intense over-pressurisation impulse (blast wave), which produces anatomical and physiological injury due to direct impact is the primary kind. Primary blast injury affects the gas-filled structures, especially the lungs, gastrointestinal tract, and middle ear. Secondary injury refers to injury inflicted by flying debris or bomb component. Owing to the impact of the explosion, the victim sustains tertiary injury as the victim is thrown away. Any explosion-related injuries, other than the primary, secondary and tertiary types, are classified as quaternary injury.[1]

Primary blast injuries of the auditory system cause significant morbidity, but is often neglected. Since the signs of ear injury are usually present at time of initial evaluation, it is mandatory to evaluate hearing loss, tinnitus, otalgia, vertigo, bleeding from the external canal, tympanic membrane (TM) rupture or mucopurulent otorrhea.[1] All patients exposed to blast should have an otologic assessment and audiometry. TM rupture, ossicular disruption, cochlear damage, and wound inflicted by foreign body in the ear are the common auditory damage sustained by victims. Tympanic membrane perforation is the most common injury to the middle ear.[2]

Evidence from literature shows that ear injury among bomb blast victims is a silent trauma with a high rate of sensorineural hearing loss, TM perforations and tinnitus.[3] Among the victims of Boston Marathon bombings, blast-related otologic injuries were established as a major cause of ongoing morbidity.[4] Retrospective analysis of United States service members injured in Operation Iraqi Freedom and Operation Enduring Freedom from October 2006 to October 2007 showed that 24% suffered moderate to profound hearing loss.[4] The prevalence blast-related ear injuries sustained by the military personnel during Operation Iraqi Freedom was 30.7%.[5]

The current study was planned to evaluate the frequency of blast-related otologic injuries among blast victims. In addition, we wanted to determine the association of certain factors such as distance, and presence of victims in open or closed space, and the amount of exposed explosive, with the frequency of hearing loss and TM perforation.

Patients and Methods

This retrospective study was conducted at the Aga Khan University Hospital (AKUH), Karachi, and comprised charts of patients who were victims of bomb explosions

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between January 2011 and July 2013. Patients were stable enough to have an ontological examination and hearing assessment. All other patients with incomplete records, missing data, with history of ear complaints or prior ear surgeries were excluded.

During the chart review, patient demographics, date of blast, date of ear examination and of pure tone audiometry (PTA), presence or absence of symptoms, type, duration and intensity of symptoms, otological findings for presence of tympanic membrane perforation, presence of blood/clot or discharge in external auditory canal and pure tone audiometry findings were collected. In addition, information on the approximate distance from the blast, and presence of victim in an open (in an area where blast occurred, market, road, ground, praying area) and closed space (house, car), amount of explosive was obtained from the print media.

All patients who had ear-related complaints and abnormal PTA findings were called for telephonic interview, after a follow-up period of at least 2 months. These patients were asked about improvement of symptoms, and any other missing information was also obtained.

SPSS 16 was used for data analysis. Frequency and percentages were reported using cross tabulation with size of bomb, distance of person from blast and the presence of victim in open or closed space. To see the association of associated variables in crosstab, binary logistic regression analysis was performed and odds ratio was calculated with 95% confidence interval (CI). P<0.05 was considered significant.

Results

Of the 100 patients, 81(81%) were men and 19(19%) were women. Besides, 68(68%) patients were aged ≤ 30 years. Also, 78(78%) subjects were exposed to ≤ 80kg of explosives and 68(68%) were at a distance of >10 m. Furthermore, 61(61%) patients were exposed to explosion in open space (Table-1).

The prevalence of ear injuries was 21(21%). There was a significant difference (p=0.026) in the occurrence of symptoms in the subgroups of those exposed to weight of explosives (8(38.1%) ≤ 80 kg vs. 12(15.4%) >80 kg of

Table-1: Demographic profile of victims.

Prolife	N
Men	81
Women	19
Age	
≤ 30 years	68
> 30 years	32
Weight of the explosives*	
Exposure to ? 80 kg of explosives	78
Exposure to > 80 kg of explosives	21
Victims' distance from the site of explosion	
≤ 10 m	32
> 10 m	68
Presence of victim	
Open space	61
Close space	39

* data not available for one victim.

Table-2: Association of weight of explosion with ontological findings.

Otological parameters		Weight of explosion				Odds ratio	95% Confidence interval	P value
		>80kg (n=21)		≤80 kg (n=78)				
		n	%	n	%			
Symptoms of ear problem	Yes	8	38.1	12	15.4	3.38	1.16, 9.91	0.026*
	No	13	61.9	66	84.6			
Deafness	yes	8	38.1	9	11.5	4.72	1.54, 14.48	0.007*
	No	13	61.9	69	88.5			
Tinnitus	yes	5	23.8	3	3.8	7.81	1.69, 36.07	0.008*
	No	16	76.2	75	96.2			
Discharge	yes	6	28.6	7	9.0	4.06	1.19, 13.8	0.025*
	No	15	71.4	71	91.0			
Ear ache	yes	5	23.8	6	7.7	4.8	1.36, 16.94	0.047*
	No	16	76.2	72	92.3			
Left ear TM status	Perforated	7	33.3	7	9.0	1.97	0.060 , 0.65	0.008*
	intact	14	66.7	71	91.0			
Right ear TM status	Perforated	3	14.3	6	7.7	0.5	0.11 , 2.19	0.35
	intact	18	85.7	72	92.3			

TM: Tympanic membrane

*P<0.05 considered significant for odds ratio.

Table-3: Association of weight of explosion with otological findings.

Otological parameters		Distance				Odds ratio	95% Confidence interval	P-value
		≤10 meter (n=32)		>10 meter (n=69)				
		n	%	n	%			
Symptoms of ear problem	yes	14	43.8	7	10.3	7.90	2.65 , 23.55	<0.01*
	No	18	56.2	61	89.7			
Deafness	yes	13	40.6	5	7.4	10.77	3.14, 36.9	<0.01*
	No	19	59.4	63	92.6			
Tinnitus	yes	4	12.5	4	5.9	2.25	0.5, 9.6	0.275
	No	28	87.5	64	94.1			
Vertigo	yes	1	3.1	1	1	2.19	0.12, 35.16	0.597
	No	31	96.9	67	31			
Discharge	yes	8	25.0	6	8.8	4.13	1.22, 13.88	0.02
	No	24	75.0	62	91.2			
Ear ache	yes	6	18.8	5	7.4	2.86	0.80, 10.21	0.105
	No	26	81.2	63	92.6			
Left ear TM status	Perforated	10	31.2	4	5.9	0.14	0.04, 0.49	<0.01*
	intact	22	68.8	64	94.1			
Right ear TM status	Perforated	6	18.8	4	5.9	4.92.	1.14, 21.17	0.032*
	Intact	26	81.2	64	94.1			

TM: Tympanic membrane
*P<0.05 considered significant for odds ratio.

Table-4: Association of presence of victim in closed or open space with otological findings.

Otological parameters		Presence of victim				Odds ratio	95% Confidence interval	P value
		Closed space (n=39)		Open space (61)				
		n	%	n	%			
Symptoms of ear problem	Yes	7	17.9	14	23.0	1.58	0.55, 4.57	0.319
	No	32	82.1	47	77.0			
Deafness	Yes	6	15.4	12	19.7	1.61	0.52, 5.01	0.40
	No	33	84.6	49	80.3			
Tinnitus	yes	4	10.3	4	6.6	0.59	0.14, 2.54	0.48
	No	35	89.7	57	93.4			
Discharge	yes	7	17.9	7	11.5	0.69	0.21, 2.23	0.53
	No	32	82.1	54	88.5			
Ear ache	yes	4	10.3	7	11.5	1.10	0.30, 4.04	0.88
	No	35	89.7	54	88.5			
Left ear TM status	Perforated	6	15.4	8	13.1	1.24	0.39, 3.90	0.71
	Intact	33	84.6	53	86.9			
Right ear TM status	Perforated	2	5.1	8	13.1	0.179	0.021,1.49	0.11
	Intact	37	94.9	53	86.9			

TM: Tympanic membrane
*P<0.05 considered significant for odds ratio.

explosives); and distance from the site of explosion (14(43.8%) ≤ 10 m vs. 7(10.3%) >10 m) (p<0.01), except for relation of distance to vertigo, tinnitus and ear ache (p=0.597, 0.275 and 0.105, respectively). There was no significant difference in all symptoms in relation to the presence of victim in closed space vs. open space (Tables-2-4).

With respect to weight of explosives, there was substantial difference in the occurrence of deafness, tinnitus, vertigo, discharge and earache between the two groups. The odds of experiencing various symptoms of ears was high in those who were exposed to >80 kg of explosives. The odds of hearing loss was 4.72 (95% CI 1.54, 14.48) times in those exposed to >80 kg than in those who

were exposed to ≤ 80 kg of explosives. The left TM was intact in 71(91%) and 14(66.7%) of the patients who were exposed to ≤ 80 kg and >80 kg of explosives, respectively. The right TM was intact in 72(92.3%) and 18(85.7%) of the patients who were exposed to ≤ 80 kg and > 80 kg of explosives, respectively. Except for vertigo, there was significant association between weight of explosives (>80 kg) and symptoms of deafness, tinnitus, ear discharge and ear ache. Left ear perforation was more significant and right ear perforation ($p<0.05$).

Deafness 13(40.6%), tinnitus 4(12.5%) and discharge from ears 8(25%) were the prominent symptoms that occurred in those who were ≤10 m from the site of explosion. Ear ache, vertigo and tinnitus had no significant association with distance (≤10 m). Left and right ear TM was intact among those who were >10 m away from the site of explosion compared to those who were within 10 m from site of explosion, but the perforation was significant on the left ear when the distance of explosion was ≤10 m ($p<0.05$). The odds of hearing loss in those who were within 10m was 8.62 (95% CI 2.72, 27.28) times than those who were >10 m from the site of explosion.

There was no significant difference in the occurrence of ear symptoms between the groups who were exposed in closed or open space explosions ($p>0.05$). There was no significant association with any of the measured ontological parameters and the presence of victim in closed space ($p>0.05$).

Discussion

Damage to the ear is a primary blast injury. Transient or permanent hearing loss or tinnitus occurs due to blast-related ear damage to the sensitive structures of the inner and middle ear, such as the cochlea, ossicular chain, TM and vestibular system.

There is not much information on the impact of weight of explosives on the hearing loss. However, in our study, the odds of occurrence of overall symptoms of ear problem, except vertigo were significant with exposure to heavier explosives. While in case of distance from explosion, the odds of occurrence of hearing loss, and ear discharge was significant in those who were within 10m from the place of explosion. In both the above situations, left ear TM perforation was significant than right ear TM perforation.

In our study, 21% patients were diagnosed with blast-related ear injury. In the Boston Marathon bombing, 90% of hospitalised patients sustained TM perforation.[3] Of 3,981 military personnel injured in the Operation Iraqi Freedom, 30.7% were diagnosed with blast-related ear injury.[5] Inner/middle ear injury involving tinnitus (19.3%) and TM rupture (8%) were the most common otologic injury. A retrospective analysis of hearing thresholds and otologic complaints in more than 250 patients with blast-related injuries from the global war on terror showed that tinnitus, ear pain and dizziness were present in 49%, 26% and 15% of the patients.[6] Another study reported that 14%patients experienced a combination of tinnitus and hearing loss.[7] In another study, hearing loss (72.73%) and tinnitus (66.67%) were the most common symptoms and TM membrane perforations were encountered in 31 ears of 22 out of 33 patients.[8] Nawaz et al.[9] reported bilateral or unilateral hearing loss with bilateral or unilateral tinnitus in 23.33% who were affected by bomb blasts in Peshawar.

In our study, left ear TM perforation was significant among those who were within 10m from the site of explosion. Tympanic membrane rupture was seen in 27.6% patients who were within <10 m from the centre of the explosion.[7] In the Boston Marathon blast, proximity to blast (relative risk [RR]=2.7, $p<0.01$) were positive predictors of perforation.[3] Among 52 patients, there was no difference in the severity of symptoms (deafness, vertigo and tinnitus; $p<0.05$) with regard to the distance (0-0.3 m, 3.3-6 m, >6 m)from blast.[10] Tympanic membrane perforation was evident in 16% of explosion-injured patients in the Operation Enduring Freedom and Operation Iraqi Freedom.[11]

In our study, there was no significant difference in the occurrence of hearing loss among the patients who were in closed or open space explosion. However, in a cross-sectional study involving 76 military personnel injured from blast injury in Southernmost Thailand, the prevalence of sensorineural hearing loss among patients in the open-, semi-open and closed space groups was 62.77%, 67.86% and 73.33%, respectively.[12] The average weight of explosives was 11.42kg and mean distance from explosion was 5.66m and both had no significant influence on the incidence of hearing loss or other symptoms of ear problems.[12]

Conclusion

There was a significant association between hearing loss and quantity of explosion or distance from explosion. The presence of victim in closed or open space was not associated with hearing loss. Perforation of TM, especially left ear, was significantly associated with quantity of explosion or distance from explosion. Generally, tinnitus and hearing impairment is regarded as a temporary phenomenon which resolves itself over time without the need for medical intervention. However, there is an increased risk for substantial hearing impairment, particularly at high frequencies. Therefore, irrespective of

symptoms, all victims should be subjected to otologic consultation, or at least an audiometric screening test to exclude hearing impairment.

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