

Blast Injury of the Ears: The Experience from Yala Hospital, Southern Thailand

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Objective: To report acute and subacute consequences of blast injury to the ear from terrorists' bombings experienced from Yala Provincial Hospital, Southern Thailand.

Study design: Retrospective chart review was done on 54 patients who suffered otologic injuries from bombing attacks in Yala Province from January to May 2005. Only 33 patients who had complete otologic and audiologic examination with a 3-month follow-up were studied.

Material and Method: The ear symptoms, the size of tympanic membrane perforation, degree of hearing loss at first examination within 30 days after injuries were recorded. After a 3-month follow-up, the rate of spontaneous healing, rate of operation needed and long-term complications including hearing loss were analyzed.

Results: The two most common initial symptoms were hearing loss (72.73%) and tinnitus (66.67%). Tympanic membrane perforations were encountered in 31 ears of 22 out of 33 patients. Spontaneous healing occurred in 23 ears (74.19%) with the highest incidence in small perforations (size < 50%). All healings occurred within 8 weeks. Tympanoplasty was done on the rest, except one patient. Eight patients (24.24%) had sensorineural hearing loss without tympanic membrane perforation. They still have sensorineural hearing loss, which is rather mild and typically affects in high tone with five of this group having normal hearing in speech range. Eleven patients from the tympanic membrane perforation group still have mixed hearing loss, which were also mostly mild.

Conclusion: Patients with aural symptoms after a blast injury need thorough otologic and audiological examination. The spontaneous healing of tympanic membrane perforation from explosive injury was relatively high (74.19%) after an 8-week follow-up, only 8/31 ears required surgical repair. At 3-months follow-up, more than two-thirds of the patients still had residual hearing loss, which was rather mild and affected mainly in high tone.

Keywords: Blast injury, Tympanic membrane perforation, Hearing loss

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Blast injury is uncommon in peacetime. Although sporadic cases from accidents have been encountered, most otolaryngologists in Thailand have little experience on this matter. Terrorism started in the southern part of Thailand in January 2004, and many patients have suffered injuries from bombing since then.

In an explosion, solid or liquid material is converted rapidly into gas, resulting in sudden release of energy that varies based on types and sizes of bomb. After an explosion, blast wave spreads outward from the explosion faster than sound speed. The wave consists of a positive phase which has high pressure lasting a few milliseconds and a negative phase which is less than atmospheric pressure and lasts longer about tens of milliseconds⁽¹⁾. In a small confined space, the pressure wave reflections will cause more damage. At a far distance from the explosion, the blast or pressure

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waves gradually lose energy and diminish into acoustic waves which can still cause acoustic trauma⁽¹⁾.

Blast injuries are commonly divided into 4 types: *Primary blast injuries* are caused by pressure waves created during the explosion, *secondary injuries* are caused by flying objects, *tertiary injuries* occurs when the displaced victims collide with surrounding obstacles and *quaternary injuries* refer to explosion-related injuries including burns, asphyxia and toxic exposure⁽²⁾. Primary blast injuries usually involve gas-containing organs such as middle ears, lungs and bowels. The damage is caused by rapid collapse and then expansion of the organ during the positive and negative phase of pressure wave consecutively. The blast wave stretches and displaces tympanic membrane causing laceration and hemorrhage. Disruption of ossicles but not tympanic membrane perforation may protect the inner ear from permanent damage^(1,3). Acoustic waves that exceed 140 dB SPL cause inner ear damage. Middle ear damage and hearing loss are common after a single exposure of high pressure and duration of greater than 1.5 milliseconds as the ear reaction time is 20 milliseconds⁽⁴⁾. Inner ear injury usually manifests as temporary tinnitus and hearing loss but severe injury to the organ of corti with permanent damage may occur⁽³⁾. The effect of a blast on the ear depends on the rapidity of the pressure to reach its peak, the peak pressure and duration of positive phase. The severity of damage depends on the bomb type, the distance from the explosions, the obstacles and whether patients are in a confined or open space^(1,5). Mrena (2004) studied ear damage from a 3-kg ammonium nitrate bomb detonated in a large confined space and found that rupture of tympanic membrane occurred in patients within 10 m from the explosion and acute acoustic trauma was still possible at 70 m distance⁽⁶⁾.

The present study was aimed to describe otologic blast injuries in a Thai provincial hospital, regarding the incidence of hearing loss and tympanic membrane perforation and the outcome after a 3-month follow-up.

Material and Method

The present study was based on a series of 33 patients from Yala Hospital who had otologic injuries from terrorists' bombing from January to May 2005. There were 110 patients suffering blast injuries with three deaths, 54 of which were injured in open and 56 in a semi-open space. Fifty-four patients had Otolaryngologic consultation for ear and hearing problems. Among these 54 patients, 35 were injured in

semi-open spaces and 19 were in open spaces. The semi-open space is an area covered with a roof and contains only incomplete walls such as an open-air restaurant or a waiting area with no doors and a front wall. There was no incidence of bombing in a small confined space such as a bus. The bombs were relatively small and mortality was low. Due to the chaotic situations, most patients were poor at judging their distance from the bombs and the data are considered unreliable and inconclusive.

The majority of cases were from explosions at a noodle shop on the 16th of January 2005. All patients with otologic symptoms (i.e.: tinnitus, hearing loss, ear pain, ear fullness, ear discharge, sound distortion, dizziness or vertigo) had otologic and hearing evaluation done in the first week after injuries except a few patients who sustained multiple severe injuries requiring other urgent medical and/or surgical managements. Ten patients who were later referred to other hospitals with no complete data and one patient with a previous history of radical mastoidectomy were also excluded from the present study. Altogether 33 cases completed the follow up period of 3 months and were included in the present study.

The ear symptoms, the size of perforation and degree of hearing loss were recorded at first examination. The perforation size was estimated by otolaryngologists and classified into three groups: < 50%, 50-80% and > 80% of the total area of tympanic membrane. Medical and surgical management were recorded. Ossicular chain disruption was identified at the time of operation. The follow-up plan included monthly ear examination and hearing test for three months. However, some patients had only the first and third month examination.

Demographic data of the patients, associated injuries, and whether the explosion occurred in an open or semi-open space were also studied. The results were presented in frequency tables.

Results

There were 22 male and 11 female patients aged 8 to 53 years old (average 30.93). Nine of them were military personnel and the rest were civilians. All patients had no previous history of tinnitus, ear diseases or hearing problems before the injuries. The most common symptom was hearing loss found in 24 out of 33 patients (72.73%) followed by tinnitus (n = 22; 66.67%). Twelve patients complained of both tinnitus and hearing loss. Other symptoms were earache (n = 4; 12.1%), dizziness (n = 1; 3%) and fullness in the ear

Table 1. Ear symptoms correlate to otologic and audiological findings in 33 patients, 27 of which had hearing loss by audiometry

Audiological and otologic findings	Ear symptoms				
	Hearing loss	Tinnitus	Pain in ear	Fullness in ear	Dizziness
Sensorineural hearing loss in 8 patients	5	5	-	1	1
TM perforation in 22 patients (3 had normal audiogram)	19	14	4	1	-
Normal audiogram and no TM perforation in 3 patients	3	3	-	1	-
Total	27	22	4	3	1

TM = tympanic membrane

Table 2. Patients were classified by being injured in an open spaces or semi-open spaces

	Open space	Semi-open space	Total
All patients	16	17	33
Sensorineural hearing loss	4	4	8
TM perforation	10	12	22

(n = 3; 9%). No patient had symptoms of sound distortion or vertigo. The details of symptoms are listed in Table 1. Three patients who complained of tinnitus with hearing loss had no perforation of tympanic membrane

and normal audiogram, although one of them had small hemorrhages on both tympanic membranes. Eight patients had hearing loss (by audiometry) without tympanic membrane perforation, but only five of them complained of hearing loss. Among 22 patients with tympanic membrane perforation, three of them with small perforations had normal audiogram. Both the tympanic membrane perforation group and sensorineural hearing loss group could be found in explosions in open and semi-open areas (Table 2). The average initial audiogram and after the 3-month follow-up are shown in Fig. 1.

Twenty-two patients (31 ears) had tympanic membrane perforation that occurred bilaterally in nine

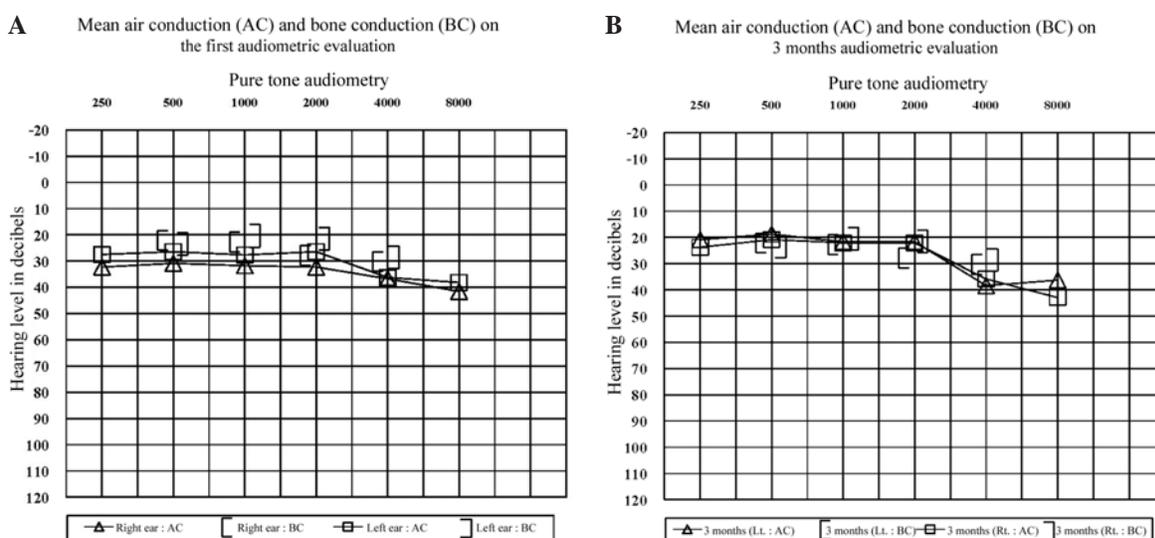


Fig. 1 Mean air conduction (AC) and bone conduction (BC) on the first audiometric evaluation (A) and at 3-month follow-up (B)

Table 3. The size of tympanic membrane perforation and spontaneous healing rate

Size of perforation	< 50%	50-80%	> 80%
Spontaneous healing after 8 weeks	10 (90.9%)	11 (68.75%)	2 (50%)
Surgery (tympanoplasty)	1	5	2
Total	11	16	4

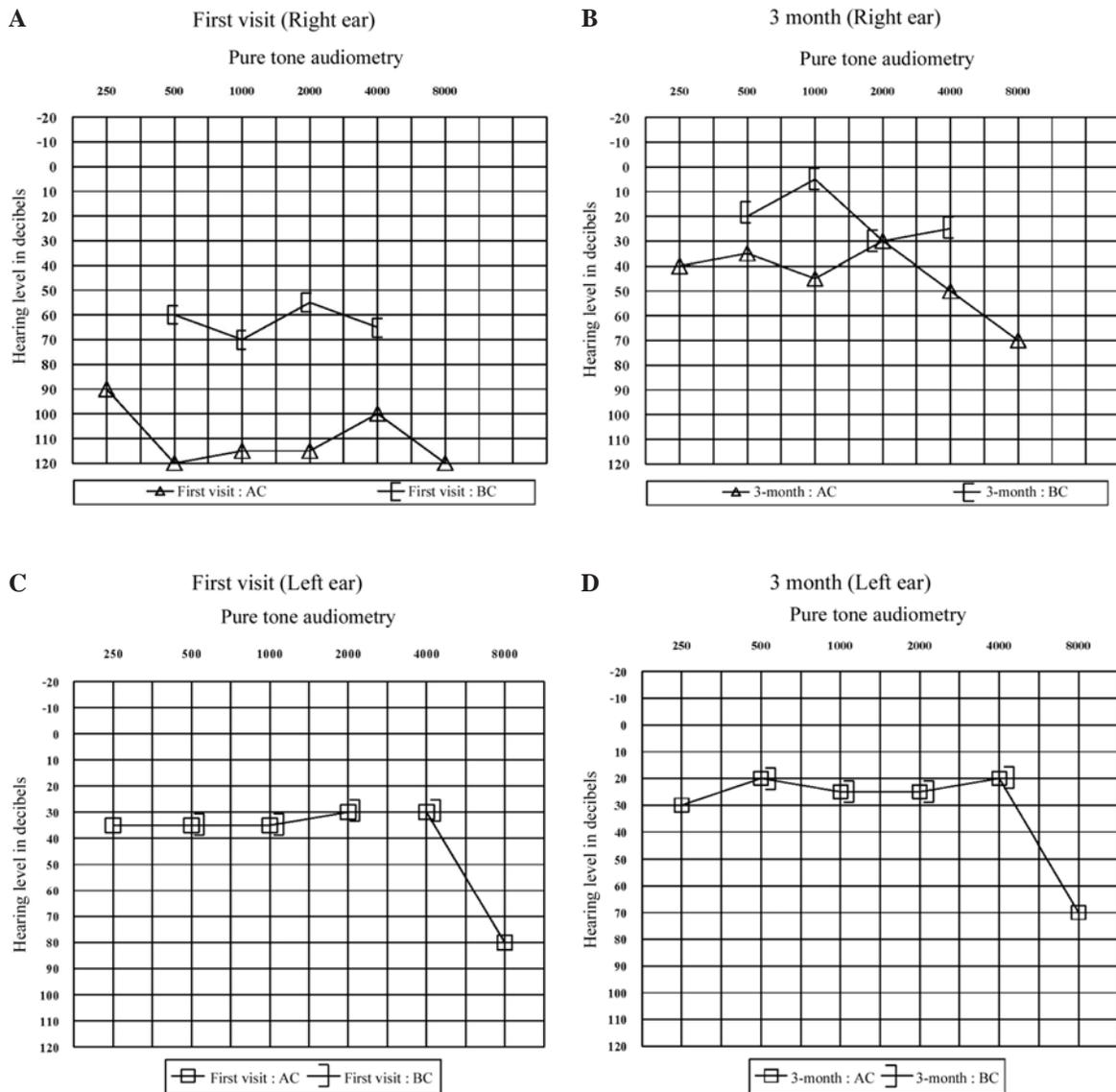


Fig. 2 One patient had right-sided mixed hearing loss and 80% perforation of right tympanic membrane which later required tympanoplasty, the initial severe hearing loss of the sensory component (A), recovered to mild degree in 3 months (B), the left ear which had initial mild sensorineural hearing loss with typical high tone loss (C), recovered slightly at 3-month follow up (D)

patients and unilaterally in 13 patients. The size of perforation and spontaneous healing rate are shown in Table 3. Spontaneous healing occurred in 74.19% (23 ears) within eight weeks. Spontaneous healing was much higher among smaller perforations less than 50%. Tympanoplasty was performed in eight ears and ossicular chain disruption was encountered in one ear. One patient refused surgery. All tympanic membrane grafts healed well at 2-months follow up.

Thirteen patients had associated injuries that were severe in four cases. Most injuries were penetrating and burn injuries except one patient who had blast injury of the lung and intestine. Eleven of these patients had tympanic membrane perforations while the other two with slight burns on their legs had sensorineural hearing loss.

At the end of three months, eight patients from 27 who had initial hearing loss (by audiometry) recovered to normal hearing. Eight patients from the hearing loss without perforation group still had sensorineural hearing loss, which was mild, and typically affected the high tone. Five of this group had normal hearing in speech range. Eleven patients from the tympanic membrane perforation group still had mixed hearing loss, which was also mostly mild. Interestingly, one patient with severe hearing loss recovered to mild degree in three months (Fig. 2). No patient complained of tinnitus or other ear symptoms after three months.

Discussion

Most reports on blast ear injuries focus on tympanic membrane perforation. In the present series, the authors used criteria for blast ear injuries as recommended by Mrena⁽⁶⁾ which includes patients with appropriate blast exposure and acute subjective hearing loss, or other otologic complaints such as tinnitus, hyperacusis or sound distortion. Aural symptoms without hearing loss should be recorded in association with blast injuries. Some symptoms such as tinnitus and hyperacusis can be permanent and affect the future quality of life. Many blast injury patients in Yala province did not receive otologic and audiological evaluation and thus the incidence of otologic injuries may be lower than it should be.

Mrena⁽⁶⁾ reported the result of a shopping mall bomb explosion (large confined space) in Helsinki showing that patients with ear drum perforation were within 10 m (7 m in average) from the center of the bomb and sensorineural hearing loss occurred in those who were as far as 70 m (average 11.9 m). Patients in the present report were a collection of many terrorist's

bombings in chaotic situations. The size of the bombs, the exact location of the bombs' centers and the exact distance from the bombs are not accurate enough to make any conclusions.

Tympanic membrane perforation did not seem to correlate with other gas containing organ injuries, i.e. lungs and bowels and is not a warning sign for observing the possible injuries to those organs^(2,7).

Initial treatment of tympanic membrane perforation from a blast injury is still controversial ranging from prompt myringoplasty, prompt patching of perforation or no intervention. The suitable time of later tympanoplasty is also controversial^(1,8,9).

In the present series all patients with tympanic membrane perforation did not receive any initial treatment such as ear cleaning, eversion of the membrane or paper patch except one patient who had ear cleaning after injury. This patient had 80% perforation that required tympanoplasty. No oral antibiotic or ear drop was prescribed. Spontaneous healing of tympanic membrane perforation occurred in 74.19%, which is comparable to other reports^(1,8). Miller⁽⁹⁾ found an unexpectedly low incidence (38%) of spontaneous healing in his series of 124 tympanic membrane perforations after massive explosion in a crowded confined space which is a different situation from the presented patients. In the present study, spontaneous healing occurred very high in small perforation (< 50% in size). Four perforations which were larger than 80%, also healed spontaneously in two (50%). In a review by Garth⁽³⁾, there was a large difference in the incidence of ossicular chain damage among reports. Vertigo is also an uncommon problem. In the present report, ossicular chain disruption was found only in one case, which reflects the less severe nature of these bombs. There was only one patient who complained of dizziness. No vertigo was found in the present report.

More than two-thirds of the patients had some degree of residual hearing loss, although mostly mild and did not quite affect the speech range. Further follow up with audiometry should be done. Audiological evaluation is recommended in all patients with aural symptoms after blast injuries.

Conclusion

Otologic injury from a bombing attack was increasingly found in Southern Thailand. In the present study, spontaneous healing of tympanic membrane perforation after blast injury is relatively high (74.19%) within eight weeks which left only eight out of 31 ears that required surgical repair. However, three months

after the injuries, more than two-thirds of the patients still had mild, high tone residual hearing loss. Patients with aural symptoms after blast injuries require thorough otologic and audiological examination.

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อันตรายต่อหูจากกระเปิด: ประสบการณ์จากโรงพยาบาลยะลา

สุนีย์ ตั้งสินมั่นคง, จีระสุข จงกลวัฒนา, วัฒนา ปิยวงศ์วิศาล, สุวัจน อธิภาส, สมพร นามเจริญชัยสุข

วัตถุประสงค์: เพื่อรายงานผลของระเบิดก่อการร้ายในจังหวัดยะลา ที่เป็นอันตรายต่อหูในลักษณะเฉียบพลัน และกึ่งเฉียบพลัน

ลักษณะการศึกษา: เป็นการศึกษาย้อนหลัง ในผู้ป่วยของโรงพยาบาลยะลาที่ได้รับอันตรายต่อหู จากเหตุการณ์ระเบิดหลายครั้งในจังหวัดยะลา ตั้งแต่เดือนมกราคม ถึง พฤษภาคม พ.ศ. 2548 จำนวนทั้งหมด 54 ราย โดยรายงานนี้ศึกษาเฉพาะผู้ป่วย 33 รายที่ได้รับการตรวจหูและการได้ยินภายใน 30 วันหลังเกิดเหตุ และได้รับการติดตามผลครบ 3 เดือน

วัสดุและวิธีการ: ผู้รายงานได้บันทึกอาการแสดงที่เกี่ยวข้องกับหู ขนาดของแก้วหูทะลุ และระดับการได้ยิน โดยการตรวจครั้งแรกจะตรวจภายใน 30 วันหลังเหตุระเบิด และนัดหมายมาตรวจรักษาและตรวจการได้ยินเป็นระยะ ๆ เป็นเวลา 3 เดือน แล้วสรุปอัตราที่แก้วหูทะลุปิดตัวเอง อัตราที่ต้องได้รับการผ่าตัด และการสูญเสียการได้ยินที่เหลืออยู่

ผลการศึกษา: อาการแสดง 2 อาการที่พบบ่อยคือ การได้ยินลดลงพบ 72.73% และเสียงในหู พบ 66.67% การตรวจร่างกายพบแก้วหูทะลุ 31 หูในผู้ป่วย 22 ราย แก้วหูทะลุสามารถปิดตัวเอง 23 หู (74.19%) ซึ่งโอกาสปิดเองจะสูงสุดในรายที่รูทะลุมีขนาดเล็ก (< 50%) โดยจะปิดภายใน 8 สัปดาห์ ที่เหลือได้รับการผ่าตัดปะแก้วหู ยกเว้นผู้ป่วยที่ปฏิเสธผ่าตัด 1 ราย ผู้ป่วย 8 ราย (24.24%) มีภาวะสูญเสียการได้ยินแบบหูชั้นในและประสาทหู โดยที่ไม่มีแก้วหูทะลุ ซึ่งจากติดตามผลแล้วยังคงมีอาการอยู่แต่สูญเสียในระดับน้อย โดย 5 รายในจำนวนนี้การได้ยินของความเห็นในช่วงเสียงคนพูดอยู่ในเกณฑ์ปกติ ในกลุ่มที่มีแก้วหูทะลุ พบว่าผู้ป่วย 11 รายยังมีภาวะสูญเสียการได้ยินแบบผสม แต่สูญเสียน้อยเช่นกัน

สรุป: ผู้ป่วยที่มีอาการทางหู หรือการได้ยินผิดปกติหลังได้รับอันตรายจากกระเปิด ควรได้รับการตรวจหูและตรวจการได้ยินทุกราย แก้วหูทะลุจากเหตุระเบิดมีโอกาสปิดเองได้สูง ซึ่งในรายงานนี้พบได้ถึง 74.19% โดยปิดเองใน 8 สัปดาห์ และมีเพียง 8 จาก 31หูที่ต้องผ่าตัด 3 เดือนหลังเหตุระเบิด ผู้ป่วยมากกว่าสองในสามยังคงสูญเสียการได้ยิน แต่ส่วนใหญ่จะสูญเสียน้อยและเสียที่ความถี่สูง
