Blast Injury of the Ears

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Blind injury of the ears is rare in a normally peaceful society except for certain industrial accidents, it is usually found during wars or bomb-related terrorist attacks. In Thailand, this condition has come into attention with its sharp increase in incidents due to the sudden increase in numbers of bombing attacks in the southern most provinces since January 2005. For many Otolaryngologists who might not have treated blast injury of the ears regularly, it is important to become knowledgeable since blast-related ear injuries, although not lethal, require appropriate initial evaluation and long-term follow-up.

During an explosion, solid or liquid material in a bomb is rapidly converted into gas, resulting in a sudden release of energy. Blast waves, which consist of a high pressure phase and a negative pressure phase, immediately spread outward from the explosion faster than the speed of sound and damage the surroundings. The blast or pressure waves gradually lose energy over distance and diminish into acoustic waves which can still cause acoustic trauma.1

Blast injuries are 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 occur 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 the middle ears, lungs, and bowels. The damage is caused by rapid collapse and then expansion of the organ during the positive and negative phases of consecutive pressure waves.

In the ear, the initial blast wave stretches and displaces tympanic membrane causing laceration and hemorrhage and sometimes ossicular damage. An increased pressure at only 5 psi above atmospheric pressure can rupture the tympanic membrane.2 Disruption of ossicles, but not tympanic membrane perforation may protect the inner ear from permanent damage.3,4 Acoustic waves that exceed 140 dB SPL cause inner ear damage. Middle ear damage and hearing loss are common after a single exposure to high pressure and the duration of greater than 1.5 milliseconds as the normal ear reaction time is more than 20 milliseconds.3,4 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 the blast on the ear depends on the rapidity of the pressure to reach its peak, and the peak pressure and duration of the positive phase. The severity of damage depends on the bomb type, the distance from the explosion, the obstacles and whether patients are in a confined or open space.3,5 Rupture of the tympanic membrane tends to occur in patients closer to the explosion on the contrary, acute acoustic trauma can affects those that are furtheraway.5

Mrena recommended the criteria for blast ear injuries to include all patients with appropriate blast exposure and acute subjective hearing loss, or other otologic complaints such as tinnitus, hyperacusis or sound distortion.6 Symptoms of dizziness and vertigo may reflect injuries to the balancing system of the inner ear. Anyhow, most reports tend to focus on tympanic membrane perforation.

A 2006 report from the Walter Reed Army Medical Center has shown that among 257 military personnel sustaining blast-related injury, 64% of them suffered from ear injuries and hearing loss as well.6 In a recent report from Yala Hospital, 49% (54/110) of blast-injured patients are found to experience ear and hearing problems although information was available in detail for only 33 patients.6 Sensorineural hearing loss is usually high tone and temporary, but initial deafness may also occur. Spontaneous recovery can occur within hours after injuries. Some can improve from severe deafness to near-normal hearing.6 Long-term hearing loss is usually mild and affects high tone.

The most common symptoms are tinnitus and hearing loss, each of which occurs in more than 50% of the patients.6,8 Other symptoms include earache, fullness in the ear and hyperacusis. Vertigo is however an uncommon problem. Otolologic findings are usually tympanic membrane perforation, sensorineural hearing loss, conductive hearing loss and mixed hearing loss.

The incidence of tympanic membrane perforation varied among reports. Mrena found 27% among 29 patients from shopping mall explosions in Finland. Miller reported 48.8% tympanic membrane perforation in a large explosion in a confined space in Ireland.6 The incidence from Yala hospital, Thailand of many bombing attacks is 66.7% (22/33).8 Leibovici reported a high incidence of tympanic membrane perforation in 142/193 (73.6%) primary blast injuries from terrorist bombings in Israel.11 These may reflect the different factors such as the power of the bombs, the distance of...
the victims from the bombs, whether the explosions were in a closed or open space and the percentage of the victims seeking medical attention.

Tymanic membrane perforation did not seem to correlate well with other gas containing organ injuries, i.e. lungs and bowels and was not a warning sign for observing possible injuries to those organs.\textsuperscript{9,11,12} The spontaneous healing rate of tympanic membrane perforation from blast injuries is up to 73-85% in most reports which make simultaneous grafting not justified (73.8% in 3 months, Kronenberg 1993; 82%, Kerr 1975; 73.8%, Wolf 1991; 74.19%, Tungsimmunkong 2007). The spontaneous healing rate is higher in smaller perforations. Miller found an unexpectedly low rate (38%) of spontaneous healing in his study of 124 tympanic membrane perforations, which may be related to the extraordinary condition of a massive explosion in a crowded confined space.\textsuperscript{9} Cholesteatoma is one of the delayed conditions that could appear following blast-related tympanic membrane perforation, and thus should be checked for during follow up since its treatment includes surgery.\textsuperscript{13} In a review by Garth, there was a large difference in incidence of ossicular chain damage among reports.\textsuperscript{3}

Approximately 25-30% of patients with tympanic membrane perforation will eventually require tympanoplasty. Helling suggested that early intervention of tympanic membrane perforation (suctioning, eversion of perforations and paper patch) may decrease the need for delayed operation.\textsuperscript{5} Certain numbers of the patients had some degree of residual hearing loss, although most were mild and did not affect the speech range and communication capability. Kerr found that 30% of the patients still experience remaining high tone sensorininal hearing loss after 1 year.\textsuperscript{1} Initial otologic and audiological evaluation is recommended in all patients with aural symptoms as part of their blast injuries with appropriate follow up among those with abnormal findings.

REFERENCES