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An Overview of the Mechanics and Pathology of Auditory System Blast Injuries

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ABSTRACT:-

Our expertise of blast injuries to the auditory system is limited and rare. This page covers the existing literature and provides a description of how blast waves interact with the ear, as well as information on the mechanisms of injury, pathology, clinical characteristics, and an overview of management concepts. Few otolaryngologists in Great Britain see many cases of blast injury to the ear, which is uncommon in times of peace. Occasionally, there are more casualties after a terrorist bombing, which leads to sporadic events, or there are isolated mishaps that result in isolated incidents. Otological injury is frequently missed in a patient who has several wounds, so it's important to note that Hadden et al. (1978) found just 15 perforated tympanic membranes among the 1535 victims of terrorist explosives in Belfast. There is a chance that some ear injuries went unreported even though many of these casualties may have been the victims of unconfined free-field explosions with a low incidence of perforations. In contrast, following a single blast at the Abercorn Restaurant, Kerr and Byrne (1975) reported on 60 ruptured tympanic membranes.

Keywords: Blast injuries; Auditory pathways.

INTRODUCTION: -

Our expertise of blast injuries to the auditory system is limited and rare. This page covers the existing literature and provides a description of how blast waves interact with the ear, as well as information on the mechanisms of injury, pathology, clinical characteristics, and an overview of management concepts. Few otolaryngologists in Great Britain see many cases of blast injury to the ear, which is uncommon in times of peace.

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The focus of this page is on the injuries brought on by blasts, however auditory impairment can also arise from continuous noise, impulse noise, or blast trauma. The source of the pressure or the features of its waveform can be used to categorise impulse noise and blast, but this division is arbitrary [4]. Small guns are typically stated to produce impulse noise, but artillery or explosions are typically said to produce blast-like sound energy. When deciding whether an impulsive noise is a blast or not, the following factors are helpful:

- Typically, impulse noise has a peak overpressure of less than 2 kPa (160 dB), although a powerful gun's muzzle blast may produce tens of kPa.
- In contrast to impulse noise, a blast involves significant air and combustion product movement.
- Low frequency mechanical clatter is frequently linked to impulse noise.

After a detonation, there is a shock wave that is basically instantaneous over-pressure and it moves through the air faster than sound. Dynamic overpressure, an area of gas flow composed primarily of combustion byproducts, is located behind the shock wave. A brief positive pressure phase is created when these two factors come together, and a prolonged subatmospheric phase follows.

DISCUSSION:-

The effect of blast on the ear

Injuries are more likely to be caused by flying debris than by the blast wave itself. These wounds will resemble other projectile-related penetrating soft tissue wounds in a lot of ways. Blood vessels may be injected into the tympanic membrane, there may be subepithelial haemorrhages, small split-like perforations or there may be multiple or complete perforations. There have been few studies of the human ear, therefore data on how ears respond to blast that come from animal models cannot be directly applicable to people because each species' responses vary [5]. In one of the earliest studies on the human ear, Zalewski (1906) employed static over-pressures and discovered that 37 kPa was the lowest pressure at which the tympanic membrane ruptured (5.4 psi) [6].

Stuhmiller (1989) demonstrated relatively distinct changes in stress throughout the tympanic membrane using static pressure loading in a model, with particularly high levels of stress being detected towards the periphery [7]. According to Stinson (1985)'s research, the unequal pressure distribution over the drum will make the tympanic membrane's stressing patterns much more challenging. A blast places the drum under stress levels that are well over its typical physiological thresholds, changing its mechanical properties [8]. Stress within the drum may push the lamina propria's radial fibres past their elastic breaking points, leading to the rupture of some of these fibres and an increase in the compliance of the tympanic membrane. In chinchillas subjected to repeated 166 dB impulsive stimuli, Eames et al. (1975)

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observed an increase in compliance that gradually decreased over the course of the next two weeks [9, 10].

Immediately following the explosion, blast injury victims frequently experience profound sensorineural hearing loss and tinnitus. Hearing typically returns in its whole within a few hours after this transient threshold shift and tinnitus. While some individuals' hearing will gradually improve, others will experience a permanent hearing loss [11]. Teter et al. (1970) analysed the audiograms of explosion victims and documented four alternative audiometric configurations, while a high tone sensorineural loss appears to be the most prevalent audiometric picture in blast victims [12]. Since blast injury typically lacks the 4 kHz dip associated with noise-induced hearing loss, a new mechanism of harm may be at play. As hearing loss is frequently restricted to high tones and strong speech discrimination is retained, many patients may be unaware of their hearing loss [13].

Tympanic membrane perforation and ossicular disruption may protect the cochlea to some extent, according to some studies. In guinea pigs subjected to a greater blast (resulting in middle ear disruption), Akiyoshi et al. (1966) discovered less cochlear damage than in guinea pigs exposed to smaller blasts [14]. Animals exposed to several shock waves were studied by Hamernik et al. (1984a) and Eames et al. (1975), who reported findings that were similar [15,16]. This is not unexpected because subsequent shock waves will have less energy to transfer to the cochlea due to the initial breakdown of the conducting mechanism. Interestingly, despite the fact that none of the blast victims had ossicular damage, Kerr and Byrne (1975) discovered no evidence of this phenomena [17, 18].

Treatment

The majority of medical professionals concur that healthy ears do not need active treatment. Although there isn't much to lose by trying these, especially if the hearing loss is severe or in an only hearing ear, there isn't much proof that treating sensorineural loss with steroids, vasodilators, or vitamin supplements makes any difference to the recovery.

A perilymph fistula needs to be taken into account in individuals who experience persistent dizziness or variable hearing loss. If symptoms persist and a fistula is suspected, a tympanotomy should be done despite the fact that this consequence is uncommon but significant. A graft should be used to seal any fistulas discovered during tympanotomy.

Given that cholesteatoma affects 7.6% of ears (Kronenberg et al., 1988), it is advisable to assess cases in which the tympanic membrane has been ruptured, and the middle ear and mastoid should be thoroughly examined if there is any suspicion of cholesteatoma. Following a bomb injury, cholesteatoma may be severe [19].

Prevention

The construction of armoured vehicles in a military environment may offer the occupants significant protection from an external blast. Ear muffs or ear plugs can be utilised by those

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who aren't fortunate enough to have this protection. While ear muffs are typically thought to provide the best defence against continuous or impulsive noise exposure, Jonsson (1990) has demonstrated that ear plugs provide more effective defence against blast waves [20]. In models exposed to overpressures of 190 kPa, ear plugs provided enough protection to make perforation unlikely, with only 14 kPa detected in the ear canal. 100 kPa canal pressures were measured using ear muffs. Because of how ear muffs function, the blast can easily dislodge them, making them of little use.

CONCLUSION:-

Since some smaller plugs might be forced down the canal by the blast and cause direct damage to the tympanic membrane and middle ear, it is possible that the design of ear plugs matters. There would be no possibility of this happening if a larger plug was inserted into the concha in a manner similar to how a hearing aid mould is. There are earplugs with a valve or a metal disc that allow the user to hear conversation and offer decent protection against impulse noise. Despite the fact that they haven't been tested in this environment, it is likely that these would likewise offer effective defence against blast waves. Further study is required in the area of ear plug design for blast defence.

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