Acoustic Trauma: Minimum Exposures to Continuous Noise

Robert A Dobie
Elliott H Berger

NHCA; Grapevine TX, Feb 8, 2019

How it started

• Berger: Single MRI session (even w/HPDs) can lead to minimal TTS (ABR; Jin et al 2018); can we predict risk of PTS using ISO 1999?
• Dobie: let’s look at Dix Ward’s (1991) paper
• Berger: why don’t you update Ward’s analysis of acoustic trauma and present this at NHCA?
• Dobie: why don’t you?
• Berger: let’s do it together.

Definitions

ACOUSTIC TRAUMA
H. B. PECKHAM, M.D., Annals of Surgery, 1945

From the Department of Surgery (Division of Otolaryngology), University of Chicago, Chicago, Ill.

Oft may think of trauma as due only to direct contact between the primary force and some part of the body. However, it may be pointed out that the force may originate at some distance and be propagated to the body like a sound wave through the surrounding medium (air, water). An important example is the blast wave.

The peripheral ear is a mechanism especially constructed to respond to pressure (sound) waves propagated by the molecules of the air at the rate of about 1,700 feet per second. The normal stimulus for the ear represents an exceedingly small pressure disturbance. When these pressure waves are sufficiently great they may traumatize the exquisitely delicate neural elements suspended in the fluid of the labyrinth.

Acoustic trauma (boiler maker’s deafness, explosion deafness, etc.) is a term used here to denote injury to the neural elements of the ear by noise. The
Acoustic Trauma

- Older authors (and, sadly, even some of our contemporary colleagues): any hearing change caused by noise (temporary or permanent, acute or chronic)
- Our review is limited to pure tone PTS from continuous noise

Acoustic trauma vs. “acoustic shock”

- Recent papers (Westcott 2006; Hooper 2014; Baguley et al 2016) suggest that sudden unexpected sounds that don’t cause PTS are associated with
  - Hyperacusis
  - Otalgia
  - Tinnitus
  - Dizziness
  - Sleep disturbance
- Mostly from clusters of call center employees in Australia, Denmark, and GB (social contagion?)
- Brief sounds, levels ≥ 82 dBA (McFerran & Baguley 2007)
- No documented objective findings

Ward 1991;
“Hearing Loss from Noise and Music”
Presented at Audio Engineering Society.

“Bob – It sure would be nice to be able to add to this sparse collection of points, but so few people have the foresight to get an audiogram before acoustic trauma.
- Dix”

Our goal was to do just that.
Methods

• Search for papers with exposures (level, duration) and audiometric evidence of PTS (present at least one week later)
• Sources: Ward 1991 references, RAD and EHB own files (> 6000 PDFs each), other ref. lists
• PubMed (Human, English)
  – “acoustic trauma” OR (hearing loss AND (noise OR music) AND (sudden OR acute))
  – 577 hits, only 11 met criteria based on title, abstract
    * Included 19 re MRI (none documenting acoustic trauma)

Methods (cont.)

• Also searched Defense Technical Information Center, and queried 47 colleagues
• Only 9 papers reported acoustic trauma with exposure data and audiometry
  – 3 from Ward 1991 review
  – 2 from PubMed search
  – 3 from authors’ files
  – 1 from reference list of paper from authors’ files
• PubMed missed most of the 9

9 informative papers

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davis et al. 1950</td>
<td>TTS experiment</td>
</tr>
<tr>
<td>Lenarz &amp; Gulzow 1983</td>
<td>Acoustic reflex test</td>
</tr>
<tr>
<td>Arriaga &amp; Luxford 1993</td>
<td>“</td>
</tr>
<tr>
<td>Hunter et al. 1999</td>
<td>“</td>
</tr>
<tr>
<td>Elonka 1986</td>
<td>“</td>
</tr>
<tr>
<td>Orchik et al. 1987</td>
<td>Cordless phone</td>
</tr>
<tr>
<td>Singleton et al. 1984</td>
<td>“</td>
</tr>
<tr>
<td>Kung &amp; Sataloff 2006</td>
<td>Siren</td>
</tr>
<tr>
<td>McMillan &amp; Kileny 1994</td>
<td>Bicycle horn</td>
</tr>
</tbody>
</table>
Methods (cont.)

- Converted levels to equivalent diffuse field levels (dBA) for comparability to OSHA, NIOSH, etc. (methods on request; we hope to publish)
- Ambiguities
  - Durations sometimes had to be estimated
  - Offending tone (reflex tests) unclear; chose tone with highest dBA level
  - Some level measurement methods unclear
  - Many of our cases lacked peer review
Tentative levels/durations capable of causing acoustic trauma in most susceptible
Caveats

- Case reports are anecdotal
- Lowest level of medical evidence (below randomized trials, cohort, case-control, cross-sectional, case series)
- Special case of “publication bias” (results can’t be regarded as typical)
- Acoustic trauma cases may represent tiny fraction of population (most susceptible)

Intense exposures with no PTS:
4 experiments (89 Ss) and an accident (some had very large TTS)

- Davis et al 1950 (n = 19)
- Eldred et al 1955 (n = 10)
- Schori 1976 (n = 40)
- Brownson 1973 (n = 20)
- Raleigh et al 1963 (n = 2, after steam line rupture)
CONCLUSIONS

• “Acoustic trauma” (AT) means permanent threshold shift after a single exposure, to be distinguished from occupational NIHL and so-called “acoustic shock”

• AT can occur in few seconds at levels > 130 dBA, or after 10 seconds at levels > 120 dBA (ignoring one outlier)

• Lack of AT does not mean “safe” (neuropathy?)

• Acoustic reflex cases had significant prior hearing loss (which is why they required such high levels)
CONCLUSIONS (cont.)

• AT exposures were atypical of industrial noise (tonal or narrow-band, probably more hazardous dB-for-dB than broad-band noise)
• Reported AT cases probably represent most susceptible fraction of population (89 subjects in TTS experiments had no PTS after more severe exposures)
• All reported AT exposures exceeded OSHA limits; AT is unlikely to occur in compliant programs or after MRI with hearing protection

Acknowledgment

• Christian Giguere consulted re methods of estimating diffuse field levels from HLs, coupler levels, and mannequin levels
• Bill Clark consulted re historical literature in the fields of TTS and acoustic trauma
Hypothetical distribution of TTS after single intense brief exposure

Rare subject with TTS of 50 to 60 dB, then PTS (acoustic trauma)?