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1



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2

continued

Acoustic Trauma from Recreational Noise Exposures

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3

continued

Disclosures

- Dr. Fligor is an employee of Lantos Technologies, Inc., a privately-owned early-commercial medical device company. Dr. Fligor has ownership interest in Lantos Technologies, Inc.
- Dr. Fligor owns Boston Audiology Consultants, Inc., a private clinical and technical consulting practice.
- Dr. Fligor is chair of the WHO/ITU working group making recommendations for manufacture of personal audio systems (portable listening device, portable music player).
- Dr. Fligor receives an honorarium from AudiologyOnline for presenting.

4

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Preventing and Understanding NIHL Annual Series, Summer 2018

- “The Noise Outcomes in Servicemembers Epidemiology (NOISE) Study: Exploring Risk Factors for Tinnitus and Hearing Loss in Veterans and Service Members” by M. Samantha Lewis, PhD (Pacific University, Hillsboro, OR; VA RR&D Service and NCRAR, Portland OR), **June 20, 2018**
- “Auditory Processing Disorder and Blast Trauma” by Gail Whitelaw, PhD, PASC (The Ohio State University, Columbus OH), **June 13, 2018**
- “Assessment of Firearm Noise Exposures and Hearing Loss Prevention” by CAPT William Murphy, PhD, (NIOSH, Cincinnati OH), **June 6, 2018**

5

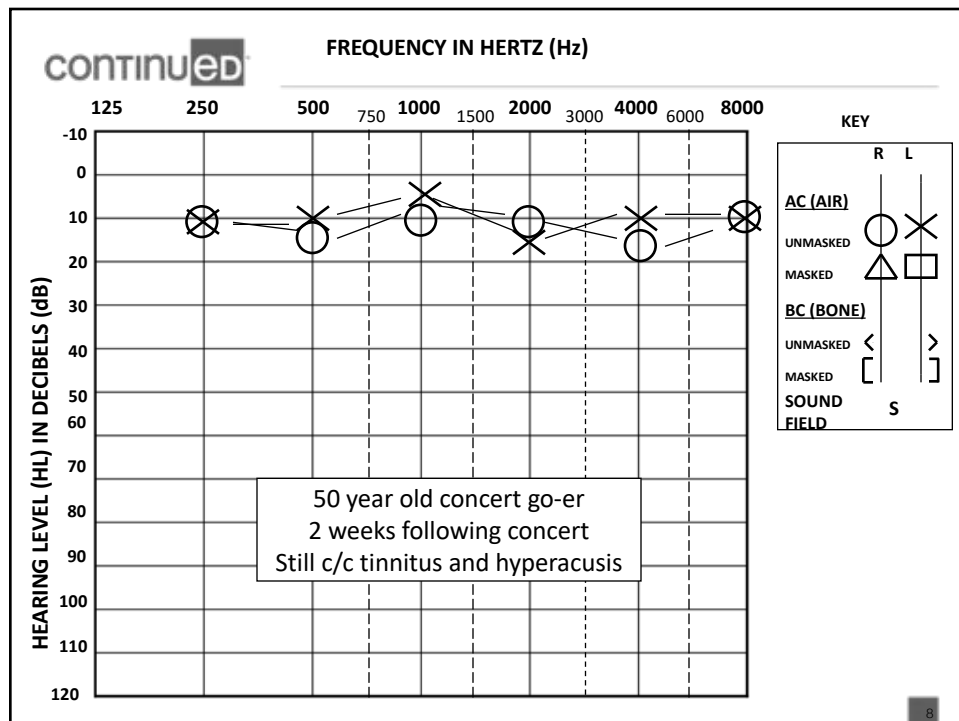
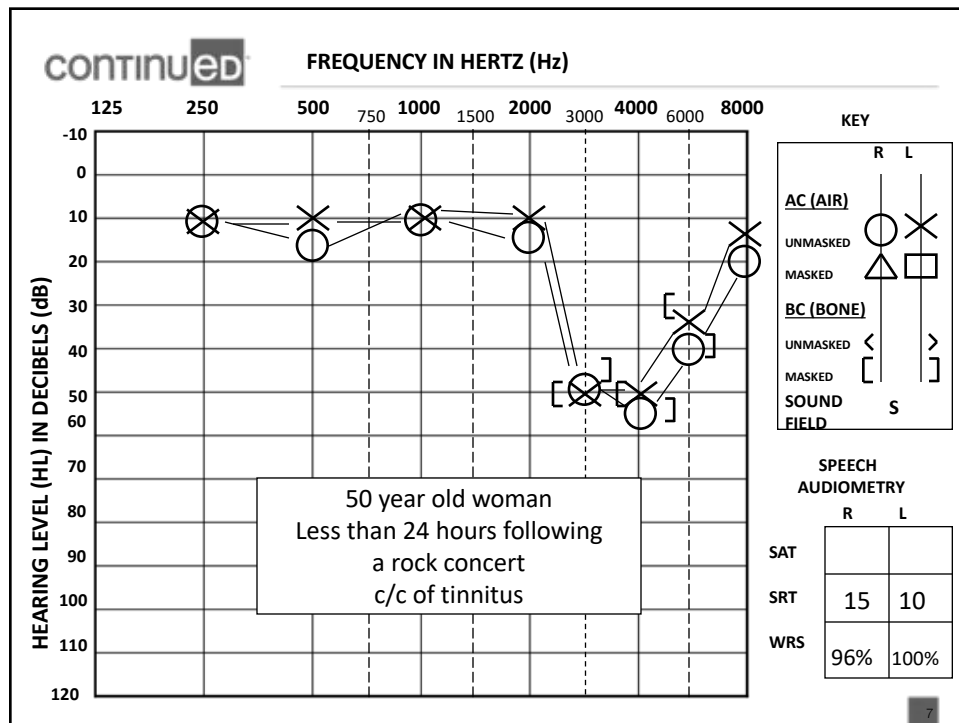
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Case Study: 50 year-old woman, acoustic trauma following rock concert

- 50-year-old woman attended a rock concert (2007) at a <1000 seat venue, left after ~1.5 hours as levels were “way too high.”
- Experienced ringing in her ears on the drive home, still very pronounced ringing the next day so saw an ENT.
- Noise exposure history was otherwise negative, and otologic history was non-contributory to complaint of tinnitus.
- Lawsuit against the band and concert venue, citing unremitting tinnitus and hyperacusis, settled out of court.

6

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Preliminary opinion

- TTS of 35-50 dB, with unresolved tinnitus and hyperacusis is consistent with acoustic trauma
- Previous recordings made by me at the same venue on 2 different occasions of a different band indicated levels of 100-105 dB(A) and 107-110 dB(A); Avg level at outside venues = 103.4 dB(A) (Clark, 1992)
- Models of TTS growth indicated for fractile 0.5, the 35-50 dB TTS would result from 98.6-107.4 dBA
- 85 dB(A), trade 3 DRC:
 - 1-2 hrs, 98.6 dB(A) = 289% - 579% Noise dose
 - 1-2 hrs, 107.4 dB(A) = 2211% - 4422% Noise dose

9

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Acoustic Trauma

10

Injury From Noise Exposure, Acoustic Trauma

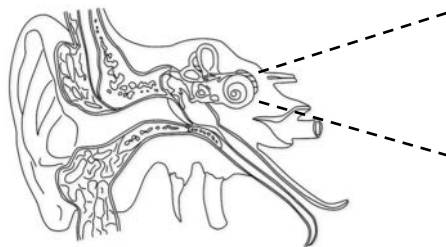
- Force of transient sound capable of exceeding the elastic limit of the tissue of the:
 - Organ of Corti (Sensorineural): ~132 to 184 dB SPL (peak equivalent)
 - Eardrum (Conductive): ~184 dB SPL to >194 dB SPL (peak equivalent)
 - 5 pounds per square inch (psi) = 184 dB SPL
 - 1 atmosphere = 14.7 psi (max dB at sea level = 194 dB SPL)
- Ossicular discontinuity (shock wave) >194 dB SPL
 - Also Traumatic Brain Injury, APD, lung and viscera injury

Hint: Exam Q1 and Q2 answer on this page

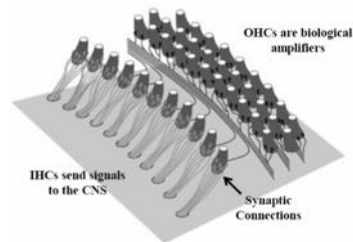
11

Injury From Noise Exposure, Acoustic Trauma

- Continuous sound that transfers enough energy to cochlea to result in necrosis of OHC, IHC, and cause glutamate excitotoxicity of 1st order afferent neurons of spiral ganglion (cochlear synaptopathy)
 - Rats: 4000% dose; Guinea pigs: 2500% (where 100% = 85 dBA, 8-hr Leq)
 - 109 dBA for 75 minutes (=4000%); 109 dBA for 47 minutes (=2500%)



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12

Injury From Noise Exposure, Chronic

- Too loud, for too long, too often
 - The Greedy Outer Hair Cell (OHC): ~78 dBA to ~132 dBA
 - More waste product (oxygen byproducts) than can be managed by antioxidant defenses
 - Cascade of molecular events, programmed cell death (apoptosis)
 - OHC breaks into bits, supporting cells maintain structural integrity
- Some concern for glutamate excitotoxicity leading to cochlear synaptopathy (Kujawa)

Hint: Exam Q3 answer on this page

13

Injury From Noise Exposure, Chronic Exposure AND Acoustic Trauma

- Noise-Induced Temporary Threshold Shift (NITTS), 3-6k Hz
- Noise-Induced Permanent Threshold Shift (NIPTS), 3-6k Hz
- Tinnitus (typically tone-like, hissing; ~peak of noise-notch)
- Hyperacusis
- Diplacusis (abnormal pitch perception)
- Suprathreshold Speech Intelligibility In Noise Decline

- Necrosis: lots of inflammation vs. Apoptosis: limited inflammation

14

Acoustic-Trauma From Recreational Noise

- Firearms (unprotected firearms exposure)
 - Including, fireworks
- Live Music Events
- Recorded Music
- Musician, DJ, Audio Engineer
- Motor Sports (NASCAR, Indy, Truck Rally, etc.)

15

Firearms (and Fireworks): #1 Recreational Acoustic Trauma

Firearm Type	Peak Sound Level (dB):
<u>Small Caliber Rifle</u>	<u>140-145</u>
<u>Medium Caliber Rifle</u>	<u>157-160</u>
<u>Large Caliber Rifle</u>	<u>160-174</u>
<u>Shotgun</u>	<u>152-166</u>
<u>Small Pistol</u>	<u>150-157</u>
<u>Large Pistol</u>	<u>158-174</u>

Injury risk increases 10-fold with every 10-fold increase in rounds fired

Add SPL for short barrel, muzzle break, and shooting in enclosed area

Michael Stewart, PhD, Audiology Online, July 3, 2008

CAPT William Murphy, PhD, Audiology Online, June 6, 2018

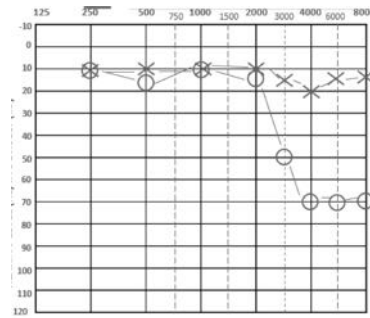
Hint: Exam Q4 answer on this page

16

...and Fireworks

Gupta & Vishwakarma (1989), Deepawali festival Fireworks at 3m: 126-156 dB SPL

Ward & Glorig (1961), case study 2"x3/16" firecracker went off in patient's hand, unilateral NIPTS and tinnitus



17

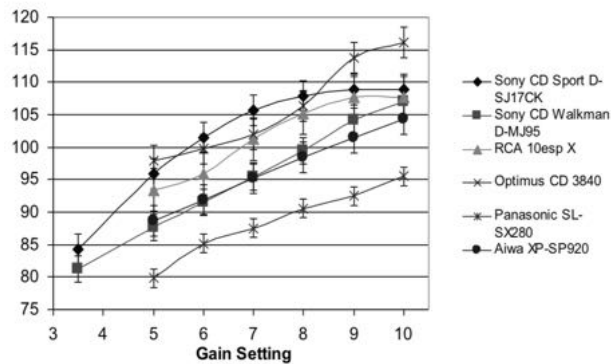
Live Music Events: Acoustic Trauma?

- Individual Cases
 - Exposure exceeds ~2500% Dose (100% Dose = 85 dBA Leq, 8-hr)
 - Chicago (civil suit v. Tom Petty)
 - Boston (civil suit v. Whitesnake)
- Forensic Audiology
 - Community Noise Measurement Records (and distance from speakers where levels were documented)
 - Seating chart and ticket stubs
 - Loudspeaker/sound reinforcement location relative to seats
 - Inverse Square Law (6-dB decrease, every doubling of distance; 6-dB increase, halving of distance... assumes no reflections)

18

Recorded Music: Acoustic Trauma?

- Older Technology (e.g. CD Players)

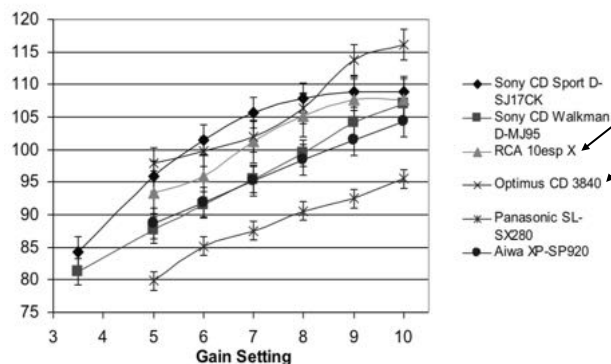


Fligor & Cox (2004)

19

Recorded Music: Acoustic Trauma?

- Older Technology (e.g. CD Players)



Aftermarket earphones,
percussion peaks =
136 dB SPL

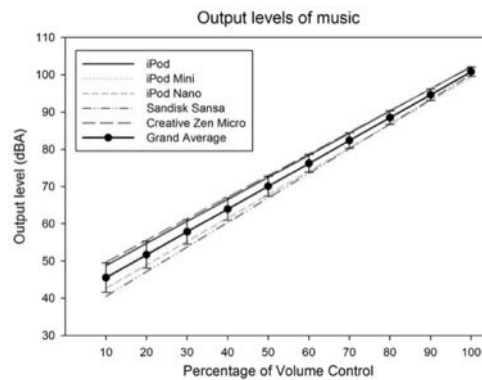
Hint: Exam Q5 answer on this page

Fligor & Cox (2004)

20

Recorded Music: Acoustic Trauma?

- Newer Technology (e.g. Smartphones, HD Players)

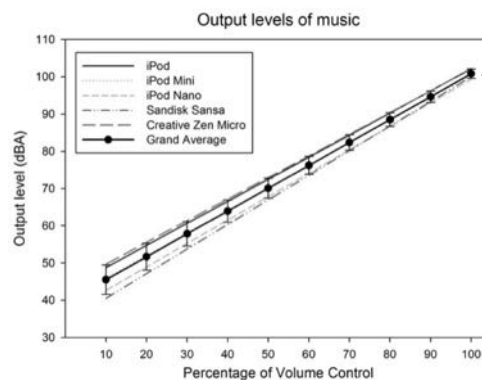


Portnuff, Fligor & Arehart (2011)

21

Recorded Music: Acoustic Trauma?

- Newer Technology (e.g. Smartphones, HD Players)



Percussion peaks =
104.6 to 126.9 dB SPL
(Max peaks Creative Zen
Micro with iPod earbuds)

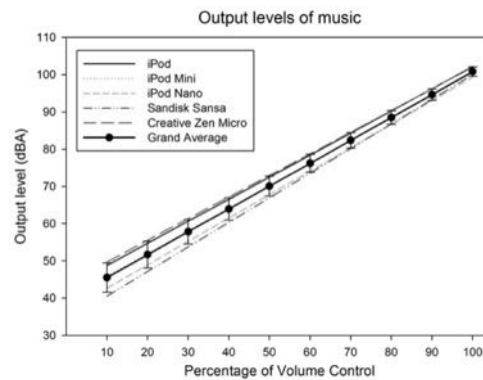
Hint: Exam Q6 answer on this page

Portnuff, Fligor & Arehart (2011)

22

Recorded Music: Acoustic Trauma?

- Aftermarket Audiophile, and Custom in-ear monitors?



Portnuff, Fligor & Arehart (2011)

Max voltage output ~ 0.5 V
 Apple Earpod = 105 dB/Volt
 at 1k Hz
 UE quadruple driver = 139
 dB/volt at 1k Hz

- UE16?
- JH16?
- 64 Audio A18?

23

Musician, DJ, Audio Engineer: Acoustic Trauma?

- Dance Club attendees & DJs (Argentina): Typical sound levels in the dance clubs were 104.3 dBA – 112.4 dBA; Doses routinely > 1600% (Serra, et al., 2005)
- Musicians and audio engineers: depends on use of floor wedges (105 – 110 dBA) vs. Custom in-ear monitors (80 – 122 dBA)
 - Risk for amplifier malfunction, white noise at full voltage

24

Motorsport: Acoustic Trauma?

- NASCAR Race (Rose et al., 2008):
 - 150 feet from race track = 101 dBA (average, 96.5 – 104 dBA)
 - 20 feet from race track = 106 dBA (average, 99 – 109 dBA)
 - Duration, 4 hours
 - Dose @ 150 feet = 2016%
 - Dose @ 20 feet = 6400%
- ATV, jetskis, motorcycles >100 dBA (consider exposure duration; 6.25 hrs at 100 dBA = 2500% noise dose)

Hint: Exam Q7 answer on this page

25

Protective Measures: Hearing Protection

- Passive
 - Non-custom
 - Custom

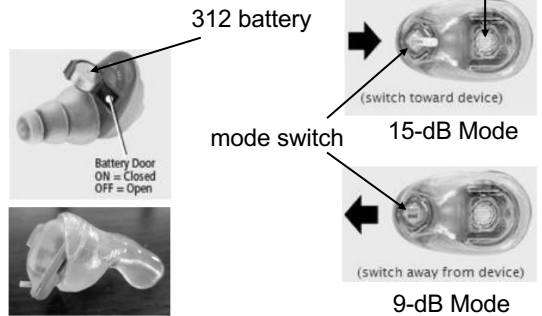


- Custom vs. Non-custom: Consistency of fit, predictability of protection
 - PAR vs. NRR of non-custom vs. custom (Neitzel, et al., 2004)

26

Protective Measures: Hearing Protection

- Active
 - Non-custom
 - Custom



- Custom vs. Non-custom: necessity of indirect routing (through microphone), not direct (flanking the device, passing into canal)

Hint: Exam Q10 answer on this page

27

Protective Measures: Chemicals/Medications

- Current: intratympanic steroid (prednisone) injections
- Future: rescue – NAC (Kopke), D-Met (Campbell)
- Future: prophylaxis – ACEMg (LePrell)

Hint: Exam Q8 and Q9 answers on this page

28

Conclusions:

- Acoustic trauma from recreational exposures is possible
- Unprotected firearms exposure is #1 cause of recreational NIHL, can cause immediate acoustic trauma
- Very high level continuous sound can result in severe noise overdose, leading to necrotic death of cells in cochlea, inflammatory process causes widespread damage
- Listening to recorded music cannot cause acoustic trauma, except with certain aftermarket earphones/custom in-ear monitors