Pressure buffering by tympanic membrane displacements.

In vivo measurements of the middle ear pressure fluctuations during elevator motion

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Background – ME pressure

1. Gas exchange of the middle ear (ME)
2. ET pressure equilibrations
3. Volume changes of the mastoid mucosa

4. TM displacements
    1. Fast reacting pressure buffer
    2. Viscoelastic properties
    3. Pars tensa vs. flaccida
    4. Pressure load, degeneration, and atrophy

Methods – direct ME pressure

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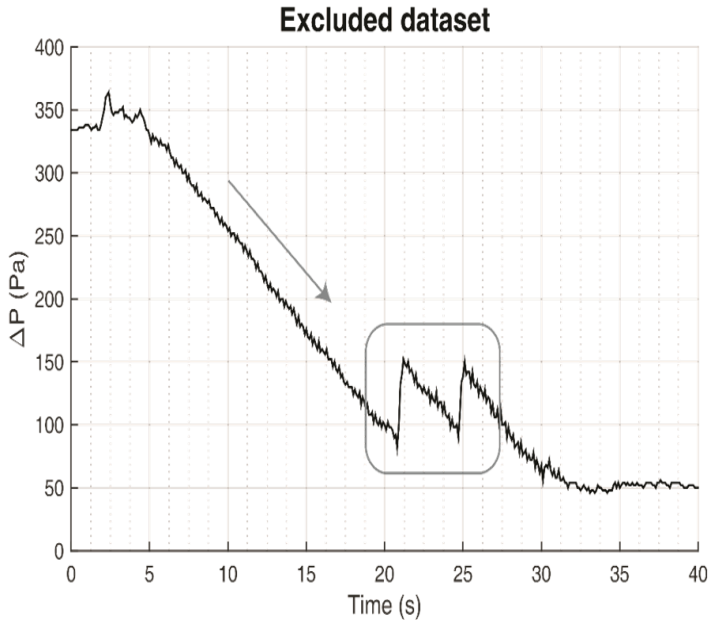
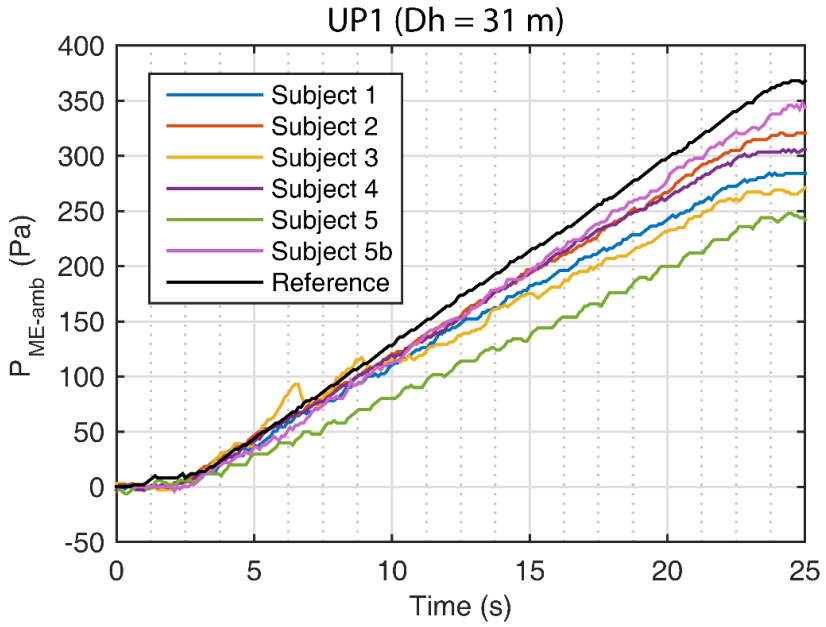
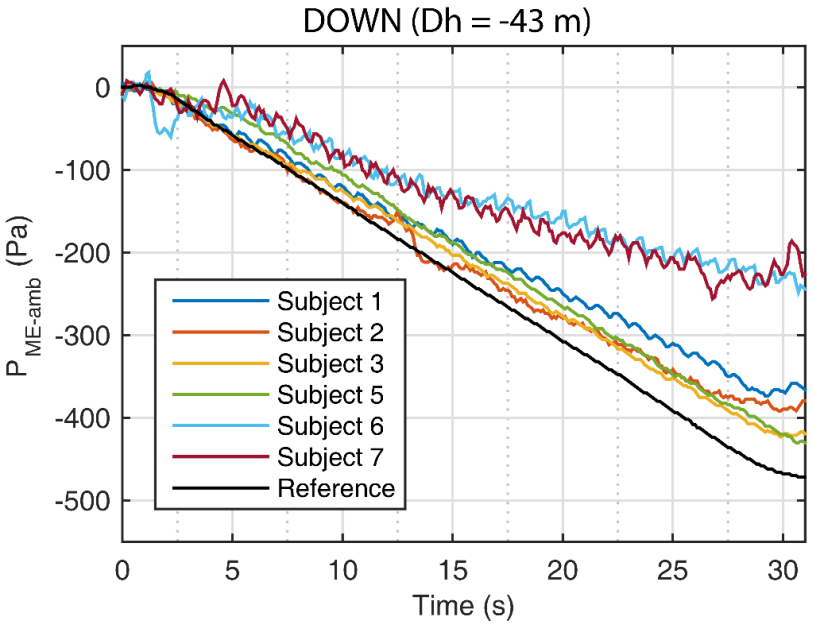
- Seven otologically normal patient
- Elevator trips were involved in the routine transfer of patients between units
- Exclusions: ET openings during trips



Results





Pressure fluctuations in the ME's vs. reference. Original recordings have been aligned and normalized.

Methods – TM buffer

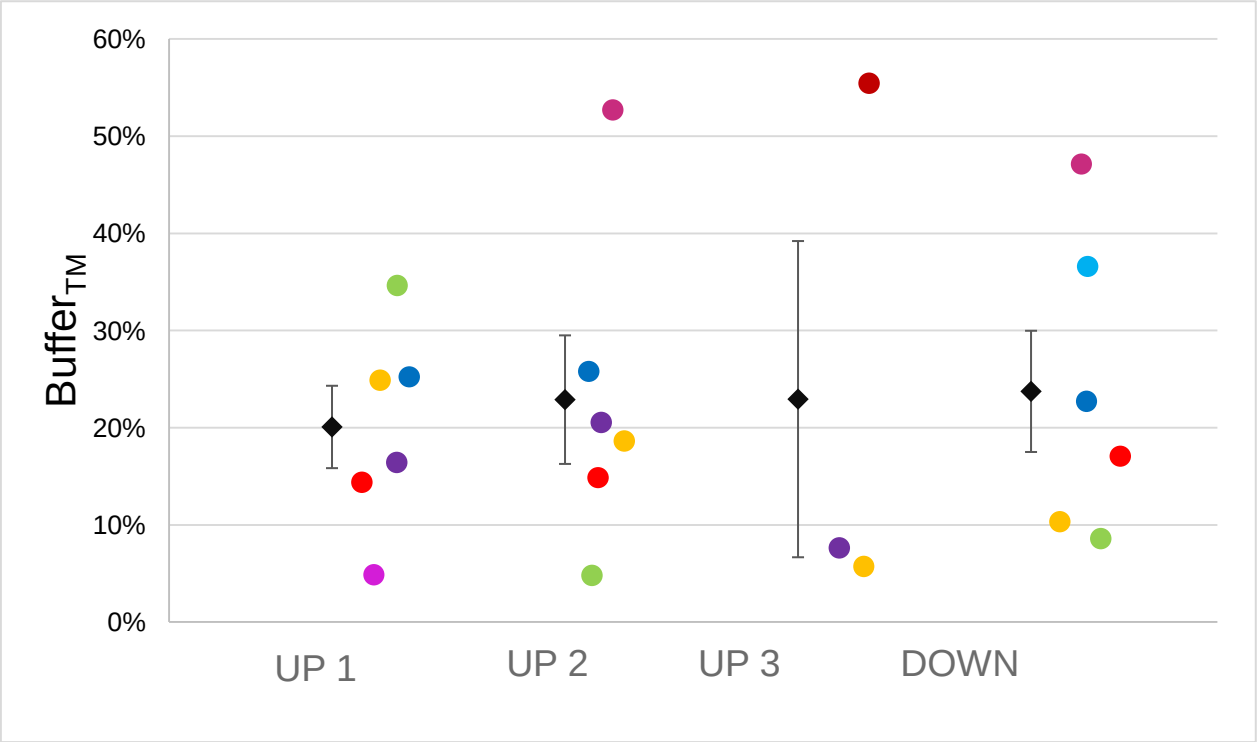
$$Buffer_{TM} = \Delta P_{ME}/\Delta P_{amb}$$

Where:

ΔP_{ME} = the pressure change in the ME; ie. the difference between end and start pressures measured in the ME's during the elevator trips

ΔP_{amb}= the pressure change in the ambient = the difference between end and start pressures measured in ambient within reference recordings

Results – TM buffer



Distribution of TM buffering values (Buffer$_{TM}$) for a pressure change of 20Pa/s during elevator motions gave similar means averaging overall 22.3 %.

Methods – ME volume

$V_{ME} = Dn*R*T_{ME}/ABS(P'-P'')*1{,}000{,}000$ (Boyle's Law)

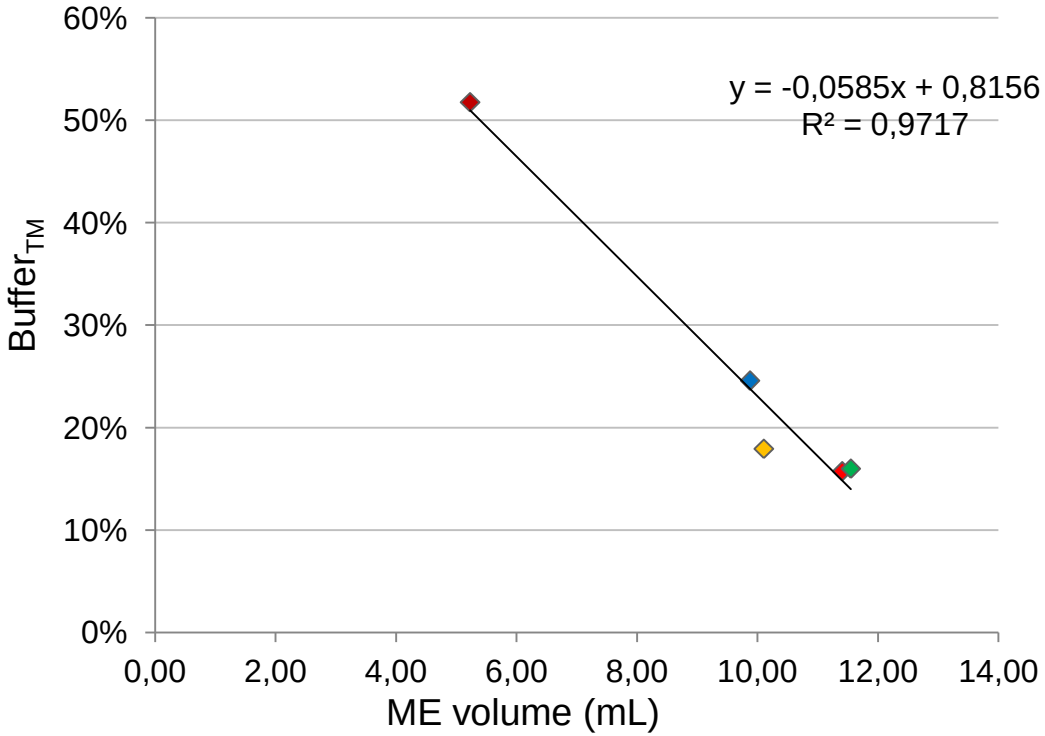
Constants:
p_amb = 101325 Pa
T_amb = 295 K
R = 8,31 J/(K.mol)
T_ME = 310 K
DV = 1,00E-07 m^3
Dn = 4,13327E-06 mol

Variables:
P', P'' peak MEpressure during different inflation or deflation experiments

Results – ME volume (5 cases)

Subject	V_{ME} (ml)
1	9.88 ± 0.50
2	11.41 ± 1.33
3	10.11 ± 0.71
5	11.55 ± 0.23
7	5.23 ± 0.34

Results – TM buffer vs. ME volume



The buffering effect of the TM correlated linearly with estimated ME volumes.

Discussion

- Pressure buffering during smaller environmental pressure changes have been demonstrated
- Such “short term” pressure changes must be explained by the TM buffer

- TM buffering is probably important in sustained abnormal ME pressures (degeneration and atrophy)
- TM buffering is improved in ME’s with a small volume

- This situation corresponds to ME’s with obliteration of the mastoid, and thus, it may explain more favorable outcome

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