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Correlation between retractions of the pars flaccida and the pars tensa

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Abstract

Retractions of the pars flaccida (PF) and the pars tensa (PT) were assessed in 250 atelectatic ears in an attempt to find out the way in which the differences in mechanical properties of the two parts of the tympanic membrane are reflected clinically. Retraction of PF was found in 217 ears (86.8 per cent) and retraction of PF in 150 (60 per cent). The concomitant presence of both types of retraction was observed in 117 ears (46.8 per cent) while 133 (53.2 per cent) had only one type, 100 of them (75.1 per cent) PF retraction and 33 (24.9 per cent) PT retraction. When only one type of retraction was present, the empirical probability of having a PF retraction was 75.1 per cent, while the probability of having a PT retraction was only 24.9 per cent. Clinically, the more frequent occurrence of PF retraction in the absence of PT retraction than vice versa reflects the greater collapsibility of the PF. When both types of retractions were present, we found a positive correlation between their severity.

Key words: Middle ear; Atelectasis; Middle ear ventilation

Introduction

Under negative intratympanic pressure the two parts of the tympanic membrane, namely the pars flaccida (PF) and the pars tensa (PT) may become retracted, either separately or concomitantly. The aim of the present study was to reveal the relationship between PF and PT retractions and to determine how the basic differences in their mechanical properties are reflected clinically.

Material and methods

Out of 542 consecutively examined ears in our predominantly otological practice, 250 were found to have PT retraction, PF retraction or both. Our study focuses on those cases. Ears previously operated on (including for ventilating tube insertion) or presenting cholesteatoma or tympanic membrane perforation were excluded.

Degree of pars tensa retractions

The degree of PT retraction was defined according to the classification of Sadé (Sadé and Berco, 1976) as follows.

Grade 0: Normal PT without retraction.
Grade 1: PT is slightly retracted, i.e. retraction to the level of the annular ligament.
Grade 2: PT touches the ossicular chain.
Grade 3: PT reaches the level of the promontory without adhering to it.
Grade 4: PT reaches the promontory and adheres to it.

Degree of pars flaccida retraction

The degree of PF retraction was defined according to a modification of Sadé's classification for PT retraction, as follows (Sadé *et al.*, 1981):

Grade 0: Normal PF without retraction
Grade 1: PF is slightly retracted, but does not touch the neck of the malleus.
Grade 2: PF reclines on the malleus neck.
Grade 3: As for grade 2, accompanied by partial destruction of the scutum, without keratin accumulation.
Grade 4: Major retraction of PF with keratin accumulated deep in its fundus, and not amenable to cleansing by suction; this situation corresponds to attic cholesteatoma*, and ears in this category were therefore excluded from the study.

Analysis of data

The correlation between the degrees of PF and PT

*Cholesteatomatous ears were not included in the study.

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retraction was assessed by means of the Chi-square test for quasi-independence. Additional analysis of the data was aimed at assessing the probability of existence of PF retraction in the absence of PT retraction and vice versa.

Results

The distribution of the degree of PT and PF retractions is presented in Table I. Out of 250 atelectatic ears included in this study, 217 (86.8 per cent) presented some degree of PF retraction and 150 ears (60 per cent) some degree of PT retraction. The concomitant presence PF and PT retraction was seen in 117 ears (46.8 per cent) while 133 (53.2 per cent) had only one type of retraction.

Where both types of retraction were present, a direct positive correlation between the degrees of their severities was observed (chi-square of 26.76 with eight degrees of freedom, corresponding to a *p*-value of less than .001).

Among the 133 ears with only one type of retraction, PF retraction was present in 100 ears (75.1 per cent), while PT retraction was seen in only 33 ears (24.9 per cent). The appropriate 95 per cent confidence intervals for the probabilities in the population are (66.5 per cent, 83.7 per cent) and (16.3 per cent, 33.5 per cent) for the PF and for the PT, respectively. Thus we have a very clear indication that when only one type of retraction is present the probability that that retraction will be in the PF is much higher than in the PT.

TABLE I

CORRELATION BETWEEN THE DEGREE OF PT AND PF RETRACTIONS

A. Frequency distribution

	Grade of PT retraction				
Grade of PF retraction	0	1	2	3+4	Total
0		21	7	5	33
1	73	40	4	9	126
2	21	30	12	9	72
3	6	6	5	2	19
Total	100	97	28	25	250

B. Column percentages: distribution of PF retraction for each degree of PT retraction*

	Grade of PF retraction				
Grade of PF retraction	0	1	2	3+4	Total
0	–	21.65	25.00	20.00	13.20
1	73.00	40.24	14.79	36.00	50.40
2	21.00	30.93	42.86	36.00	28.80
3	6.00	6.19	17.86	8.00	7.60
Total	100.00	100.00	100.00	100.00	100.00

C. Row percentages: distribution of PT retraction for each degree of PF retraction*

	Grade of PT retraction				
Grade of PF retraction	0	1	2	3+4	Total
0	–	63.64	21.21	15.15	100.00
1	57.94	31.75	3.17	7.14	100.00
2	29.17	41.67	16.67	12.50	100.00
3	31.58	31.58	26.32	10.53	100.00
Total	40.00	38.80	11.20	10.00	100.00

Chi square: 26.76.
p value = 0.0008.
Degree of freedom: 8.
*Percentages were detailed to two significant digits.

Discussion

One of the consequences of persistent negative pressure in the middle ear is retraction of the tympanic membrane. Retraction can be regarded as an anti-pressure-gradient mechanism since it results in reduction of the volume of the middle ear cavity and negates, or cancels the negative pressure continuously, as it develops. This phenomenon may explain why the negative pressure in atelectatic ears is not high (Buckingham and Ferrer, 1973; Sadé *et al.*, 1976).

According to Shrapnell (1832), and later also Lim (1968a, b) and Hentzer (1989), the role of the PF is to protect the middle ear against pressure changes. Working in rats, Hellstrom and Stenfors (1983) showed that minor pressure changes (2 mmH_20) are reflected in the position of the PF. However, the PF is capable of exerting only a small effect on pressure equilibration; where the negative pressure persists, further retraction is called for, this time by the PT.

The positive correlation found in this study between the degrees of PF and PT retractions (Table I) can be explained on the basis of the mechanical properties of the tympanic membrane. The PT and the PF, comprising the lateral wall of the same cavity, are both exposed to the same intratympanic pressure. When negative pressure develops in the middle ear there is a tendency for the tympanic membrane to be retracted. Since the PF, unlike the PT, lacks an organized collagenous backbone (Lim, 1968a, b; Hentzer, 1989), this part of the tympanic membrane will be the first to retract (Stenfors *et al.*, 1979; Hellstrom and Stenfors, 1983). As with any other membrane, any part of the drum that retracts becomes more rigid in the process, as its tensile force increases (Beer and Johnson, 1976). Once the retracted PF becomes rigid enough to withstand the retraction forces exerted by the negative pressure (for example once it reaches grade 1 of PF retraction), the retraction stops progressing. However, if negative pressure is not completely compensated for, a different part of the tympanic membrane, the most flaccid at that particular time point will now tend to retract. In a significant number of cases it is now the PT that retracts. This retraction leads to increased tension and increased rigidity of the PT. Again, once the rigidity is high enough to withstand the retraction forces exerted by the negative pressure, e.g. when PT retraction reaches grade 1, the retraction stops progressing. If the negative pressure is not yet compensated for, or if further negative pressure develops, another part of the TM will retract. In most cases the partially retracted PF proceeds now from grade 1 to grade 2. The progress continues in

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this way until both PF and PT reach maximal atelectasis. This process is well in agreement with the positive correlation observed in this study.

The retraction of the TM at any given time occurs at the most flaccid part of the membrane. In this dynamic process, the PF is usually the first to retract on account of its low rigidity.

Our findings that PF retractions are more prevalent than PT retractions (Table I), and that PF retractions without PT retractions occur more frequently than vice versa suggest that in humans, as in rats (Hellstrom and Stenfors, 1983), even mild negative intratympanic pressure is sufficient to cause the flaccid part to retract. Mild middle ear negative pressure may be frequent and a physiological variant of the normal pressure fluctuations of the middle ear cavity. Because of inherent rigidity of the intact PT, it probably withstands the relatively mild negative pressure that occurs under aletectatic conditions (Buckingham and Ferrer, 1973; Sadé, *et al.* 1981). Thus the intact PT probably oscillates only on its peripheral fold, reaching for a relatively long period of time no more than grade 1 of PT retraction (Bekesy, 1960; Sadé, 1993). Damage to the collagenous layer of the PT (Sadé, 1993), resulting from an earlier inflammation, previous ventilating tube insertion, or persistent negative pressure, seems to be a prerequisite for deeper retraction. Damage to the PT collagenous backbone may be so severe that the PT becomes even weaker than PF; this might explain why PT retractions occasionally occur in the absence of PF retraction.

Retractions of the PF quite often become permanent when the PF adheres at least partly to the structures medial to it, as evidence by Widemar *et al.* (1986) on rats (Widemar *et al.,* 1986). PT retractions may also become permanent when they progress from grade 3 to grade 4 (Sadé and Berco, 1976). Since it seems to be easier for the PF to retract to the medial structures of the shallow Prussak space (on account of the short distance to the medial wall of this space) and adhere to them than for the PT to reach its deeper medial structures, PF retractions probably become permanent more frequently than PT retractions. When the PF adheres to the bony structures found medial to it, its pressure-compensating ability diminishes and any further increase in negative intratympanic pressure, will now affect only the PT.

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