BIOCHEMICAL CHANGES IN THE INNER EAR FLUIDS AS THE DIAGNOSTIC INDICATOR IN CERTAIN HEARING DISORDERS

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1. The fluid system of the inner ear was formerly thought to consist of the endolymph (otic fluid) and the perilymph (periotic fluid). Recent observations have not only doubted the site of the fluid formation and absorption but have added the possibility of one more fluid system called Cortilymph. (Engstrom, 1960).

2. Perilymph and endolymph have been considered inaccessible in the past because of the anatomical location of the human labyrinth and the possibility of inflicting trauma with the destruction of cochlear and vestibular functions. Modern surgical procedures and micro chemical analysis of the inner ear fluids however, have provided a variable data recently. Whereas, perilymph has been shown to have a composition much like that other extra cellular fluids, the endolymph has a remarkably high potassium content and a low sodium content similar to that of intra-cellular fluids. (Smith, *et al.,* 1954),

3. Kaieda (1930) and Ledoux (1941) and his associate did experiments on the inner ear fluids of the animals like cat and dog and observed small but reliable differences in the osmotic pressure of these liquids and compared with that of cerebro-spinal fluid and blood plasma.

4. Smith *et al.,* (1954) showed that endolymph potassium concentration was thirty times that of periiymph and spinal fluid whereas sodium concentration of perilymph was ten times higher than that of endolymph. The concentration of the chloride ion was about ten per cent lower in endolymph than in perilymph. But no difference was found in the concentration in any of the above mentioned three ions between perilymph and spinal fluid. If the tunnel of corti is supposed to be filled with endolymph, then it would be seen that the high potassium content would seriously interfere in the conduction of sound in the nerve fibres that cross the tunnel. Hence it is aparent that the fluid in the tunnel of corti is unlikely to be endolymph and it is named as cortilymph.

5. Biochemistry and biochemical methods of investigations have produced marked illumination in many problems in regard to hearing and hearing loss. Rauch and Kostlin (1958) have defined the constituents of normal human inner ear fluids. In the following table, a comparison of biochemical composition of inner ear fluids with C.S.F. and blood serum is given:

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Substance or measure	Blood serum	C.S.F.	Perilymph	Endolymph
Sodium mEq/Litre	141	141	135-150	13-16
Potassium mEq/Litre	5	2.5	7-8	140-160
Chlorine mEq/Litre	101	126	135	120-130
Magnesium mg/100 ml	2	2	2	—
Protein, total	7,000	10-25	70-100	20-30
Corbon dioxide mEq/Litre	27	18	10	20
.Phosphor Anorg mg/100 ml	2	1	1-3	0.8-1.3
PH	7.3S	7.35	7-2	7.5

Walter and Raymond (1950) observed the difference in the protein contents of the two fluid system. Rauch and Kosltin (1958) have observed higher protein values in the both endolymph and perilymph.

6. The similarity between the chemical composition of the perilymph and th« CSF and the existence of the aqueduct of the cochlea which joins subarachnoid and perilymphatic spaces suggest that perilymph is indeed cerebrospinal fluid.

7. There are some reports like that of Shea (1963) which suggest the excessive amount of CSF escaping from the oval window when the stapes is removed this again confirms the origin of perilymph.

8. The difference in the protein contents of the two fluid system as observed by Walter and Roymond (1950) also proves the concept of identity of perilymph and CSF. Thus it is concluded that the perilymph is probably derived from at least two sources:

(1) From CSF which supplies some of the crystalloids like Sodium+ which are able to diffuse through the membranous barrier. A similar diffusion of crystalloids may take place from the endolymph into the perilymph through Reissner's membrane.

(2) Experimental results suggest the perilymph in the intact ear is also produced within the labyrinth, probably as a direct blood filterate from the vessels of the spiral ligament. Axelsson's (1968) observations suggest that perilymph is formed in the scala vestibuli and gets absorbed in scala tympani.

9. Endolymph is thought previously to be secreted by stria vascularis or by the adjacent tissues of the outer sulcus. Dholman (1964) suggested that endolymph is produced by certain specialised cell regions in the walls of the membranous labyrinth. These areas are called planum semilunatum and perimacular regions. Planum semilunatum is a half moon shaped area located in the lateral wall of the ampulla. He has also proved that there are two types of cells in these regions and they are dark cells and light cells. Dark cells are engaged in absorptional activities and they absorb fluid and certain ions, dispose

of some of this material to the capillaries and return fluid and possibly other ion to the endolymph through the light cells.

10. The special composition of endolymph with its high potassium and low sodium content indicates that this fluid is produced by an active secretory energy consuming process and the region of the stria vascularis is well adopted to this purpose. Whether the ducts of the outer sulcus are also concerned with the absorption or with the pressure regulation in the scala media remains uncertain still.

11. The classical route of resorption is the endolymphatic duct and sac- Evidence is also available that the circulation of the endolymph may be radial rather than longitudinal, i.e., each section of the chochlea may be self-sustaining and remains, more or less independent of areas more apically or basally situated (Lawrence and Arbor, 1965).

12. Naphtalin and Harrison (1958) suggested that endolymph is derived from perilymph across Reissner's membrane and reabsorbed by the stria vascularis. It remains still uncertain whether the perilymph or the stria vascularis is the origin of the endolymph and whether the circulation is radial (across the scale of media) or longitudinal.

13. Cortilymph has received attention only recently. It is believed that the tunnel is completely closed in every direction and that the Cortilymph is an intraepithelial accumulation of intracellular fluid. It has also been suggested that it formed from the cerebrospinal fluid passing along the fibres of the auditory nerve through the canal of the bony spiral lamina. (Ballenger, 1969)

14. These fluids serve not only the purpose of conveying the proper nutrition to certain structures and maintaining the metabolism but they also serve a more subtle purpose of aiding the energy transformation processes. Another function of the intracranial extension of both the otic and periotic space is the maintenance of equilibrium between perilymphatic and endolymphatic fluid pressure. Normal vestibular and cochlear functions depend upon the stability of these fluids equilibrium. (Lawrence and Arbor, 1965). In 1961, Wullstein and Rauch initiated the study of inner ear fluids in abnormal ears by analysing fluid obtained from patients with various hearing disorders.

15. In 1970, Warrent L. Griffin Jr. and Herbert Silverstein have discussed the biochemical changes of the inner ear fluids obtained from patients with otosclerosis, Meniere's disease and acoustic tumours.

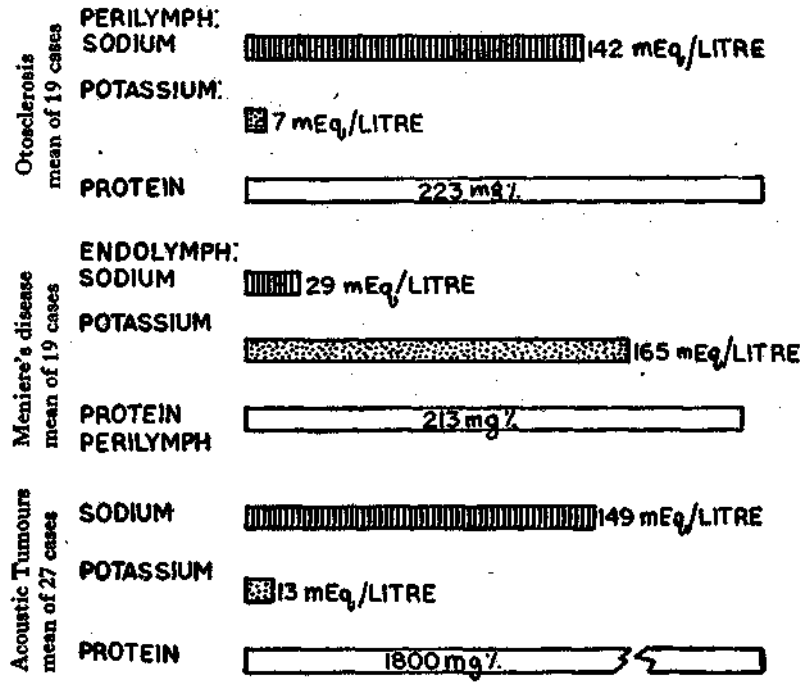
16. In otosclerosis, the fluid was obtained during stepedectomy procedure — a small amount of fluid being removed from oval window following extraction of the stapes foot plate. On analysis, the higher sodium and lower potassium volumes were found. The mean sodium value was 142 mEq/Litre and the mean potassium value was 7 mEq/Litre. The mean protein value was found to be 223 mg per cent.

17. In Meniere's disease, the fluid was obtained by the footplate puncture technique just prior to the performance of labyrinthectomy. On analysis, it was found that there was a higher potassium (mean value = 165 mEq/litre), a

lower sodium (mean value —29 mEq/litre) and a normal protein (mean value=215 mg per cent). These findings suggest that endolymph was obtained from a fluid space normally containing perilymph. The explanation for this is the presence of endolymphatic hydrops with the saccule dylated to such an extent that it had become contiguous with the under surface of the stapes foot plate. The pipet, when inserted through the stapes foot plate, collected endolymph rather than perilymph. This procedure then becomes a biochemical method for confirming the results of endolymphatic hydrops. In the same cases, again when perilymph analysis was done by taking the fluid by penetrating the round window membrane with a pipet, it was found that the sodium was high, potassium was low and protein was high.

18. In acoustic tumour cases, the fluid was obtained from the horizontal semi circular canal during the translabyrinthine approach to this tumours. It was found on analysis that in these cases a higher sodium (mean value = 149 mEq/ litre, a lower potassium (mean value = 13 mEq/liter and a markedly elevated protein (mean value = 1800 mg per cent). In cases, the protein values ranged frorn 1030 to 3580 mg per cent. It was also found that in no case of proven acoustic tumour has a perilymph protein value of less than 1030 mg per cent.

The values of Sodium, Potassium and Proteins in Otosclerosis Meniere's disease and Acoustic tumour



19. The sodium, potassium and protein values found in otosclerosis, Meniere's disease and acoustic tumour are summarised in bar graph form.

20. The biochemical changes in these conditions are distinct and it becomes readily evident that these differences might be employed as a differential diagnostic aid in addition to cochlear and vestibular investigations in hearing disorders.

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