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STUDIES ON PNEUMATIZATION OF THE TEMPORAL BONE IN TAIWAN

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Although antibiotics are randomly used in Taiwan, there are still many cases of chronic otitis media and sometimes, resulted in severe otogenic brain complications. It is interesting to search for the causes. Dr. M. Diamant reported that pneumatization of the temporal bone has the close relation with the occurrence and courses of otitis media. Prof. Kenji Yamashita first studied on the temporal air cells of the Japanese in 1935. Under the instruction of Prof. Yamashita, we had studied on the pneumatization of the temporal bone of the Fuchien-Chinese and some causative factors were found.

Yamashita used the term as "temporal air cells" instead of "mastoid air cells". Because, in well pneumatized case, the air cells existed not only at the mastoid portion, but also at the squamous portion, tympanic portion, and pyramidal portion, that is to say, on the temporal bone throughout.

We examined not only the size of the temporal air cells, but also their structure, which is divided into regular or irregular. Yamashita offered six types of pneumatization according to the degree of development and structure of pneumatization.

Yamashita stated that the area of outer air cells has the high correlation with whole temporal air cell volume, therefore, Dr. Tsunendo Kurata measured the size of the temporal air cells with planimeter in x-ray

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projection using Sonnenkalb's technic. Materials used were 100 healthy Japanese (50 males and 50 females) and 100 healthy Fuchien-Chinese (50 males and 50 females), totally 200 individuals, 400 ears. Age of the materials ranged 17-30 years. He concluded that individual dissimilarity with regard to the extent of the temporal air cells was great (Table I) but there are no differences in the size of the temporal air cells with regards to sex, side, and race (Table II).

Table I. **Coefficient of variation** (**Kurata**)

V=44.35±1.85% (Fuchien-Chinese+Japanese in Taiwan)
V=44.45±2.62% (Japanese in Taiwan)
V=53.25±4.71% (Japanese in Kinki-province, after Yamashita)

Table II. **Type of pneumatization** (**Kurata**)

Type	Japanese			Fuchien→Chinese			Male	Female	Total	%
	Male	Female	M+F	Male	Female	M+F				
I	7	10	17	11	10	21	18	20	38	9.5±1.5
II	39	29	68	21	25	46	60	54	114	28.5±2.3
III	11	20	31	13	23	36	24	43	67	16.8±1.9
IV	8	6	14	8	2	10	16	8	24	6.0±1.2
V	25	15	40	29	27	56	54	42	96	24.0±2.1
VI	10	20	30	18	13	31	28	33	61	15.3±1.8

Using the same method, Kurata examined the correlation between the size of the temporal air cells and the size of frontal sinus, cranial index, width of the angle of lower jaw, bizygomatic diameter, morphological facial height, stature, shoulder-breadth, and so on. A fairly considerable correlation exists between the size of the temporal air cell and the size of the frontal sinus, was found. But no correlation between the extent of the air cell system and cranial index or any of the other anatomical characters examined, was noted (Table III).

Table III. **Coefficient of correlation between (Kurata)**

Frontal sinus and temporal air cells:	r=0.382±0.061
Cranium-length and temporal air cells:	r=0.142±0.069
Cranium-width and temporal air cells:	r=0.051±0.071
Width of the angle of low jaw and temporal air cells:	r=0.175±0.069
Bizygomatic diameter and temporal air cells:	r=0.135±0.070
Morphological facial height and temporal air cells:	r=0.159±0.0069
Stature and temporal air cells:	r=0.189±0.068
Shoulder-breadth and temporal air cells:	r=0.140±0.069

Kurata examined the structure of the air cell system in the case of different types of pneumatization. He found that 9.85±1.5 per cent was large cellular, 46.0±2.5 per cent, medium cellular, 38.8±2.4 per cent, small cellular, and 5.8±1.2 per cent, the structure was obscure. In 21 per cent of the cases, the cellular arrangement is absolutely regular. The thickness of the intercellular wall is quite variable (Table IV). Yamashita also reported that the better the pneumatization, more regular the structure and the structure is symmetric on both sides, particularly in the case of very good or very poor development of pneumatization. No difference is demonstrable with regards to race and sex.

Table IV. **Structure of pneumatization (Kurata)**

Large cellular:	9.85±1.5%
Medium cellular:	46.0 ±2.5%
Small cellular:	38.8 ±2.4%
Obscure:	5.8 ±1.2%

Dr. Tatsuya Kawasaki studied on the pneumatization of 200 temporal bones of both sides, 50 male and 50 female Fuchien-Chinese. He filled the air cells with iron sand and calculated the pneumatization volume (iron sand 1 gram i. e. 2 c.c.). He compared his data with those of Yamashita and concluded that the pneumatization volume of Fuchien-Chinese is smaller than that of Japanese, especially the extents of air cell systems in saggital and frontal dimensions. As Diamant reported that the chronic otitis media patient has smaller air cell system, this is one of the reasons why there are many cases of chronic otitis media in Taiwan.

The occurrence of the petrous-tip air cells is 21.5 per cent in Fuchien-Chinese and 42 per cent in Japanese. This is one of the reasons why there were few petrositis in Fuchien-Chinese, even before the discovery of antibiotics.

The occurrence of the hypotympanal, squamous, and retrosigmoidal air cells is higher in Fuchien-Chinese than in Japanese. Therefore, clinically, we had to remove these cell groups totally in mastoid operation (Table V).

Table V. **Comparison of the occurrence of each air cell groups between Fuchien-Chinese and Japanese (Kawasaki)**

Air cell groups	Japanese	Fuchien-Chinese	D/md
Epitympanal	78.0	82.5	0.6545
Hpypotympanal	63.0	87.0	7.503
Zygomatic arch	59.0	60.0	0.119
Squamous	45.0	67.0	2.648
Sinodural	76.0	82.0	1.045
Perisinous	90.0	92.5	0.501
Mastoid-tip	64.0	59.0	0.596
Retrosigmoid	16.0	51.5	4.500
Deep subantral	85.0	92.5	1.450

One of us, P. C. Li also studied on the pneumatization of the temporal bone radiologically. Materials used were 475 skull x-ray films of Taiwanese of Fuchien descendant, 254 males, and 221 females. The outer temporal air cells were taken with Schüller's method, and the pyramid air cells were taken with Stenvers' method. The materials had included 200 temporal bones of Kawasaki's study, for comparisons between anatomical and radiological relations.

Summarizing the whole study, the significant findings are as followings:

1) Anatomically measured air cell volume value is highly positively correlated with the radiologically measured area value.

2) The frequency distribution of the temporal air cells is almost the same as the normal distribution or very close to it, especially the coefficient of pneumatization is almost a normal distribution.

3) The size of pneumatization of male is greater than that of female, but the coefficient of pneumatization is the same in both sexes.

4) Comparison of anatomical and radiological studies shows the structure tends to be irregular, especially in the arrangement on radiological study, and the structure is not much different between sexes and sides.

5) X-ray film sometimes does not show the actually present air cells in the pyramid, only half of the air cells are demonstrated. The air cells of the apex of pyramid are visible on films in high percentage, about 80 per cent, but the perilabyrinthine air cells in about half of the cases, are not seen, even actually present (Table VI).

Table VI. **Frequency of the pyramid air cells of Fuchien-Chinese** (Li)

Male and Female 475 cases	non-pneumatized pyramid	perilabyrinthine cells, only	perilabyrinthine and apex cells
X-ray finding	328 69.1%	38.5 8.1%	108.5 22.8%
correct percentage	236 49.8%	142 29.8%	97 20.4%

Y. L. Hsu studied on the correlation between the pneumatization of the temporal bone and constitutional evidence of the mucous membrane in the upper air way, such as tonsil hypertrophy and adenoid vegetation. The materials used were 200 primary school pupils affected with tonsil hypertrophy or adenoid vegetation, and 200 healthy school pupils as a control. The degree of development, structure, and type of the outer group of the temporal air cells were examined in the x-ray picture according to Sonnenkalb's technic. The pneumatization of tonsil hypertrophy or adenoid vegetation patients is poorer than healthy children. The degree of development is lower and the structure is more irregular than that of healthy children. Clinically,

Table VII. **The difference in pneumatization type, developmental degree and structure of the temporal bone between tonsillar hypertrophy or adenoid vegetation patients and healthy persons. (Hsu)**

		Tonsillar hypertrophy or adenoid vegetation pts.		Healthy person		D/md
		200 pts. (400 ears)	%	200 pts. (400 ears)	%	
Pneumatization-type	I	8	2.00±0.99	38	9.5±1.5	4.16
	II	23	5.75±1.65	114	28.5±2.3	8.04
	III	142	35.50±3.38	67	16.8±1.9	4.81
	IV	13	3.25±1.25	24	6.0±1.2	1.58
	V	110	27.50±3.16	96	24.0±2.1	0.92
	VI	104	26.00±3.09	61	15.3±1.8	2.99
Developmental degree	good	173	43.25±3.50	219	54.8±3.52	2.33
	poor	227	56.75±3.50	181	45.2±3.52	2.33
Structure	regular	44	11.00±2.21	171	44.0±3.51	7.95
	irregular	356	89.00±2.21	224	56.0±3.51	7.95

when these patients are affected by otitis media, the inflammation will become chronic. It is proved that the disposition of the mucous membrane in the upper air way influences the pneumatization mechanism (Table VII).

Further Hsu calculated the correlation coefficient between various morphology of the skull and pneumatization size. Materials were 50 male and 50 female Fuchien-Chinese adults and concluded the followings:

a) There are no significant correlations between general morphology of the skull and pneumatization size except the weight of the skull. Temporal air cells made the weight of the skull lighter.

b) There are significant correlations between the pneumatization of outer groups and morphology of the mastoid portion, tympanic portion.

c) There are some significant correlations between the pyramidal air cells and morphology of the petrous portion (Table VIII).

Table VIII. **(Hsu)**

a) Whole pneumatization-size and weight of the skull: $r = -0.29$

b) Pneumatization-size of the outer air cell groups and
- length of the process mastoidea: $r = +0.31$
- breadth of the process mastoidea: $\eta yx = 0.41$
- thickness of the process mastoidea: $r = +0.36$
- thickness-breadth index of the process mastoidea: $\eta yx = 0.62$, $\eta xy = 0.39$
- mastoid angle: $\eta yx = 0.43$, $\eta xy = 0.41$
- inclination of the mastoid process against the sagittal-vertical plane: $\eta xy = 0.45$
- surface area of the pneumatic mastoid region: $\eta xy = 0.63$
- bulging of the process mastoidea: $\eta yx = 0.35$
- prominence of the temporal line: $\eta xy = 0.69$
- distance between the height of the temporal line and the middle cranial fossa-floor: $r = +0.40$
- length of the incisura mastoidea: $\eta yx = 0.33$
- breadth of the incisura mastoidea: $r = -0.14$
- depth of the incisura mastoidea: $r = -0.16$
- breadth of the trigonum digastricum: $\eta yx = 0.37$

bulging towards the inferior of the trigonum digastricum: length: r=−0.5, breadth: ηxy=0.37

curvature of the mastoid antrum-tegmen: r=+0.35

depth of the sulcus sinus sigmoidei: r=+0.36

distance between the posterior wall of the external ear canal and the sulcus sinus sigmoidei: r=+0.41

largest breadth of the sulcus sinus sigmoidei: ηyx=0.26

largest depth of the sulcus sinus sigmoidei: r=−0.17

height of the zygomatic arch: ηxy=0.31

c) Pneumatization size of the pyramidal air cells and curvature of the anterior pyramdial plane

curvature of the anterior pyramidal plane: a, r=−0.19 b. ηxy=0.39

breadth of the pyramid: r=+0.23

breadth of the anterior pyramdial plane: r=+0.32

distance between the superior edge of the pyramid and the internal acoustic porus: r=+0.28

size of the impressio trigemini: r=−0.24

These facts have contributions to mastoid operation. In cases of so called dangerous temporal bone, when pneumatization is arrested, the dura of the middle cranial fossa is overhanged downward, and position of the sigmoid sinus is extremely forward.

We may also conclude that the morphology of temporal bone does not influence the pneumatization

Table IX. **Degree of development of operated sides (59 sides). (Hsu)**

Degree \ Sex	Male	Female	♂+♀	M%±m%
I	0	0	0	—
II	0	0	0	—
III	6	7	13	22.1±5.4
IV	31	15	46	77.9±5.4
Total	37	22	59	—

Degree of development of healthy sides (45 sides)

Degree \ Sex	Male	Female	♂+♀	M%±m%
I	2	0	2	4.4±3.1
II	5	4	9	20.0±5.9
III	10	8	18	40.0±7.3
IV	11	5	16	35.6±7.1
Total	28	17	45	—

mechanism, but pneumatization influences the development of the temporal bone.

Diamant reported that almost all chronic otitis media patients have small air cell system. Hsu examined 59 cases (37 male and 22 female) of chronic otitis media, which were operated by himself at the Provincial Taipei Hospital (during 1946-1956). Age varied from 1-30 years old. 18 cases were epiretrotympanal type, other 41 cases were cholesteatoma. x-ray projections were according to Sonnenkalb's method and Stenvers' method. From x-ray and operative findings, Hsu classified the degree of deve-

Table X. **Structure of operated sides (59 sides). (Hsu)**

Structure \ Sex	Male	Female	Total
Regular	0	0	0
Relatively regular	0	0	0
Relatively irregular	0	0	0
Irregular	37	22	59

Structure of healthy sides (45 sides)

Structure \ Sex	Male	Female	♂+♀	M%±m%
Regular	2	0	2	4.4±3.1
Relatively regular	2	2	4	8.9±4.2
Relatively irregular	6	5	11	24.4±6.4
Irregular	18	10	28	62.2±7.2
Total	28	17	45	—

lopment, structure and type of air cell systems in the ill sides and healthy sides. Pneumatization of the ill sides are arrested, and the development of air cell systems of the healthy sides are better than the ill sides in the same individual (Tables IX, X & XI).

Table XI. **Pneumatization types of operated sides (59 sides). (Hsu)**

Type \ Sex	Male	Female	♂+♀	M%±m%
I	0	0	0	—
II	0	0	0	—
III	0	0	0	—
IV	0	0	0	—
V	6	7	13	22.0±6.2
VI	31	15	46	78.0±6.2
Total	37	22	59	—

Pneumatization types of healthy sides (45 sides).

Type \ Sex	Male	Female	♂+♀	M%±m%
I	2	0	2	4.4±3.1
II	2	1	3	6 7±3.7
III	3	3	6	13.3±5.1
IV	2	1	3	6.7±3.7
V	8	7	15	33.7±7.0
VI	11	5	16	35.6±7.1
Total	28	17	45	—

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