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RESEARCH ARTICLE

THE PATTERN OF MASTIOD PNEUMATIZATION IN UNCOMPLICATED CSOM

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ABSTRACT

Background: Chronic suppurative otitis media has remained prevalent in most developing countries including Nigeria with plain mastoid radiograph still playing a part as an investigation tool in patients with this disease.
Aim: To determine the pattern of mastoid pneumatization in patients with uncomplicated chronic suppurative otitis media using plain radiograph of the mastoid.
Methodology: This was a prospective hospital based study, which was carried out in the Otorhinolaryngology clinic and Radiology Departments of Aminu Kano Teaching Hospital, Kano. All first attendees that presented with symptoms and signs of chronic suppurative otitis media whose investigations included plain mastoid radiograph and met the inclusion criteria were enrolled into the study. Quantitative measurement of the mastoid air cells was obtained from the radiograph using mastoid planimetry. The collected data was entered into the computer and analyzed using Statistical package for Social Sciences (SPSS) Version 15 and Minitab 12.0.
Results: A total of 121 patients enrolled in the study. There were 62(51.2%) males and 59(48.8%) females. Their ages ranged from 5 - 80 years (mean=19 years ± 14 SD). They were mainly students (66.6%) who presented with ear discharge (100%), hearing impairment (100%), tinnitus (59.6%), otalgia(1.6%) and vertigo (2.5%). The examination findings were mainly Tympanic Membrane perforation and Conductive Hearing Loss (100%) demonstrated.
The mean area of mastoid air cells were: 4.7cm^2 and 12.97cm^2 in the diseased and normal ears respectively; with a prevalence of sclerotic or poorly pneumatized mastoid ranging from 59.8-62.5% (diseased ear) to 2.9-8% (non-diseased ear). There was significant correlation between the disease and mastoid pneumatization ($P<0.05$). Similarly, mastoid pneumatization pattern correlated well with the duration of the disease ($P<0.05$). On the contrary, sex, age and the side of the ear affected had no correlation with mastoid pneumatization.
Conclusion: CSOM is associated with high prevalence of poorly pneumatized mastoid, which is made worse by prolonged duration of disease and thus an evidence for the environmental theory of mastoid pneumatization and may be a possible indicator of a difficult mastoidectomy.

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INTRODUCTION

Chronic suppurative otitis media has remained prevalent in most developing countries, resulting in significant morbidity amongst those with the disease, especially children. It is a common cause of hearing impairment, disability and poor school performance or poor productivity at work. (Nwankwo and Salisu, 2005; Nwabusi and Ologe, 2002) It is defined as a long-standing infection of a part or whole of middle ear cleft characterized by ear discharge and a permanent perforation of the tympanic membrane (TM). This condition is considered "chronic" if the TM (tympanic membrane) defect is present for three months (Nwankwo and Salisu, 2005; Steven and Cecelia, 2003). The disease may progress to involve the mastoid bone, when infection fails to resolve completely or may be chronic from its onset. Also, inadequate antibiotic therapy may result in persistence of low grade infection with ultimate development of chronic mastoiditis (Eric, 1980). Studies have shown that chronic middle ear disease like this suppresses the pneumatization of the mastoid air cells, while the outcome of some researches is contrary to this finding. (Ruhl and Pensak, 1999; Kim *et al*., 2012) Therefore, there is need to find out the

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pattern of mastoid pneumatization amongst CSOM patients in our setting where the disease is highly prevalent. This will ensure effective treatment, in the long run. Besides, a study on this will help to update and also bridge the gap in the current the literature.

Although, high resolution CT scan is now established as the gold standard in assessing the mastoid air cell system (Steven and Cecelia, 2003; Virapongse *et al*., 1985; Waizel-Haiat *et al*., 2011). However, for reasons of high cost, most patients with CSOM in our environment cannot benefit from this investigation; hence plain radiograph is still in use in the assessment, and it's quite reliable. (Virapongse *et al*., 1985; Waizel-Haiat, 2011; Ashwani *et al*., 2006; Harold, 2012; Balasubramanian, 2012; Todd *et al*., 1987)

The aims of the present study were:

1) To determine the prevalence of the types of mastoid air cell system in patients with uncomplicated CSOM
2) To determine the relationship if any, between age, sex, the side of the ear affected and the duration of disease on pattern of mastoid pneumatization in patients with uncomplicated CSOM

MATERIALS AND METHODS

Study population

The study population was all consecutive patients from age 5 years and above with diagnosis of uncomplicated CSOM that presented to the Otorhinolaryngology clinic of AKTH Kano that were eligible for the study.

Sample size determination

The sample size for this study was determined using the fisher's formula (Singh, 1996). The minimum sample size for the study was 120 as calculated from the formula:

$$N = \frac{(Z, -X)^2 (P) (1-P)}{d^2}$$

Where "N" = Minimum sample size

At 95% confidence level Z,-X = 1.96 from statististical table.
P = the best estimate of the population prevalence obtained from literature (7.2% was obtained from a similar study done in Jianji specialist Hospital China). (Sui *et al*., 1996)

$$N = \frac{1.96^2 \times (0.072)(0.928)}{0.05^2}$$
$$= 102.67$$

It is estimated to be 120, because of attrition

Ethical consideration

An ethical clearance was obtained from the hospital's Ethics review committee. All eligible patients/guidance gave informed consent before administration of the data form

Diagnostic criteria

The diagnosis is clinical as outlined in standard otology text (Smith and Mackenzie, 2007). These included all the following:

- Otorrhoea of at least 3 months duration
- Hearing loss
- Otoscopic finding of TM perforation (Smith and Mackenzie, 2007)
- For the purpose of this research, Uncomplicated CSOM is define as any structural change in the middle ear cleft associated with a permanent defect in the TM that has been present for at least 3 months without clinical or radiographic evidence of spread outside the middle ear cleft.

Limitation

The limitations of the study relate to the inadequacy of mastoid radiograph to detect some complications.

Eligibility criteria

Inclusion criteria:

This included all first attendee CSOM patients that presented to the ORL clinic of AKTH Kano, during the period of study, with the following:

- At least 3 months history of otorrhoea,
- History of hearing loss.
- Otoscopic finding of TM perforation

Exclusion Criteria:

- Those with complicated CSOM (those with cholesteatoma inclusive)
- Age less than 5years
- Those without plain mastoid radiographs
- Those who refuse to give informed consent

Study design

A specially designed form was used to record information such as age, sex, religion, marital status tribe, address and occupation. Patient's symptoms were also recorded. A detailed ENT and general examinations were performed with the participant seated on the chair. Otoscopy (Welch Allynotoscope, REF.11720) was performed and findings documented. Subsequently, each participant's plainimetric assessment was also documented.

Measurement techniques

The planimetric measurement method was used to outline the mastoid air cell system (MACS) by marking out on the lateral view of mastoid radiograph placed on a well illuminated viewing box. The marked area of mastoid pneumatization on the radiograph was then transferred to a graph paper using carbon paper; where the number of mm^2 was counted directly.

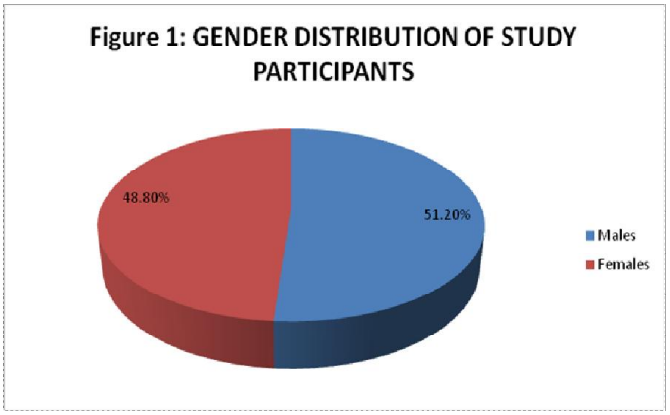
The measured area in mm^2 on the graph paper was then converted to cm (Roghani *et al*., 1999; Apuhan *et al*., 2011). The measured plainimetric areas of MACS was divided into two categories; pneumatized mastoid (greater than $8cm^2$) and non-pneumatized mastoid (less than $8cm^2$). This division was based on the study done by Chaterjee *et al.* (Chatterjee *et al*., 1990; Manolis *et al*., 2009), who found out the range of area of mastoid air cell system to be 8 to 22 Sq cm in their study on 50 Indians (Ashwani *et al*., 2006).

Data analysis

The result of collected data using the study instrument was entered into the computer system for analysis. Statistical package for Social Sciences (SPSS) Version 15 statistical software was used for data analysis. Qualitative data were summarized using frequencies and percentages, while quantitative variables were summarized using measures of central tendency and dispersion. Chi-square was used to establish the relationship between the variables (age, sex, the side of the ear affected) and the quantitative measurements of the mastoid pneumatization.

RESULTS

The total number of patients enrolled in the study was 121. Their ages ranged from 5 - 80 years (mean=19 years ± 14 SD). Majority (59.5%) was below 19years; mainly Muslims (92.6%) of Hausa ethnic group (85.1%) and predominantly (84.3%) reside in Kano. Table 1-2. It was observed that most of the patients were students (66.1%) with a slight male (51.2%) preponderance Figure 1-2. The commonest symptom was ear discharge (100%); mainly Muco-purulent type, while the least common was otalgia (1.6%)



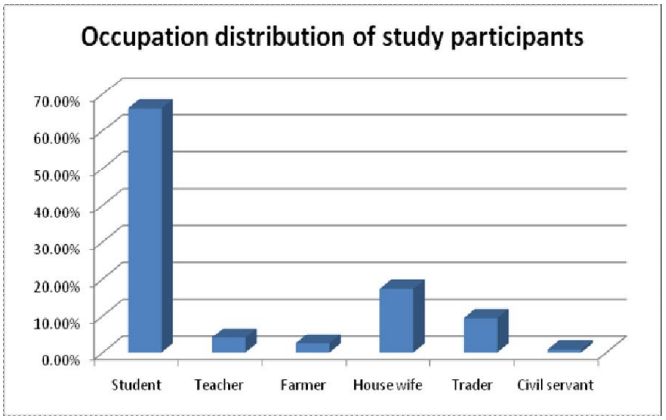


Figure 2. Occupational distribution of study participants

Each patient had his/her 2 ears examined and investigated, given a total 242 ears in the study. The number of the diseased ears was 183 (75.6%) while 59 (24.4%) ears were normal. However, most of the ears with CSOM had central TM perforation (58.5%) of which all of them (100%) had conductive hearing loss. Majority (46%) had weber's test lateralized to the right ear. Table 4

Table 1. Age distribution of study participants

Age(years)	Frequency	Percentages (%)
0-9	37	30.6
10-19	35	28.9
20-29	21	17.4
30-39	19	15.7
40-49	4	3.3
50-59	2	1.7
>60	3	2.3
Total	121	100

Table 2. Certain biodata of study participants

Ethnicity	Frequency	Religion	Frequency	Address	Frequency		
		Islam	Christianity	Kano	Jigawa	Katsina	Bauchi
Hausa	103(85.12%)	103	0	86	14	1	2
Fulani	6(4.96%)	6	0	4	2	0	0
Igbo	4(3.31%)	0	1	4	0	0	0
Yoruba	1(0.83%)	0	1	1	0	0	0
Esako	1(0.83%)	0	2	1	0	0	0
Ebira	5(4.13%)	3	1	5	0	0	0
Igala	1(0.83%)	0	9	1	0	0	0
Total	121(100%)	112(92.6%)	9(7.4%)	102(84.3%)	16(13.2%)	1(0.8%)	2(1.7%)
	100%	100%		100%			

Table 3. Symptoms of CSOM amongst study participants

Symptoms		Right	Left	Total	Percentage total
Ear discharge –Mucopurulent		91(50%)	79(43%)	170(93%)	100%
--Mucoid		5(3%)	8(4%)	13(7%)	
Hearing impairment-	Present	96(52.5%)	87(47.5%)	183(100%)	100%
Tinnitus	-Present	57(31.1%)	52(28.4%)	109(59.6%)	100%
-Absent		39(21.3%)	35(19.1%)	74(40.4%)	
Others(Otalgia)	-Present	2(1.1%)	1(0.55%)	3(1.6%)	100%
-Absent		94(51.4%)	86(47%)	179(97.8%)	

*Vertigo: (3)2.5% of participants

* In the normal ears, only 1.7% had tinnitus as the presenting symptom.

Table 4. Signs of CSOM amongst study participants

Signs		Right	Left	Central	Total	Percentage
TM Perforation –Central		50	52	-	107(58.47%)	100%
	-Sub-total	43	30	-	73(39.89%)	
	-Total	3	0	-	3(1.64%)	
Rinne's test	-Positive	0	0	-	0	100%
	-Negative	96(52.5%)	87(47.5%)	-	183(100%)	
Weber's		56(46.3%)	49(40.5%)	16(13.2%)	121(100%)	100%

* In the normal , 1 ear (1.7%) had ear wax, and thus CHL

Table 5. Pattern of mastoid Pneumatization in normal and diseased ears

Health status	Right Poorly pneumatized	Well pneumatized	Total	Left Poorly pneumatized	Well pneumatized	Total
Diseased ears	60(62.5%)	36(37.5%)	100%	52(59.8%)	35(40.2%)	100%
Normal ears	2(8%)	23(92%)	100%	1(2.9%)	33(97.1%)	100%
Total	62 (51.2%)	59 (48.8%)	121(100%)	53 (43.8%)	68 (56.2%)	121(100%)
χ^2	21.4			29.8		
P-Value	$< 0.05^a$			$< 0.05^a$		
CI	4.3-86			6.4-375.2		
OR	19			49		
Fisher exact p-value	$< 0.05^a$			$< 0.05^a$		

* Mean area of mastoid air cells in the normal ears = 12.97 sq.cm± 11.79 SD.* Mean area of mastoid air cells in the diseased ears = 4.7 sq.cm ±4.34 SD. a: statistically significant

Table 8. Pattern of mastoid pneumatization based on age in diseased ears

Age	Right Poorly pneumatized	Well pneumatized	Total	Left Poorly pneumatized	Well pneumatized	Total
Children(≤18years)	41(65.1%)	22(34.9%)	100%	34(66.7%)	17(33.3%)	100%
Adult(>18years)	19(57.6%)	14(42.4%)	100%	18(50%)	18(50%)	100%
Total	60 (62.5%)	36 (37.5%)	96(100%)	52 (59.8%)	35 (40.2%)	87(100%)
χ^2	0.8			0.3		
P-Value	0.37^d			0.57^d		

[d]; Not statistically significant.

Table 9. Pattern of mastoid pneumatization based on age in normal ears

Age	Right Poorly pneumatized	Well pneumatized	Total	Left Poorly pneumatized	Well pneumatized	Total
Children(≤18years)	2(25%)	6(75%)	100%	0	20(100%)	100%
Adult(>18years)	0	17(100%)	100%	1(7.1%)	13(92.9%)	100%
Total	2 (8%)	23 (92%)	25(100%)	1(2.9.%)	33(97.1%)	34(100%)
χ^2	1.8			1.5		
P-Value	0.17^e			0.2^e		
Fisher's exact p-value	0.09^e			0.41^e		

[e]; Not statistically significant.

Table 10. Pattern of mastoid pneumatization based on duration of CSOM

Age	Right Poorly pneumatized	Well pneumatized	Total	Left Poorly pneumatized	Well pneumatized	Total
Long duration(>82months)	41 (95.3%)	2 (4.7%)	100%	32 (86.5%)	5 (13.5%)	100%
Short duration(≤82 months)	19 (35.8%)	34(64.2%)	100%	20(40%)	30 (60%)	100%
Total	60 (62.5%)	36 (37.5%)	96(100%)	52 (59.8%)	35 (40.2%)	87(100%)
χ^2	33.9			18.4		
P-Value	$<0.05^f$			$<0.05^f$		
CI	8-168.8			-		
OR	36.7			-		
Fisher's exact p-value	$<0.05^f$			-		

[f]; Statistically significant.

The mean area of mastoid air system was found to be 4.7cm.sq in the ears suffering from CSOM, whereas it was found to be 12.97 cm.sq in the non diseased ears. The prevalence of poorly pneumatized mastoid in the right (diseased mastoid air cells and the non-diseased mastoid air cells) were; 62.5% and 8% respectively. This difference was statistically significant ($\chi^{2(Yates)}$=21.4, p<0.05, Fisher's exact p-value<0.05). Similarly, the observed prevalence of poorly pneumatized mastoid in the left (diseased and non-diseased mastoid air cells) were: 59.8% and 2.9% respectively. Also found to be statistically significant ($\chi^{2(Yates)}$=29.8, p<0.05, Fisher's exact p-value<0.05). However, there was no significant difference between the effects of the disease on the right ear compare to the left ear. Table 5 The age group had no significant relationship with mastoid pneumatization pattern in these patients (χ^2 = 0.52 , p = 0.47, for the right diseased ears, χ^2 = 2.4 , p = 0.11 for the left diseased ear) Table 8. Similarly, in the normal ears, there was no relationship between mastoid pneumatization pattern and age (Right $\chi^{2(Yates)}$=1.8 p = 0.17, Fisher's exact p-value= 0.09, Left $\chi^{2(Yates)}$=1.5 p = 0.2, Fisher's exact p-value= 0.41). Table 9. The mean durations of the disease were: 83.9 months (right ear), 80.8 months (left ear) and 82 months (average). The duration of disease ≤ 82 months was taken as shorter duration and the value above that was taken as longer duration of disease. It was however observed that the majority (95.3%) of those with longer duration of disease had poorly pneumatized mastoid air cells in both ears and the difference between the two groups was statistically significant (Right ; $\chi^{2(Yates)}$=33.9, p<0.05, Fisher's exact p-value<0.05& Left χ^2 = 18.4, P<0.05). However, similar outcome was observed in both ears.

DISCUSSION

Chronic suppurative otitis media is a disease that is highly prevalent amongst children in the developing countries including Nigeria. (Nwankwo *et al*., 2005; Nwabusi and Ologe, 2002; Monasta *et al*., 2012) Its consequences on mastoid air cells is that of sclerosis, as reported by various studies on secretory otitis media, as well as a study on CSOM , outside our locality (Ruhl and Pensak,1999; Kim *et al*., 2012; Ashwani *et al*., 2006; Sui *et al*., 1996; Valtoen *et al*., 2005; Qvarnberg, 1982). Also, it has been an issue of debates for decades ; whether the sclerosis observed was due to congenital inheritance or acquired changes(environmental theory) as a result of infection or inflammation of the middle ear (KOÇ *et al*., 2004; Kumar *et al*., 2012).This present study was undertaken to evaluate the pattern of mastoid pneumatization amongst patients with CSOM and also to elucidate other factors that may affect the patient's mastoid air cell pattern. A prevalence of sclerotic mastoid air cells ranging from 59.8% (left) to 62.5% (right) was observed in the ears with CSOM. This is similar to the findings of Ashwani *et al*. (2006) who reported a prevalence of 52% following a study carried out on 50 Indians with unilateral CSOM. The similarities is perhaps due the fact that both population has similar characteristics like illiteracy, poverty, cultural beliefs and so on that may delay presentation for medical care, thus prolonging middle ear infection and resulting in more sclerotic mastoid. Although a better standard of living and easier access to health care in India compare to Nigeria could possibly explain why the prevalence of sclerotic mastoid in the diseased ears is slightly higher in the current study compare to that reported by Ashwani *et al*. (2006). On the contrary, a lower prevalence range of 2.9% (left) to 8% (right) for sclerotic mastoid was noted in the normal ears, amongst the 59 patients (49%) with unilateral CSOM, in this study. However, Ashwani *et al*. (2006) reported a prevalence of 16% for the normal ears. The findings in this control is an indication that acquired factor like CSOM is responsible for the sclerosis in the diseased ears. Also, it suggests that the Indians has less pneumatized mastoid air cells (84%) in the normal ears compare to the normal ears in this current study population (92-97.1%) which is mainly of Hausa ethnic origin (85% of the patients). Like other studies (Ruhl and Pensak, 1999; Kim *et al*., 2012; Ashwani *et al*., 2006; Sui *et al*., 1996; Valtoen *et al*., 2005; Tos and Stangerup, 1985; Qvarnberg, 1982), it was observed that poorly pneumatized mastoid (sclerotic) air cells have significant relationship with CSOM, when compared with the normal ears. This is in support of the environmental theory of mastoid pneumatization. And it is similar to the outcome of Tos's research (Tos and Stangerup, 1985), whose finding also supports the theory. Tos stated that a wide variations of air cells and decreased development of air cells system were due to confrontation of the middle ear mucosa in childhood to pathologic stimulus such as acute otitis media, tubal occlusion and chronic otitis media (environmental theory) (Tos and Stangerup, 1985; KOÇ *et al*., 2004). The most prominent symptoms amongst these patients was ear discharge (100%), while the least common was Otalgia (1.6%) which is a lower percentage compared to Similar study done by Kumar *et al*, where 17% of the patient had Otalgia. This is probably because most of the patients is the later study had cholesteatomaas compare to this current one in which cholesteatoma patients were excluded. (Kumar *et al*., 2012) The examination findings showed that more than half (58.47%) of the diseased ears had central perforation and 39.89% had subtotal TM perforation. This is slightly similar to the findings of Ogisi *et al*. (2004) But different in the sense that total perforation was also observed in this study unlike the former. About 52.5% of the diseased ears had conductive hearing loss in the right ear with weber's test lateralized to the same side in 46% of them. The Rinne's test findings were in agreement with the distribution pattern of the disease in this study, in which 52.5% had right CSOM compare to the left with 47.5%. However, the weber's test showed that the majority (46.3%) had lateralization to the right (worst ear) which is in conformity with the findings of more sclerosis in the right (62.5%) compare to the left ears (59.8%). The mean area of mastoid pneumatization in the diseased and the non-diseased ears were : 4.7 sq.cm and 12.97 sq.cm respectively. This is similar to the observation made by Andreasson (Roghani *et al*., 1999) and Flisberg (Ashwani *et al*., 2006) in which ; 4.4 sq.cm (Ashwani *et al*., 2006) and 12.7 sq.cm (Roghani *et al*., 1999) were the observed value for the diseased and the normal respectively.On the contrary, Ashwaniet.al, discovered a slightly different value; both for the diseased (6.8sq.cm) and the non-diseased (10.8sq.cm).[9]This can possibly be due to the same reason deduced for the slight difference in the prevalence above.

Furthermore, age distribution pattern of patients in this study showed no significant difference in the pattern of mastoid

pnuematization between children and adult. Also, between sides of the ear affected. This is similar to the finding of other researchers who have reported a higher prevalence of sclerotic mastoid (82.2%) amongst pediatric age group and adult, without significant difference between the two groups (Apuhan *et al*., 2011; KOÇ *et al*., 2004). In contrast, Tumarkin had carried out a study amongst the slum dwelling population in the UK, which showed a different pattern of pneumatization amongst children. (Robinson *et al*., 1993) Similarly, evaluation of the data; grouped according to gender showed no significant difference in mastoid pnuematizationpattern between male and female nor significant difference between right and left ear. This is similar to the findings of Lee *et al.* (2005) who found no statistically significant difference between male and female mastoid air cells system. However, some authors, have reported a different pattern of mastoid pneumatization as it relates to sexual dimorphism (Tos *et al.,* 1985). Also, in this study, longer duration (>82months) of the disease was significantly associated with poorly pnuematized mastoid air cells, which is similar to the study done by TOS and others on chronic otitis media (Valtoen *et al*., 2005; Tos and Stangerup, 1985; KOÇ *et al*., 2004). On the contrary, Ashwani *et al.* found no significant difference between mastoid pnumatization pattern in CSOM patients and the duration of the disease (Ashwani *et al*., 2006).

Conclusion

Chronic suppurative otitis media is associated withpoor pneumatization (sclerosis) of mastoid air cells (59.8-62.5%), especially in those that harbor the disease for more than 82months. On the contrary, age, sex and the side of the ear affected has no effect on the mastoid Pneumatizationpattern. Thus, this evidence strongly support the environmental theory of mastoidpneumatization and suggests a more difficult mastoidectomy in CSOM patients. Therefore, we advocate for prompt presentation for treatment so as to limit mastoid sclerosis and thus reduce the problem of difficult mastoidectomy, in those that may need the surgery.

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