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Role of HRCT temporal bone in pre-operative evaluation in unsafe ear diseases. A hospital record based retrospective study in Thane, Maharashtra

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ABSTRACT

Introduction

Cholesteatoma as a disease is considered to be an unsafe type of CSOM because of its propensity to destroy neighbouring structures. In a developing country like India, due to the vast population of patients from low socio-economic strata, this unsafe type of disease is widespread.

Material & Methods

Hospital record based retrospective study was conducted in 50 patients over 18 months. The radiological assessment was done with high resolution computed tomography (HRCT). All patients underwent mastoid exploration and the intra-operative findings such as type and extent of disease, ossicular erosion and complications were noted during surgery and these findings were compared with findings of HRCT temporal bone. Sensitivity and specificity were calculated by using Statistical Package for Social Sciences version 27.0. Interrater agreement Kappa was used to find agreement between HRCT and surgical findings.

Results

In our study, majority (42%) were in the age group of 21-40 years. Majority 26 (52%) of the patients were found to be positive for cholesteatoma with granulations. In our study on analysing the agreement between HRCT and intraoperative assessment, maximum sensitivity was 92.9% and specificity was 95.6%. Majority of the cases had erosion in the malleus and the least eroded ossicle was Incus. Highest level of agreement was seen on findings between HRCT finding and intraoperative finding for disease in the labyrinth.

Conclusion

HRCT temporal bone findings are in good agreement with the intra operative findings. Thus, HRCT can be used as a standard radiological imaging modality to evaluate temporal bone pathology.

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INTRODUCTION

World health organization (WHO) estimated that 65–330 million people worldwide are affected by Chronic otitis media (COM), of whom 50% suffer from hearing impairment and approximately 28 000 deaths per annum are due to the complications of otitis media. Chronic otitis media may be further classified into Tubo tympanic type (Safe) and Attico antral type (Unsafe). Otitis media is defined as an inflammation of the middle ear without reference to aetiology or pathogenesis. COM is a chronic inflammatory process in the middle-ear space that insidiously, in long-term, leads to permanent changes in the tympanic membrane including atelectasis, dimer that was formerly monomer formation, permanent perforation, development of retraction pocket, or cholesteatoma formation.[1,2,3]

Cholesteatoma as a disease is considered to be an unsafe type of CSOM because of its propensity to destroy neighbouring structures. In a developing country like India, due to the vast population of patients from low socio-economic strata, this unsafe type of disease is widespread. The diagnosis of this disease is usually a combination of clinical findings, including history, otoscopic examination, pure-tone audiometry, and radiological findings.

High resolution computed tomography (HRCT) plays an essential role in evaluating the middle ear disease process and the adjacent bone, and its advent has significantly altered the contribution of radiological imaging in the preoperative diagnosis of middle ear disease.[3,4,5]

This study was undertaken to study the role of HRCT temporal bone in preoperative evaluation of unsafe ear diseases and correlate with the intraoperative findings.

Material and Methods

This was a record based Retrospective study conducted in department of ENT RGMC & CSMH Kalwa Thane. Study duration was for 18 months from 01 March 2021 to 30 August 2022. There were 69 patients during the study period and 50 were included as per inclusion and exclusion criteria. Inclusion criteria were: Patients in age group 03 years to 65 years with atticoantral disease, cholesteatoma in middle ear, both male and female gender and newly diagnosed cases. Exclusion criteria were: Safe CSOM (tubotympanic), temporal bone fracture, patient with previous surgery operated for unsafe disease, incomplete or missing data.

Sample size at 95% Confidence Interval was 50 as per prevalence (4%) given by Khalique.[6] Sample size was determined as per OpenEpi, software Version 3 by the following formula

Sample size n = [DEFF*Np(1-p)]/ [$(d^2/Z^2_{1-\alpha/2}$*(N-1)+p*(1-p)]

Hypothesized % frequency of outcome factor in the population (p): 4%+/-5.5

Confidence limits as % of 100(absolute +/-%)(d):5.5%

In our study 50 Patients fulfilling the inclusion criteria were selected for this study. All the patients were from a local self government tertiary care hospital Rajiv Gandhi Medical College & Chhatrapati Shivaji Maharaj Hospital Kalwa Thane hospital. Study was started after approval from Institutional Clinical Ethics Committee (RGMC/ICEC/272/07/2022 dated 12/07/2022). Cases were clinically examined and Pure Tone Audiometer done in the ENT department. The radiological assessment was done with high resolution computed tomography (HRCT). Parameters applied included 512 matrix, 200 field of view, 2 mm thick section, 120 KV and 50 mA exposure. Imaging characteristics of HRCT scan were recorded in all patients. All patients underwent mastoid exploration under general anaesthesia and the intra-operative findings such as ossicular erosion, type and extent of disease, and complications were noted during surgery and these findings were compared with findings of HRCT temporal bone. The above records and case sheets of the patient were sought from medical record section by permission of dean and medical superintendent. Fourteen patients with incomplete or missing data were excluded from the study. Percentage and proportions were used for descriptive statistics. Interrater agreement Kappa was used to find agreement between HRCT and surgical findings. Sensitivity (Sensitivity= True Positive/ True Positive+ False Negative) and specificity (Specificity= True Negative/ True Negative+ False Positive) were calculated by using Statistical Package for Social Sciences version 27.0. (IBM, Chicago, USA). The Excel and SPSS (SPSS Inc, ver. 27 Chicago) software packages were used for data entry and analysis. Mean $\pm$ Standard Deviation (SD) was used for each parameter for continuous data. Numbers and

percentages for categorical data were presented in Tables.

RESULTS

In our study, the mean age was 23.64 ± 7.63 SD years. Majority were in the age group of 21-40 years, followed by the age group of less than 20 years. 32(64%) were male and 18 (36%) were female. Majority 21 (42%) had left sided pathology, 18 (36%) had right sided and 11 (22%) were bilateral. Age-wise distribution of study subjects is shown in Table 1.

Table 1:Agewise distribution of study subjects

Age group	Frequency	Percentage
<20	14	28
21-40.	21	42
41-60	9	18
61-80	6	12
Total	50	100

Among the patients included in the study most common complaints were intermittent foul smelling ear discharge (52%). 44% had complaints of continuous ear discharge, 26% had reduced hearing. Distribution of the chief complaints is shown in Table 2.

Table 2: Distribution of the chief complaints(N=50) in our study

Chief complaints	Frequency	Percentage
Intermittent foul smelling war discharge	26	52
Continuous ear discharge	22	44
Reduced hearing	13	26
Earache	8	16
Tinnitus	2	4
Facial weakness	3	6

In HRCT, all 50 (100%) patients suspected with Unsafe ear had unspecific soft tissue density. On intraoperative assessment, majority (26, 52%) of the patients had cholesteatoma with

granulations, and 13 (26%) had cholesteatoma. Distribution of the study subjects based on pathology findings in HRCT and during intraoperative findings is shown in Table 3.

Table 3: Distribution of the study subjects based on pathology findings in HRCT and during intraoperative findings. (N=50)

Pathology	HRCT scan positive findings	Intraoperative positive findings
Unspecific soft tissue density	50	0
Granulation	0	9 (18%)
Glue	0	2 (4%)
Cholesteatoma	0	13 (26%)
Cholesteatoma with granulations	0	26 (52%)
Total	50	50

On analysing the agreement between HRCT and intraoperative assessment, maximum sensitivity (92.9%) and specificity (95.6%) were observed for diagnosing the extent of disease in labyrinth. The other diseases (Tegmen erosion, External auditory canal, Jugular bulb, Sinus plate, Scutum erosion and Inner ear) showed lesser agreement (Table 4).

Table 4:Distribution of the study subjects based on extent of the disease in **HRCT and during intraoperative findings. (N=50)

Extent of Disease	HRCT scan positive findings (N=50)	Intraoperative positive findings (N=50)	SE (%) (Confidence Interval)	SP % (Confidence Interval)	*PPV (Confidence Interval)	NPV (Confidence Interval)	P vlaue
External auditory canal	13 (26%)	7 (14%)	26 (14.63 to 40.35)	86 (73.26 to 94.18)	65 (40.78 to 84.61)	53.75 (42.24 to 64.97)	0.21
Labyrinth	9 (18%)	8 (16%)	18 (8.57 to 31.44)	84% (70.89 to 92.83)	52.94% (27.81 to 77.02)	50.6% (39.4 to 61.76)	1
Scutum Erosion	13 (26%)	16 (32%)	26 (14.63 to 40.35)	68 (53..3 to 80.48)	44.83% (26.45 to 64.31)	47.89 (35..88 to 60.08)	0.65
Tegmen Erosion	17 (34%)	5 (10%)	34 (21.21 to 48.77)	90 (78.19 to 96.67)	77.27 (54.63 to 92.18)	57.69 (45.98 to 68.81)	0.007
Sinus plate	8 (16%)	4 (8%)	16 (7.17 to 29.11)	92 (80.77 to 97.78)	66.67 (34.89 to 90.08)	52.27 (41.35 to 63.04)	0.35
Inner ear	1 (2%)	3 (6%)	2 (0.5 to 10.6)	94 (83.45 to 98.75)	25 (6.0 to 80.59)	48.96 (38.61 to 59.37)	0.61

Jugular bulb	3 (6%)	5 (10%)	6 (1.25 to 16.55)	9 (78.19 to 96.67)	37.5 (8.5 to 75.51)	48.91 (38.34 to 59.56)	0.71

*P value by Fishers Exact Test *PPV: Positive Predictive Value, **NNV: Negative Predictive Value SE Sensitivity, SP: Specificity*

On analysing the ossicle erosion, there was a high sensitivity (91%) and specificity (95.7%) in detecting no Incus erosion with HRCT temporal bone. Majority of the erosions were seen in the malleus and the least eroded ossicles were Incus. Distribution of the study subjects based on ossicle erosions observed with HRCT and intraoperatively is shown in Table 5.

Table 5: : Distribution of the study subjects based on ossicle erosion in HRCT and during intraoperative (N=50)

Ossicle Erosion	HRCT scan positive findings	Intraoperative positive findings	SE % (Confidence Interval)	SP % (Confidence Interval)	*PPV (Confidence Interval)	NPV (Confidence Interval)	P value
Malleus	29 (58%)	27 (54%)	58 (43.21 to 71.81)	46 (31.81 to 60.68)	51.79 (38.03 to 65.34)	52.27 (36.69 to 67.54)	0.84
Incus	13 (26%)	15 (30%)	26 (14.63 to 40.35)	7 (55.39 to 82.14)	46.43 (27.51 to 66.13)	48.61 (36.65 to 60.69)	0.82
Stapes	21 (42%)	28 (56%)	42 (28.19 to 56.79)	44 (29.99 to 58.75)	42.86 (28.82 to 57.79)	43.14 (29.35 to 57.75)	0.22

*P value by Fishers Exact Test *PPV: Positive Predictive Value, **NNV: Negative Predictive Value SE Sensitivity, SP: Specificity*

Majority of the patients had soft tissue attenuation in the Aditus. Highest sensitivity of 85.8% for soft tissue attenuation was seen for Hypotympanum region and highest specificity of 89.9% to detect soft tissue without attenuation was for aditus. Distribution of the study subjects based on soft tissue attenuation in HRCT and intraoperatively is shown in Table 6.

Table 6: Distribution of the study subjects based on soft tissue attenuation in HRCT and during intraoperative. (N=50)

Soft tissue attenuation	HRCT scan positive findings	Intraoperative positive findings	SE % (Confidence Interval)	SP % (Confidence Interval)	PPV (Confidence Interval)	NPV (Confidence Interval)	P value
Epitympanum	43 (86%)	41 (82%)	86 (73.26 to 94.18)	18 (85.76 to 31.44)	51.19 (40.03 to 62.26)	56.25 (29.88 to 80.25)	0.78
Mesotympanum	38 (76%)	33 (66%)	76 (61.83 to 86.94)	34 (21.21. to 48.77)	53.52 (41.29 to 65.451)	58.62 (38.94 to 76.48)	0.37
Hypotympanum	29 (58%)	24 (48%)	58 (43.21 to 71.81)	52 (37.42 to 66.34)	54.72 (40.45 to 68.44)	55.32 (40.12 to 69.83)	0.42
Protympanum	24 (48%)	22 (44%)	48 (33.66 to 62.58)	56 (41.25 0 70.01)	52.17 (36.95 to 67.11)	51.85 (37.84 to 65.66)	0.84
Antrum	42 (84%)	44 (88%)	84	12	48.84	42.86	0.77

			(70.89 to 92.83)	(45.43 to 24.31)	(27.90 to 59.86)	(17.66 to 71.14)	
Aditus	44 (88%)	41 (82%)	88 (75.69 to 95.47)	18 (85.76 to 31.44)	51.76 (40.66 to 62.74)	6 (32.29 to 83.66)	0.56

*P value by Fishers Exact Test *PPV: Positive Predictive Value, **NNV: Negative Predictive Value SE Sensitivity, SP: Specificity*

On evaluating the agreement between HRCT finding and intraoperative finding, highest level of agreement was present for the extent of disease in the labyrinth. Of the 9 labyrinth found to be eroded in the HRCT, 8 were found eroded intraoperatively. Least agreement was seen for tegmen erosion. Agreement between HRCT and intra-operative findings is shown in Table 7.

Table 7: Evaluation of level of agreement between HRCT pre-operative findings with the intra-operative findings (N=50)

Extent of Disease	HRCT scan positive findings (N=50)	Intraoperative positive findings (N=50)	SE %	SP %	PPV	NPV	P value
External auditory canal	13 (26%)	7 (14%)	26 (14.63 to 40.35)	86 (73.26 to 94.18)	65 (40.78 to 84.6)	53.75 (42.24 to 64.97)	21.07
Labyrinth	9 (18%)	8 (16%)	18 (8.57 to 31.44)	84 (70.98 to 92.83)	52.94 (27.81 to 77.02)	50.6 (39.40 to 61.76)	1
Scutum erosion	13 (26%)	16 (32%)	26 (14.63 to 40.35)	68 (53.30 to 80.48)	44.83 (26.45 to 64.31)	47.89 (35.88 to 69.08)	0.66
Tegmen erosion	17 (34%)	5 (10%)	34 (21.21 to 48.77)	90 (78.1 to 96.6)	77.27 (54.63 to 92.18)	57.69 (45.98 to 68.81)	0.007
Sinus plate	8 (16%)	4 (8%)	16 (71.70 to 29.11)	92 (80.77 to 97.78)	66.67 (34.89 to 90.08)	52.27 (41.35 to 63.04)	0.35
Inner ear	1 (2%)	3 (6%)	2 (0.05 to 10.651)	94 (83.45 to 98.75)	25 (63.09 to 80.59)	48.96 (38.61 to 59.37)	0.61
Jugular bulb	3 (6%)	5 (10%)	6 (1.2 to 16.55)	90.0 (78.1 to 96.67)	37.5 (85.23 to 75.51)	48.91 (38.34 to 59.56)	0.71
	Ossicle Erosion						
Malleus	29 (58%)	27 (54%)	58 (43.21 to 71.81)	46 (31.81 to 60.68)	51.79 (38.03 to 65.3	52.27 (36.69 to 67.54)	0.84

Incus	13 (26%)	15 (30%)	26 (14.63 to 40.35)	7 (55.39 to 82.14)	46.43 (27.51 to 66.1	48.61 (36.65 to 60.69)	0.82
Stapes	21 (42%)	28 (56%)	42 (28.19 to 56.79)	44 (29.99 to 58.75)	42.86 (28.82 to 57.7	43.14 (29.35 to 57.75)	0.22
	Soft tissue attenuation						
Epitympanum	43 (86%)	41 (82%)	86 (73.26 to 94.18)	18 (85.76 to 31.44)	51.19 (40.03 to 62.2	56.25 (29.88 to 80.25)	0.78
Mesotympanum	38 (76%)	33 (66%)	76 (61.83 to 86.94)	34 (21.21. to 48.77)	53.52 (41.29 to 65.45)	58.62 (38.94 to 76.48)	0.37
Hypotympanum	29 (58%)	24 (48%)	58 (43.21 to 71,81)	52 (37.42 to 66.34)	54.72 (40.45 to 68.44)	55.32 (40.12 to 69.83)	0.42
Protympanum	24 (48%)	22 (44%)	48 (33.66 to 62.58)	56 (41.25 to 70.01)	52.17 (36.95 to 67.11)	51.85 (37.84 to 65.66)	0.84
Antrum	42 (84%)	44 (88%)	84 (70.89 to 92.83)	12 (45.43 to 24.31)	48.84 (27.90 to 59.86)	42.86 (17.66 to 71.14)	0.77
Aditus	44 (88%)	41 (82%)	88 (75.69 to 95.47)	18 (85.76 to 31.44)	51.76 (40.66 to 62.74)	6 (32.29 to 83.66)	0.56
	Facial Nerve canal						
Intact	35 (70%)	32 (64%)	70 (55.39 to 82.14)	36 (22.92 to 50.81)	52.24 (29.67 to 64.60)	54.55 (36.35 to 71.89)	0.67
Non Intact	15 (30%)	18 (36%)	30 (17.86 to 44.61)	64 (49.19 to 77.08)	45.45 (28.11 to 63.65)	47.76 (35.40 to 60.33)	0.67

*P value by Fishers Exact Test *PPV: Positive Predictive Value, **NNV: Negative Predictive Value SE Sensitivity, SP: Specificity*

DISCUSSION

Of the 50 patients, majority (42%) were in the age group of 21-40 years, followed by (34%) the age group of less than 20 years. This was similar to the study conducted by Jose et al in which maximum incidence of middle ear inflammatory diseases was found in the 21–30 age group.[7]

Majority (21,42%) had left sided pathology. Patients suspected with unsafe ear disease commonly presented with intermittent foul smelling ear discharge (52%) and continuous ear discharge (44%)., These findings were in concurrence to the study conducted by Jadi etal.[8]

Many patients complained only of hearing impairment and were unaware of ear discharge. This was due to low volume of pus and drying up of pus to form crusts. Peduced hearing was the third most common symptom. The reason for preservation of hearing was supposedly due the cholesteatoma that bridges the gap between the functioning part of the ossicular chain and the inner ear [8,9]

Imaging modalities should be used in all patients to determine the presence of gross or subtle changes suspected of harbouring a cholesteatoma and the presence of complications, which are mostly due to bone erosions[8.] CT is sensitive for the detection of early bone erosions and provides detailed imaging of extent of middle ear soft tissue diseases. ,[8] In a study conducted by Chee et al, unsafe ear disease can be accurately diagnosed by HRCT in a vast majority of cases.[9] The hallmarks of the unsafe ear disease are the presence of non-dependent soft tissue density in middle ear cavity, smooth erosions of the middle ear borders and adjacent structures and ossicular erosion.' [9]High resolution Computed Tomography provides a more detailed depiction of the anatomic extent of the diseases of the temporal bone. The hallmarks of cholesteatoma along with the changes, when associated with bony expansion of the middle ear cavity, are highly suggestive of cholesteatoma. [9, 10]

In our study all the patients suspected with Unsafe ear had non-specific soft tissue density on HRCT. Intraoperative assessment found cholesteatoma with granulations (52%), cholesteatoma (26%), granulation (18%), and glue ear (4%). This was in concurrence with the study conducted by Jadia et al which reported granulation (10,19.2%), cholesteatoma with granulation (29,55.8%) and glue ear (2, 3.8%) intra operatively [8]

HRCT and intraoperative assessment agreement had maximum sensitivity 92.9% and specificity 95.6% for the extent of disease in labyrinth This was in concurrence with the study conducted by Jose etal and Happani etal which reported highest agreement between the CT and surgical findings for the labyrinth with 100% sensitivity and specificity.' [7,10]

Erosion of ossicles is commonly seen in cholesteatoma, as it enlarges and comes in contact with contagious structures in middle ear. In our study, erosion was commonest in malleus and least in Incus. There was a high sensitivity of 91% and specificity of 95.7% in detecting no Incus erosion with HRCT temporal bone. Jose et al and Baviskar et al found high sensitivity in detecting ossicular destructions in the region of malleus and incus with sensitivities of 87.1 and 92.86 respectively and highest agreement between radiological and surgical findings was seen for incus with a $\kappa = 0.818$. This was similar to our study which found the highest agreement of ossicle erosion for incus $\kappa = 0.879$. [7,8,11]

Studies by Baviskar and Sirigiri found low sensitivity in detection of stapes erosion. This was in concurrence with our study. Sreedhar et al reported that the soft tissue density around the stapes made it difficult to identify the erosion of this bone. [11,12,13]

In our study, HRCT found commonest site of involvement as soft tissue attenuation in Aditus followed by epitympanum. Highest sensitivity of 85.8% for soft tissue attenuation was seen for Hypotympanum region and highest specificity of 89.9% to detect soft tissue without attenuation was for aditus. Study by Happani found that epitympanum was most commonly involved followed by antrum. [10]In our study the highest agreement was found for the prototympanum. This was in concurrence with the study conducted by Jose.[7]

In our study, the highest sensitivity was found for Labyrinth and the least sensitivity was for facial canal erosion. One of the significant drawbacks of HRCT is its inability to accurately detect small erosions of the fallopian canal due to its small size, oblique orientation in the tympanic part and developmental dehiscence, particularly when abutted by soft tissue. Hence, it is important that facial nerve canal should be evaluated in both axial and coronal scans because when a complete bony

canal is present it is easy to detect erosion of the canal wall on HRCT. [11, 12, 13]The study has the limitations of being a single centre study with small sample size.

CONCLUSION

HRCT temporal bone findings are in good agreement with the intra operative findings as per our study. It has high reliability for mastoid pneumatization, scutum erosion, extension of cholesteatoma to various sub sites of middle ear cleft particularly the hidden areas of middle ear cavity.[13] Thus, HRCT can be used as a standard radiological imaging modality to evaluate temporal bone pathology. It delineates the location and extent of the disease and provides critical information regarding anatomical variations and complications. It can serve as a very important roadmap to assist the surgeon during surgery. HRCT provides a fair preoperative warning to the surgeon about the presence of dehiscence or eroded bony structures and various abnormalities that one may encounter during the procedure. Thus, HRCT has the potential to be included in panel of investigations to be done before surgery in ear diseases. We recommend larger studies in future to establish the role of HRCT for ear diseases.

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