Role of high-resolution computed tomography temporal bone in the evaluation of unsafe chronic suppurative otitis media

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ABSTRACT

Background: Unsafe or atticoantral chronic suppurative otitis media (CSOM) is characterized by scanty, purulent, and foul-smelling discharge with attic or marginal tympanic membrane perforation. This can be associated with serious complications. **Objective:** The objective of the study was to evaluate the pre-operative high-resolution computed tomography (HRCT) temporal bone findings in unsafe CSOM and to determine its usefulness in patients undergoing surgery. **Materials and Methods:** In this prospective study, 50 random patients with clinically diagnosed as unsafe CSOM from the ENT Department were subjected to HRCT temporal bone in the Department of Radiodiagnosis, Sriram Chandra Bhanj Medical College, Cuttack. The radiological findings were compared with the intraoperative findings. **Results:** The study results show a good correlation between the pre-operative (HRCT) and intraoperative findings. Cholesteatoma was seen in 35 cases. Ossicle erosion was seen in 40 cases with incus being the most commonly eroded ossicle, followed by scutum erosion (25 cases), mastoid cortex erosion (10 cases), sinus plate erosion (8 cases), tegmen erosion (6 cases), lateral semicircular canal erosion (4 cases), and facial canal erosion (5 cases). Among the extracranial complications (32 cases), mastoiditis was the most common complication and among the intracranial complications (3 cases), epidural abscess was most commonly seen. **Conclusion:** HRCT temporal bone helps in depicting the site, extent of the disease, bony erosions, and complications associated with the disease proving to be very helpful in surgical planning. Hence, it is necessary to preoperatively evaluate every case of unsafe CSOM with HRCT.

Key words: *Cholesteatoma, Chronic suppurative otitis media, High-resolution computed tomography, Temporal bone*

Chronic suppurative otitis media (CSOM) is a long-standing infection of a part or whole of the middle ear cleft, characterized by persistent ear discharge associated with perforation of the tympanic membrane [1]. Unsafe or atticoantral CSOM involves the posterosuperior part of the middle ear cleft characterized by scanty, purulent, and foul-smelling discharge, an attic or marginal tympanic membrane perforation. It is associated with bone eroding processes such as cholesteatoma, granulations, or osteitis, with high risk of complications. Cholesteatoma is a potentially serious condition as it can progressively enlarge and erode into neighboring structures [2]. Since temporal bone is surrounded by many vital structures such as meninges, brain, internal carotid artery, jugular bulb, and facial nerve, the associated complications are high and its gross anatomical variations make surgery difficult at times [3].

These can be avoided if recognized early and properly treated. Early surgical intervention is needed to limit the disease. The presence, location and extent of disease along with the presence of any complications determine the surgical approach to be followed and imaging plays an important role in providing these crucial information to the surgeon in this regard [4]. The advent of high-resolution computed tomography (HRCT) scanning in the 1980s has allowed superb pre-operative imaging of anatomy, some evidence of the extent of the disease, and a screen for asymptomatic complications [5]. With high contrast and good spatial resolution, computed tomography (CT) scan excels in the evaluation of bone and air space anatomy and disorders [4]. Prior knowledge of the extension and the complications of CSOM will alert the clinician and guide in surgical approach and treatment plan [5]. The present study was undertaken with an objective to study the role of HRCT as a diagnostic modality in unsafe CSOM.

MATERIALS AND METHODS

A hospital-based prospective study was carried out on patients with clinically diagnosed unsafe CSOM referred from the Department of ENT to the Department of Radiodiagnosis, Sriram Chandra Bhanj Medical College, Cuttack, Odisha, for HRCT temporal bone. After the ethical committee approval and obtaining and informed consent, a total of 50 subjects with clinically diagnosed unsafe CSOM of all ages and either sex (both males and females) were included in this study. Patients with post-operative ear status, history of trauma to temporal bone, history of neoplastic lesions of the temporal bone, and patients with congenital cholesteatoma were excluded from the study. HRCT temporal bone was performed on GE Brightspeed 16 Slice and GE Revolution Evo 128 slice CT scan machine. Intravenous contrast (iopamidol or iohexol 300 mg/ml at 2 ml/kg body weight) was administered to look for intracranial extension of middle ear disease.

Scanning was commenced from the lower margin of the external auditory meatus and extends upward to the arcuate eminence of the superior semicircular canal as seen on lateral tomogram. Slight extension of the head was given to avoid gantry tilt and thereby protects the lens from radiation. Images in axial, coronal, and sagittal planes were obtained. Scanning parameters were 140 kV, 200 mA, 0.625 mm section thickness, 0.625 mm interval, 10 mm beam collimation, and spiral pitch factor of 0.5625. The contralateral temporal bone was included for comparison in case of unilateral involvement. The images were reconstructed with a bone algorithm. All images were interpreted on GE advantage workstation using source images, multiplanar reformations, and required window settings. The data obtained were tabulated on Microsoft Word and Excel spreadsheet. Statistical analysis was done with the help of SPSS version 25. Statistical parameters such as false positive, false negative, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were used.

RESULTS

In the present study, out of the total 50 cases, 33 (68%) were male and 17 (32%) were female. Male-to-female ratio is 1.9:1. Majority of the patients were in the age group of 21–30 years (34%). The mean age was 28.2 years. The right ear was affected in 17 patients, left ear in 26 patients, and bilateral ear involvement in 7 patients. The major chief complaint was otorrhea (86%), followed by hearing loss (56%), otalgia (38%), aural fullness (34%), headache (14%), vertigo (10%), tinnitus, facial palsy and fever (each 6%), and nausea and vomiting (2%) (Table 1).

In this study, 46 (92%) cases showed soft-tissue dense lesion on HRCT which correlated intraoperatively. HRCT, hence, is 100% sensitive and specific in diagnosing soft-tissue dense lesion. However, the differentiation of soft-tissue dense lesions on HRCT into cholesteatoma and granulation tissue was not possible. Out of the total cases showing soft-tissue dense lesion on HRCT, 35 (70%) cases were found to have cholesteatoma and 11 (22%) cases were found to have granulation tissue intraoperatively.

Among the 35 cases of epitympanum cholesteatoma seen on HRCT, 0 were false positive and 1 was false negative. Mesotympanum cholesteatoma was seen in 25 cases on HRCT, of which 4 were false positive and 2 were false negative. Hypotympanum cholesteatoma was seen in 18 cases on HRCT, of which 6 were false positive and 0 false negative. Aditus ad antrum cholesteatoma was seen in 29 cases on HRCT, of which 1 was false positive and 1 was false negative. Mastoid antrum cholesteatoma was seen in 32 cases on HRCT, of which 1 was false positive and 2 false negative. Mastoid air cells cholesteatoma was seen in 11 cases on HRCT, of which 2 were false positive and 3 were false negative. Table 2 describes the site and extension of cases seen in HRCT which were correlated intraoperatively.

In this study, mastoid was sclerosed in 29 cases (58%), opacified in 14 cases (28%), and well pneumatized in 7 cases (14%) on HRCT and intraoperatively with sensitivity, specificity, PPV, and NPV of 100%. Ossicular erosion was found in 40 (80%) cases. Incus was the most commonly eroded ossicle (68%). Malleus was found to be eroded in 23 (46%) cases on HRCT and 24 (48%) intraoperatively with sensitivity of 88.8%, specificity of 92.8%, PPV of 92.3%, and NPV of 89.6%. Incus was found to be eroded in 31 (62%) cases on HRCT and 34 (68%) intraoperatively with sensitivity of 91.8%, specificity and PPV of 100%, and NPV of 84.2%. Stapes was found to be eroded in 12 (24%) cases on HRCT and 17 (34%) intraoperatively (0 false positive and 5 false negative) with sensitivity of 77.2%, specificity and PPV of 100%, and NPV of 86.8% (Table 3).

Among the extracranial complications, mastoiditis was seen in 21 (42%) cases. Mastoiditis with mastoid abscess was seen in 4 (8%) cases on both HRCT and intraoperatively. Scutum erosion was seen 25 (50%) cases on HRCT and intraoperatively with sensitivity, specificity, PPV, and NPV of 100%. Erosion of tegmen (tegmen tympani and tegmen mastoideum) was seen in

Table 1: Demographics and clinical features of the study population

Parameter	Number of patients (n=50) (%)
Gender	
Male	33 (66)
Female	17 (34)
Age in years	
0–10	5 (10)
11–20	11 (22)
21–30	17 (34)
31–40	12 (24)
41–50	1 (2)
51–60	1 (2)
61–70	1 (2)
71–80	2 (4)
Ear affected	(
Right	17 (34)
Left	26 (52)
Bilateral	7 (14)
Symptoms	
Otorrhea	43 (86)
Hearing loss	28 (56)
Otalgia	19 (38)
Aural fullness	17 (34)
Tinnitus	3 (6)
Vertigo	5 (10)
Headache	7 (14)
Facial palsy	3 (6)
Nausea and vomiting	1 (2)
Fever	3 (6)

Table 2: Site and extension of cholesteatoma

Site	HRCT	IO	FP	FN	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Epitympanum	35	34	0	1	97.2	100	100	94.1
Mesotympanum	25	23	4	2	92	87	85.1	93.1
Hypotympanum	18	12	6	0	100	86.3	66.6	100
Aditus ad antrum	29	29	1	1	96.6	95.4	96.6	95.4
Mastoid antrum	32	33	1	2	94.2	94.4	97	89.4
Mastoid air cells	11	12	2	3	80	95	85.7	92.6

HRCT: High-resolution computed tomography, FP: False positive, FN: False negative, PPV: Positive predictive value, NPV: Negative predictive value

Table 3: Ossicle erosion and complications

Erosions and complications	HRCT	IO	FP	FN	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Malleus	23	24	2	3	88.8	92.8	92.3	89.6
Incus	31	34	0	3	91.8	100	100	84.2
Stapes	12	17	0	5	77.2	100	100	86.8
Scutum erosion	25	25	0	0	100	100	100	100
Tegmen erosion	7	6	1	0	100	97.7	85.7	100
Sinus plate erosion	7	8	0	1	88.8	100	100	97.6
Lateral SCC erosion	6	4	2	0	100	95.8	66.6	100
Mastoid cortex erosion	10	10	0	0	100	100	100	100
Facial canal erosion	6	5	3	2	71.4	93.7	62.5	95.7
Intracranial	3	3	0	0	100	100	100	100
Mastoiditis	21	21	0	0	100	100	100	100
Mastoid abscess	4	4	0	0	100	100	100	100

HRCT: High-resolution computed tomography, FP: False positive, FN: False negative, PPV: Positive predictive value, NPV: Negative predictive value

7 (14%) cases on HRCT and 6 (12%) intraoperatively with 1 false positive and 0 false negative. Erosion of the sigmoid sinus plate was seen in 7 (14%) cases on HRCT and 8 (16%) intraoperatively with 0 false positive and 1 false negative. Erosion of the lateral semicircular canal wall and labyrinthine fistula was seen in 6 (12% cases) on HRCT and 4 (8%) intraoperatively with 2 false positive and 0 false negative. Erosion of the mastoid cortex was seen in 10 (20%) cases both on HRCT and intraoperatively with 100% sensitivity, specificity, PPV, and NPV.

Erosion of the facial canal was seen in 6 (12%) cases on HRCT and 5 (10%) intraoperatively having 3 false positive and 2 false negative. Three patients showed clinical signs and symptoms of facial nerve palsy. The most common site of erosion of the facial canal was the tympanic segment (involvement of labyrinthine segment seen in only one case). The sensitivity is 71.4% and specificity is 93.7% for detecting facial canal erosion. PPV is low 62.5% and NPV is 95.7%. Intracranial complications were seen in 3 (6%) cases both on HRCT and intraoperatively with 1 case showing cerebral abscess and 2 cases showing epidural abscess. Hence, sensitivity, specificity, PPV, and NPV are 100% (Table 3). Figs. 1-3 depict HRCT image of cholesteatoma and associated complications.

DISCUSSION

In this study, the incidence of CSOM was higher in males than females with a male-to-female ratio of 1.9:1, this is in accordance with the study by Kemppainen [6]; however, in the study by Vlastarakos *et al*. [7], there was a slightly higher incidence in females. The most common presenting symptom was otorrhea followed by hearing loss and otalgia which is in accordance with the study by Yorgancilar [8]. In our study, HRCT was 100% sensitive and specific in detecting a soft-tissue lesion which is in accordance with the past studies [9-12]. However, HRCT could not differentiate cholesteatoma from other soft-tissue lesions (granulation tissue, cholesterol granuloma, etc.) which was the same with the previous studies [13-15]. Secondary findings on HRCT such as non-dependent location of the soft tissue in middle ear cavity, widening of aditus ad antrum with loss of its “figure of 8” appearance, and expansion of the mastoid antrum by soft-tissue favors the diagnosis of cholesteatoma [2].

In the epitympanum, HRCT showed 97.2% sensitivity and 100% specificity in detecting cholesteatoma which correlates with the study by Sirigiri and Dwaraknath having 95% sensitivity and 100% specificity [16]. In the mesotympanum, HRCT showed 92% sensitivity and 87% specificity in detecting cholesteatoma which correlates with the study by Rai having sensitivity of 90% and specificity of 87.5%. In the hypotympanum, HRCT showed a sensitivity of 100% and specificity of 86.3% in detecting cholesteatoma which correlates with the study by Rai having sensitivity of 100% and specificity of 81.8%. In the aditus ad antrum, HRCT has sensitivity of 96.6% and specificity of 95.4% in detecting cholesteatoma, which is comparable to the study by Rai having sensitivity of 92.3% and specificity of 91.6%. In the mastoid antrum, HRCT showed 94.2% sensitivity and 94.4% specificity in detecting cholesteatoma, which correlates with

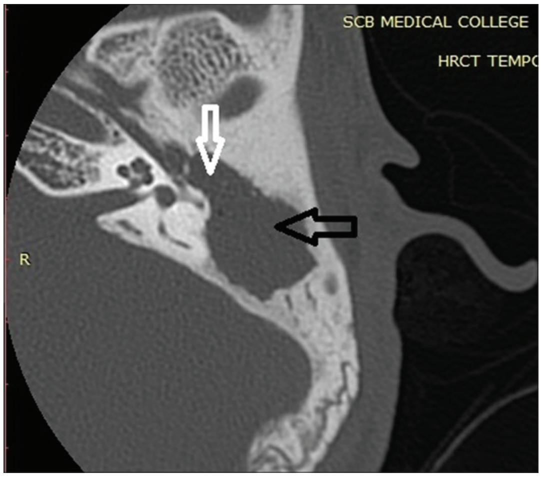

Figure 1: A case of cholesteatoma showing soft-tissue dense lesion in epitympanum with extension into mastoid antrum (black arrow) through widened aditus ad antrum (white arrow). Ossicles are not visualized due to erosion by the cholesteatoma

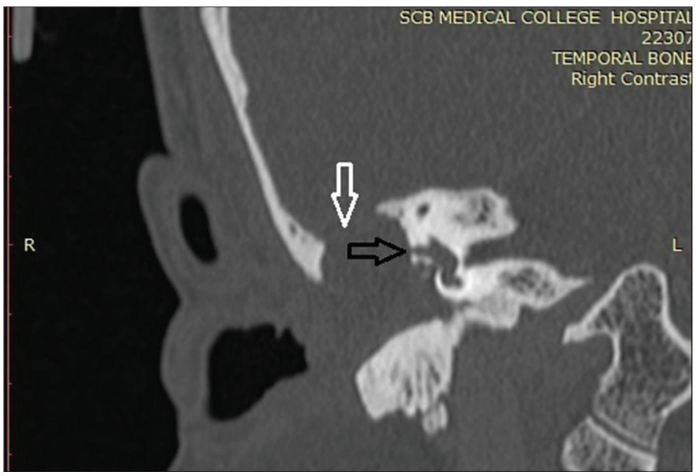

Figure 2: Image showing erosion of the tegmen mastoideum (white arrow) and erosion of the lateral semicircular canal (black arrow)

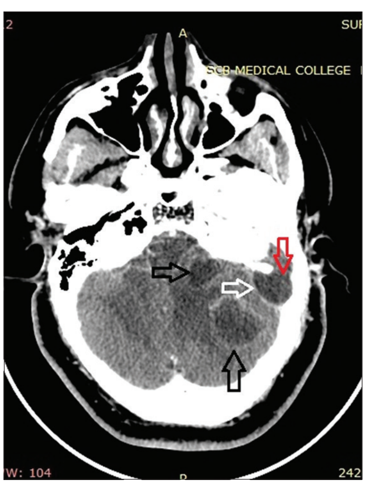

Figure 3: Image showing multiple cerebellar abscesses (black arrows). Erosion of the left sigmoid sinus plate (red arrow) by cholesteatoma with a perisigmoid sinus epidural abscess (white arrow)

the study by Rai having sensitivity of 92.8% and specificity of 90.9% [17]. In the mastoid air cells, HRCT showed sensitivity of 80% and specificity of 95% in detecting cholesteatoma, which is comparable to the study by Sirigiri and Dwaraknath with sensitivity of 86% and specificity of 100% [16].

Bone erosion was identified in 40 cases (80%). This value is in accordance with data by Alzoubi *et al*. [18] and O'Reilly *et al*. [11]. We found cholesteatoma in 87.5% of the total cases showing bony erosion which is similar to a study by Sirigiri and Dwaraknath who found cholesteatoma in 80% of patients with bony erosion [16]. In this study, ossicular erosion was the most common bony erosion seen in 80% of cases which is in accordance with the study by Prakash and Tarannum [5]. Incus was the most common ossicle eroded (68%) with sensitivity of 91.8% and specificity of 100%. This is in accordance with the findings by Tak and Khilnani who found 91% sensitivity and 100% specificity [19]. Malleus was the next most commonly eroded ossicle after incus, seen in 48% of cases with sensitivity of 88.8% and specificity of 92.8% which is correlating to the study by Prakash and Tarannum who found 89.4% sensitivity and 90.9% specificity [5]. Stapes was found to be eroded in 34% of cases with lower sensitivity of 77.2% but showing specificity of 100%. This is comparable to the study by Rai who found 75% sensitivity ad 100% specificity [17].

Scutum erosion was seen in 50% of cases. HCRT is 100% sensitive and specific to detect scutum erosion which is in accordance with the study by Juveria and Sudarshan and Rocher *et al*. [20,21]. The tegmen was found to be eroded in 12% of cases with sensitivity of 100% which is in accordance with Baviskar *et al*. [22] and Jackler *et al*. [15]. However, few studies have shown lower sensitivity values between 45 and 50% [9-11]. The sigmoid sinus plate was eroded in 16% of cases with sensitivity of 88.8% and specificity of 100%. This is in accordance with the study by Prakash and Tarannum and Chatterjee *et al*. [5,23]. Erosion of the lateral semicircular canal with labyrinthine fistula was seen in 8% of cases with sensitivity of 100% and specificity of 95.8%. This is comparable to the study by Sirigiri and Dwaraknath who found sensitivity of 100% and specificity of 94% [16]. The positive predictive value is low 66.6% which correlates with the study by Baviskar *et al*. which was 66.7% [22].

Erosion of the facial canal was seen in 10% of cases which is lesser than incidence seen by Magliulo *et al.* [24] with 27%. The most common site of facial canal erosion was the tympanic segment. This study had low sensitivity which is 71.4%, which is comparable to Magliulo *et al.* [24] (69%) with PPV of 62.5% in this study. This is possibly due to its small size, its thin bony wall, and errors due to reconstruction. However, the specificity is 93.7%, which is slightly higher compared to Magliulo *et al.* (87%). The mastoid cortex was eroded in 20% of cases with sensitivity and specificity of 100%. Similar results were also seen by Niveditha and Chidananda and Rai [3,17]. Mastoiditis with mastoid abscess was seen in 8% of cases in this study with 100% sensitivity and specificity which is similar to the study by Leskinen and Jero [25]. In this study, the intracranial complications (3 cases) were lesser than extracranial complications (32 cases). This is in consonance with the study by Yorgancilar [8]. Intracranial complications were seen in only 6% of cases which is lesser than the study done by Yorgancilar which was 30.6% [8]. This might be possibly due to the early diagnosis and treatment of CSOM before intracranial complications can manifest.

CONCLUSION

HRCT plays a great role in the pre-operative assessment of unsafe CSOM. It has got high reliability in detecting its site and extent, presence of cholesteatoma, in detecting bony erosions, status of mastoid, as well as detecting complications such as extracranial and intracranial complications, thus helping in surgical planning. This study showed good correlation between the pre-operative imaging findings and the intraoperative findings. However, the limitations of this study are the lower sensitivity in detecting facial canal erosion and stapes erosion. Early diagnosis and treatment is required to prevent the complications and to have a good prognosis. Hence, it is necessary to preoperatively evaluate every case of unsafe CSOM with HRCT.

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