Usefulness of Computed Tomography Hounsfield unit Measurement for Diagnosis of Congenital Cholesteatoma

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Aims and objectives

Congenital cholesteatoma appears as a whitish mass in the middle ear with an intact tympanic membrane in children, and it is a rare disease accounting for approximately 2% of all cholesteatoma cases (1).

Both computed tomography (CT) and magnetic resonance imaging (MRI) are used in the diagnosis of cholesteatoma and MR diffusion weight image or delayed enhancement image are evaluated for differential diagnosis (2, 3). However, the use of MRI scans is high cost and the contrast media has complications such as allergic reaction to anaphylactic shock. In addition, CT is superior to MRI for the delineation of the fine bone structures. Therefore, temporal bone CT is the imaging technique of choice for clinically suspected cholesteatoma. Although temporal bone CT has a high sensitivity of detection, its specificity is low because it is not a contrast-enhanced image, and occasionally the findings are similar to those of granulation tissue, secretion, cholesterol granuloma, or neoplasm, particularly when the lesion is not accompanied by any changes in the bone (4). Congenital cholesteatoma requires a complete resection to prevent recurrence, whereas the treatment of non-cholesteatoma group such as cholesterol granuloma or secretion is marsupialization (5, 6). Therefore, preoperative diagnosis of cholesteatoma is important.

According to a recent study (7), Hounsfield unit (HU) measurement may aid the diagnosis of cholesteatoma. Cholesteatoma can be divided into congenital and acquired types, which differ in their location, clinical history, and the status of the tympanic membrane but are indistinguishable histologically (4). Therefore, we hypothesized that the HU measurement in temporal bone CT would be useful for diagnosing congenital cholesteatoma.

The purpose of this study is to evaluate the usefulness of Hounsfield unit (HU) measurement for diagnosis of congenital cholesteatoma.
Methods and materials

The institutional review board approved this retrospective study and waived informed consent.

Patients

Among the patients who performed temporal bone CT between September 2010 and December 2012, forty-three patients who underwent surgery due to middle ear cavity lesion were enrolled in the present study. 21 patients were confirmed as congenital cholesteatoma by histopathological results and the other 22 patients were confirmed as otitis media (OM) by operation.

21 patients of the congenital cholesteatoma group were consistent with the diagnostic criteria suggested by Levenson et al. (8), including the following: (a) a whitish mass in the middle ear cavity with a normal tympanic membrane; (b) a normal pars flaccida and pars tensa of the tympanic membrane; (c) no history of otorrhea and perforation; (d) no history of otological surgery; (e) exclusion of an occluded external canal, intramembranous cholesteatoma, or giant cholesteatoma; and (f) no preclusion of a history of OM.

The OM group was used as a control group for comparing measured HU with congenital cholesteatoma group. We reviewed medical record including the patient age, gender and symptoms in both group.

Imaging protocol

Temporal bone CT was performed in the axial plane, and reformatted coronal images were obtained in all cases. Imaging parameters for CT were as follows: A Somatom Definition Flash (Siemens, Forchheim, Germany), 0.6 mm section thickness, 100 kVp, variable mAs protocol, CT dose index range 2-3 mGy, and 55 to 68 slices performed per examination.

CT image analysis

Two radiologists (Y.W.K and S.H.A) retrospectively reviewed the CT images and independently measured the HU of the soft tissue mass in axial and reformatted coronal images. The HU was measured in slice that shows the largest diameter of soft tissue mass for each case in axial and reformatted coronal images. The region of interest (ROI) was placed within the mass in the middle ear cavity as large as possible, because a large ROI is generally preferred for measuring HU to smaller the variation of its value. Therefore, the ROI circles were placed centered on the mass and laying inside 1 mm from the margin of the mass to eliminate potential artifact from the adjacent bony structure and pneumatized middle ear cavity (Figs. 1-4). The lower HU of the two each value measured
in axial and reformatted coronal images were selected in each case. And then average HU was calculated from two lower HU value by two radiologists. This average HU was defined as the representative value and was used for analysis (Table 1).

In addition, we evaluated the location of the mass, the relationship between the mass and ear ossicle, the presence or absence of bony erosion in the ear ossicle, and the status of the tympanic membrane in the congenital cholesteatoma group.

**Statistical analysis**

We performed Student $t$ test using SPSS 20 (SPSS Inc, Chicago, IL) for statistical analysis. A $P$ value of less than .05 was considered significant.
Fig. 1: Congenital cholesteatoma of the left middle ear cavity in a 3-year-old boy. Axial (Fig. 1) and reformatted coronal (Fig. 2) temporal bone CT scans demonstrating a well-defined, round soft-tissue mass in the mesotympanum of the left middle ear cavity. The measured HU is 36 in axial image and 33 in coronal image. The lower HU of the two measured value were selected in this case. This mass considered as congenital cholesteatoma.

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Fig. 2: Congenital cholesteatoma of the left middle ear cavity in a 3-year-old boy. Axial (Fig. 1) and reformatted coronal (Fig. 2) temporal bone CT scans demonstrating a well-defined, round soft-tissue mass in the mesotympanum of the left middle ear cavity. The measured HU is 36 in axial image and 33 in coronal image. The lower HU of the two measured value were selected in this case. This mass considered as congenital cholesteatoma.

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Fig. 3: Otitis media of the left middle ear cavity in a 5-year-old boy. Axial (Fig. 3) and reformatted coronal (Fig. 4) temporal bone CT scans demonstrating a well defined soft-tissue mass in epitympanum of the left middle ear cavity. It is difficult to distinguish otitis media from congenital cholesteatoma by image finding alone. The measured HU is 79 in axial image and 90 in coronal image. The lower HU of the two measured value were selected in this case. This mass considered as otitis media.

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Fig. 4: Otitis media of the left middle ear cavity in a 5-year-old boy. Axial (Fig. 3) and reformatted coronal (Fig. 4) temporal bone CT scans demonstrating a well defined soft-tissue mass in epitympanum of the left middle ear cavity. It is difficult to distinguish otitis media from congenital cholesteatoma by image finding alone. The measured HU is 79 in axial image and 90 in coronal image. The lower HU of the two measured value were selected in this case. This mass considered as otitis media.

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Table 1

<table>
<thead>
<tr>
<th>Patient</th>
<th>Location</th>
<th>Bone erosion of ear ossicle</th>
<th>Status of tympanic membrane</th>
<th>HU</th>
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Note. - HU = Hounsfield unit, M = Mesotympanum, H = Hypotympanum, E = Epitympanum.
Results

Patients

Twenty-one patients were enrolled in the congenital cholesteatoma group: 16 boys and 5 girls (mean age, 3.9 years; range, 2-7 years). Seventeen patients were incidentally discovered to have a white retrotympanic mass with an intact tympanic membrane during physical examination, including otoscopy, due to symptoms of common cold, rhinitis, or enteritis. The other four patients had symptoms of OM such as otalgia or ear fullness and had a history of OM.

Twenty-two patients were enrolled in the OM group: 13 boys and 9 girls (mean age, 6.2 years; range, 1-18 years). Fourteen patients had symptoms of OM, five patients visited for hearing test, two patients had symptoms of common cold, and two patients were suspected cholesteatoma.

CT evaluation

The mean HU was 37.36 ± 6.11 (range, 27.5-52.5) in the congenital cholesteatoma group and was 76.09 ± 8.74 (range, 58.5-96) in the OM group. The HU differences between the two groups were statistically significant ($P < 0.001$) (Fig. 5). The cutoff value of HU between the congenital cholesteatoma group and the OM group was calculated by using the median value from the maximum HU value in the congenital cholesteatoma group and the minimum value in OM group. The cut-off value is 55.5 between two groups. The measured HU less than 55.5 can be considered as congenital cholesteatoma, whereas an HU greater than 55.5 as otitis media.

The characteristics of congenital cholesteatoma (the largest diameter, location, ear ossicle erosion, and status of the tympanic membrane) are summarized in Table. The mean largest diameter was 4.98 ± 2.13 mm (range, 2.5-12 mm). The location was most commonly in the mesotympanum (14/21, 66.5%) followed by the epitympanum and mesotympanum (5/21, 24%), and then the mesotympanum and hypotympanum (2/21, 9.5%). Five patients (24%) had ear ossicle erosion and sixteen patients (76%) did not. All patients had an intact tympanic membrane.
Fig. 5: The HU of congenital cholesteatoma group and otitis media group

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Conclusion

In conclusion, the cut-off value was 55.5 HU between cholesteatoma group and OM group. HU measurement may be useful as an additional indicator in the diagnosis of congenital cholesteatoma.
References


