Sensorineural hearing loss among cerebellopontine-angle tumor patients examined with pure tone audiometry and brainstem-evoked response audiometry

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Abstract. Tumor in the cerebellopontine angle (CPA) occurs for approximately 5–10% of all intracranial tumors, where unilateral hearing loss and tinnitus are the most frequent symptoms. This study aimed to collect data on sensorineural hearing loss in CPA tumor patients in Dr. Cipto Mangunkusumo Hospital (CMH) using pure tone audiometry and brainstem-evoked response audiometry (BERA). It also aimed to obtain data on CPA-tumor imaging through magnetic resonance imaging (MRI). This was a descriptive, analytic, and cross-sectional study. The subjects of this study were gathered using a total sampling method from secondary data between July 2012 and November 2016. From 104 patients, 30 matched the inclusion criteria. The CPA-tumor patients in the ENT CMH outpatient clinic were mostly female, middle-aged patients (41–60 years) whose clinical presentation was mostly tinnitus and severe, asymmetric sensorineural hearing loss in 10 subjects. From 30 subjects, 29 showed ipsilaterally impaired BERA results, and 17 subjects showed contralaterally impaired BERA results. There were 24 subjects who with large-sized tumors and 19 subjects who had intracanal tumors that had spread until they were extracanal in 19 subjects.

1. Introduction
Tumors in the cerebellopontine angle (CPA) region are the most common tumors in the posterior fossa area, and occur for an estimated 5–10% of all intracranial tumors. CPA tumors consist of acoustic tumors and non-acoustic tumors. Acoustic tumors, such as acoustic neuroma, appear for 80–90% of CPA tumors. Meanwhile, the most common non-acoustic CPA tumors are meningioma (3–13%) and epidermoid (2–6%) [1-3]. Acoustic neuroma is a benign tumor that grows from the vestibular part of vestibulocochlear nerve. Therefore, a compression in the vestibulocochlear nerve usually causes some early symptoms, such as unilateral hearing loss, tinnitus, balance disorder, headache, numbness in the face, and diplopia [3–5]. The ability to hear pure tones is an important factor in pre-operative decision making. Harner et al. performed pre-operative audiometry of 619 neuroma acoustic patients, and most of them had a high frequency of sensorineural hearing loss. This study also showed that the larger the tumor, the more hearing ability has decreased [6,7].
Evaluating CPA tumors can also be examined with a BERA examination. The sensitivity of BERA in detecting tumors smaller than 1 cm is 85.8%, while its sensitivity with tumors that are greater than 1 cm is 95.6% [8]. The lowest sensitivity of BERA (less than 80%) was found in detecting acoustic tumor smaller than 1 cm and 100% sensitivity of BERA was found in discovering tumor greater than 2.5 cm [1,8]. In Indonesia especially in Cipto Mangunkusumo Hospital (CMH), there is no standard examination protocol for CPA tumor screening between any departments. The variety of the data in evaluating hearing loss from CPA tumor cases was the reason why the author chose to research this subject, which audiological examination should become the standard. The author was also interested in understanding the process and predisposing factors for hearing loss as a result of CPA tumors. Because there had been no research on the prevalence of hearing loss in CPA tumor patients in Indonesia, especially in CMH. This study will be useful in providing an information about hearing loss in CPA tumor patients and its relationship with the size and location of tumor. This information will become a standard for surgeons and patients in planning and managing of tumor resections. The problem this study seeks to address is that the prevalence of hearing loss in CPA tumor patients in Indonesia, especially CMH, is unknown, and there are no standard protocols from any department. Therefore, this study’s aim was to observe the characteristics of and hearing function in CPA tumor patients in CMH using pure tone audiometry and BERA during the period of 2012–2016. This study will also serve as an evaluation of audiological examination techniques to inform the treatment of future CPA tumor patients. This study was specifically aimed at observing the characteristics and hearing loss of CPA tumor patients in the ENT clinic in the Faculty of Medicine at CMH using pure tone audiometry and BERA assessment and observing the radiographic features of CPA tumor patients based on magnetic resonance imaging (MRI).

2. Materials and Methods
This study was a cross-sectional, descriptive analysis for the observation of hearing loss in CPA tumor patients and the radiographic features of CPA tumors in CMH. This study examined the pure tone audiometry and BERA results of all CPA tumor patients in CMH who had received MRI head examinations from July 2012 to November 2016. The samples and secondary data were taken as a whole (total sampling). The authors collected epidemiology data of CPA tumor patients from 2012–2016. Secondary data from July 2012 to November 2016 was taken from the medical records of CPA tumor patients that matched the inclusion criteria.

The audiology examinations used as secondary data were pure tone audiometry and BERA data. Radiographic data was collected by a radiology supervisor who assessed the MRI documentation data of the patient. Radiographic data was alternatively collected from the archive of the last 4 years (2012–2016) of the Radiodiagnostic Department of CMH. The radiology supervisor filled the patient’s radiographic evaluation data according to the author’s form. The results of the examinations recorded in the medical record were saved and documented in the research status. After editing and coding, data were saved to be processed by the computer. The results were analyzed using SPSS 20. Data were statistically analyzed using descriptive statistics and were presented in the form of text, tables, and graphics. Univariate analysis was performed to present the characteristic data of the subjects as mean values and deviations or as a frequency distribution. Meanwhile, bivariate analysis was performed to observe the relationship between the independent variable and dependent variable using the chi-square test and odds ratio (OR) with a significance value of p < 0.05.

3. Results and Discussion
3.1 Results
This cross-sectional study was aimed at obtaining an understanding of hearing function in CPA tumor patients and was performed in the polyclinic of the Division of Neurology and Division of Otorhinolaryngology at the ENT Department Community of CMH, in collaboration with the Radiology Department of CMH and the Division of Neuro-oncology in the Neurosurgery Department of CMH. The data was collected retrospectively from medical records and MRI results. The collected
Data were selected according to the inclusion and exclusion criteria. During the selected period of time, there were 104 CPA tumor patients in total, but only 30 subjects matched the criteria. The subjects’ characteristic that was observed in this study is presented in Table 1.

| Subjects Characteristic | n  |
|-------------------------|----|
| Sex                     |    |
| Male                    | 6  |
| Female                  | 24 |
| Age (years), mean ± SD  |    |
| 18–25 years             | 4  |
| 26–40 years             | 8  |
| 41–60 years             | 17 |
| >60 years               | 1  |
| Chief complaint         |    |
| Hearing loss            | 8  |
| Headache                | 13 |
| Balance disorder        | 4  |
| Others                  | 5  |
| Hearing loss            |    |
| Yes                     | 25 |
| No                      | 5  |
| Complaints on the ear   |    |
| Left                    | 10 |
| Right                   | 14 |
| Bilateral               | 2  |
| No                      | 4  |

As shown in Table 1, there were more female subjects than male. The youngest patient age was 18 years old, the oldest was 61 years old, and the mean age of the subjects was 41.07±11.24 years old. The largest group was the older adult group (41–60 years old) with 17 people. Most of the subjects’ chief complaint was headache, and the most commonly complained of symptom was hearing loss, which was obtained from 25 subjects, followed by tinnitus in 22 subjects. There were 23 subjects with severe headache complaints and 23 subjects with balance disorder. Table 2 shows that there were 11 subjects with audiometric results that showed ipsilateral tumor and normal, average hearing thresholds. The highest sensorineural disturbance from ipsilateral lesions was very severe hearing loss, which was found in 11 subjects. The median hearing threshold in patients with lesions was 48.75 dB, with a minimum hearing threshold of 5 dB and a maximum hearing threshold of 117.5 dB. Audiometric examinations on the contralateral side of the lesions was found to be normal in 19 subjects. The median hearing threshold on the contralateral side of the lesions was 15 dB, with a minimum hearing threshold of 3.75 dB and a maximum hearing threshold of 108.75 dB.
Table 2. The result of hearing function examination using a pure tone audiometry test

| Mean Hearing Threshold | Ipsilateral Side of Lesion | Contralateral Side of Lesion |
|------------------------|---------------------------|-----------------------------|
| Normal (0–25 dB)       | 11                        | 19                          |
| Mild Hearing Loss (26–40 dB) | 2                       | 7                           |
| Moderate Hearing Loss (41–55 dB) | 4                       | 1                           |
| Moderate-Severe Hearing Loss (56–70 dB) | 1                     | 1                           |
| Severe Hearing Loss (71–90 dB)       | 1                        | 1                           |
| Very Severe Hearing Loss (>90 dB)   | 11                       | 1                           |
| Pure Tone Audiometry, Median (Min–Max) | 48.75 (5–117.5) dB       | 15 (3.75–108.75) dB          |

The results of BERA examinations on the ipsilateral and contralateral sides of the lesions. The BERA results of the 30 total subjects on the ipsilateral side of the lesions showed no BERA waves formed in 18 subjects. On the contralateral side, normal BERA waves were found in 13 subjects, but there was no waveform in 1 subject, and the other 16 subjects showed abnormal BERA results. The abnormal BERA results on the contralateral side were characterized by an elongation of the wave V latency period.

The patients were considered to have hearing loss when the threshold of audiometric results were below 25 dB and/or the BERA examination result showed an abnormal or undetected wave. According to these conditions, hearing loss on the ipsilateral side of the lesions was found in 29 subjects, and hearing loss on the contralateral side of the lesions was found in 18 subjects. There were 18 out of 29 subjects who experienced hearing loss on the ipsilateral side of the lesions who also had hearing loss on the contralateral side (bilateral hearing loss). This was because the contralateral side also interfered with the BERA waves, although the audiometry result showed a normal threshold.

Table 3. The distribution of audiometry and BERA examination results

| BERA | Pure Tone Audiometry |
|------|----------------------|
|      | Ipsilateral (n = 30) | Contralateral (n = 30) |
|      | Disturbed | Normal | Disturbed | Normal |
| Disturbed | 19 | 10 | 10 | 7 |
| Normal   | 0 | 1 | 1 | 12 |
| Total    | 19 | 11 | 11 | 19 |

From the MRI results shown in Table 4, it was found that there were 15 subjects with unilateral lesions on the left side and 1 subject with bilateral lesions. There were 24 subjects who showed a large-sized tumor (>20×30 cm). The mean diameter of large-sized tumors was 42.76±11.21 mm, the smallest was 18.9 mm, and the largest was 62.9 mm. There were 19 out of 30 subjects with an

Table 4. Tumor characteristics based on radiographic imaging

| Tumor Characteristics | Total Subjects (n) |
|-----------------------|--------------------|
| Side of Tumor         |                    |
| Left                  | 15                 |
| Right                 | 14                 |
| Bilateral             | 1                  |
| Size of Tumor:Mean±SD | 42.76±11.21        |
| Large(>20×30 Mm)      | 24                 |
| Small(<20×30 Mm)      | 6                  |
| Location of Tumor     |                    |
| Intracanal            | 0                  |
| Extracanal            | 11                 |
| Intracanal and Extracanal | 19          |
intracanal lesion that had spread into an extracanal lesion. There were no tumors found in this study that were only intracanal.

In this study, a bivariate analysis was also conducted to observe the relationship between size/location of tumors and their clinical symptoms (Table 5 and 6). It was found that there was a tendency for more complaints of hearing loss, tinnitus, balance disorder, and headache in large-sized tumors, although there was no significant relationship.

### Table 5. The relationship between size of tumor and clinical symptoms

| Complaints | Size of Tumor | p-value |
|------------|---------------|---------|
|            | Large (>20 × 30 mm) | Small (<20 × 30 mm) |
| Hearing loss | Yes 21 | No 3 |
| Tinnitus | Yes 19 | No 5 |
| Ear Fullness | Yes 9 | No 15 |
| Balance Disorder | Yes 20 | No 4 |
| Facial Paresis | Yes 8 | No 16 |
| Facial Numbness | Yes 11 | No 13 |
| Headache | Yes 18 | No 6 |
| Note: Based on Fisher's exact test |

### Table 6. The relationship between location of tumor and clinical symptoms

| Complaint | Location of Tumor | p-value |
|-----------|-------------------|---------|
| Hearing Loss | Intracanal + Extracanal | Yes 18 | No 1 |
| Tinnitus | Yes 14 | No 15 |
| Ear Fullness | Yes 7 | No 12 |
| Balance Disorder | Yes 14 | No 5 |
| Facial Paresis | Yes 5 | No 14 |
| Facial Numbness | Yes 8 | No 11 |
| Headache | Yes 14 | No 5 |
| Note: Based on Fisher's exact test |

### Table 7. The distribution of tumor size and pure tone audiometry result

| Pure Tone Audiometry | Size of Tumor | Ipsilaterial (>=20 × 30 mm) | Contralateral (<20 × 30 mm) |
|----------------------|---------------|----------------------------|-----------------------------|
| Normal               | Large 7 | Small 4 | Large 15 | Small 4 |
| Mild                 | Large 2 | Small 0 | Large 5 | Small 2 |
| Moderate             | Large 4 | Small 0 | Large 1 | Small 0 |
| Moderate-Severe      | Large 1 | Small 0 | Large 1 | Small 0 |
| Severe               | Large 1 | Small 0 | Large 1 | Small 0 |
| Very Severe          | Large 9 | Small 2 | Large 1 | Small 0 |
| Total                | Large 24 | Small 6 | Total 24 | Small 6 |

The distribution of pure tone audiometry results and the size of tumors is shown in Table 7. This distribution shows that large-sized tumors contributed the most to very severe sensorineural disturbance (9 subjects) on the ipsilateral side of the lesions. On the contralateral side of the tumors, 15 subjects had normal hearing thresholds. According to Table 8, the distribution of tumor locations and pure tone audiometry examination results showed that intracanal tumors that extended to
extracanal tumors contributed the most to very severe sensorineural hearing loss on the ipsilateral side, which was found in 8 subjects.

**Table 8.** The distribution of tumor location and pure tone audiometry result

| Pure tone audiometry | Tumor Location                  |
|----------------------|---------------------------------|
|                      | Ipsilateral                   | Contralateral               |
|                      | Intracanal + Extracanal | Extracanal | Intracanal + Extracanal | Extracanal |
| Normal               | 4                  | 7          | 9                      | 10        |
| Mild                 | 1                  | 1          | 6                      | 1         |
| Moderate             | 4                  | 0          | 1                      | 0         |
| Moderate-Severe      | 1                  | 0          | 1                      | 0         |
| Severe               | 1                  | 0          | 1                      | 0         |
| Very Severe          | 8                  | 3          | 1                      | 0         |

The relationship between tumor size and audiometric features in Table 9 showed that large CPA tumors produced disturbed audiometric results on the ipsilateral side as much as 70.83% of the time. In comparison, small CPA tumors produced disturbed audiometric results on the ipsilateral side 33.3% of the time. From this proportion, it can be concluded that the effect of CPA tumor size on pure tone audiometric results is clinically significant, although it is not statistically significant. There was a significant correlation between the location of the tumor and a disturbed pure tone audiometry result, both on the ipsilateral side of the lesion (p = 0.027) and on the contralateral side of the lesion (p = 0.020). Intracanal tumors that extended to extracanal tumors were a risk factor for abnormal pure tone audiometry results on the ipsilateral and contralateral sides of the lesions.

**Table 9.** The relationship between MRI and pure tone audiometry examination

|                      | Ipsilateral Audiometry | Contralateral Audiometry |
|----------------------|------------------------|----------------------------|
|                      | Disturbed* Normal p OR CI (95%) | Disturbed* Normal p OR CI (95%) |
| Size of Tumor        |                        |                            |
| Large                | 17 7 0.111 0.72–32.87 | 9 15 0.620 0.18–7.93 |
| Small                | 2 4                    | 2 4                         |
| Location of Tumor    |                        |                            |
| Extracanal + Intracanal | 15 4 0.027 6.56 1.26–34.20 | 10 9 0.020 11.11 1.18–104.81 |
| Extracanal           | 4 7                    | 1 10                        |

*All sensorineural disturbances were categorized as disturbed*

Table 10 shows the BERA examination results based on tumor size and location. Both large and small tumors mostly produced disturbed BERA waves on the ipsilateral side. The patients with large CPA tumors showed a disturbed BERA result on the contralateral side 62.5% of the time, while 33.3%...
of patients with small CPA tumors showed a disturbed BERA result. This is clinically significant, although it is not statistically significant. The difference in patients with an intracanal CPA tumor that extended to an extracanal tumor showed a disturbed BERA result on the contralateral side 63.2% of the time, and the 17.7% of patients with CPA tumors that were only extracanal showed disturbed BERA results 45.5% of the time.

Table 11 shows that sex, age, size of tumor, and location of tumor could not be concluded as risk factors for hearing loss on the ipsilateral side of CPA tumor lesions. Table 12 shows that the difference between age (25%), size of tumors (12.5%), and location of tumors (22.9%) with the hearing loss was more than 10%, thus it was clinically correlated, although it was not statistically significant.

### Table 11. The relationship between risk factors and ipsilateral hearing loss

| Risk Factors                  | Hearing Loss | p-value | CI (95%) |
|------------------------------|--------------|---------|----------|
|                              | Yes | No |     |        |        |
| **Sex**                      |     |    |     |        |        |
| Male                         | 6   | 0  | 0.800 | 0.96–1.13 |
| Female                       | 23  | 1  |       |        |        |
| **Age**                      |     |    |     |        |        |
| 18–25 years                  | 4   | 0  | 0.600 | 0.84–1.06 |
| 26–40 years                  | 8   | 0  |       |        |        |
| 41–60 years                  | 16  | 1  |       |        |        |
| >60 years                    | 1   | 0  |       |        |        |
| **Size of Tumor**            |     |    |     |        |        |
| Large                        | 23  | 1  | 0.800 | 0.88–1.04 |
| Small                        | 6   | 0  |       |        |        |
| **Location of Tumor**        |     |    |     |        |        |
| Intracanal and Extracanal    | 19  | 0  | 0.367 | 0.91–1.33 |
| Extracanal                   | 10  | 1  |       |        |        |
| Intracanal                   | 0   | 0  |       |        |        |

*Age groups were analyzed using chi-square 2 × 2 table (age of ≤ 40 years and > 40 years)

**Tumor-location groups were analyzed using chi-square 2 × 2 table (intracanal + extracanal and extracanal)

### Table 12. The relationship between tumors and hearing loss

| Risk factors                  | Hearing Loss | p-value | CI (95%) |
|------------------------------|--------------|---------|----------|
|                              | Yes | No |     |        |        |
| **Sex**                      |     |    |     |        |        |
| Male                         | 4   | 2  | 0.545 | 0.22–9.38 |
| Female                       | 14  | 10 |       |        |        |
| **Age**                      |     |    |     |        |        |
| 18–25 years                  | 4   | 0  | 0.162 | 0.67–1.66 |
| 26–40 years                  | 5   | 3  |       |        |        |
| 41–60 years                  | 9   | 8  |       |        |        |
| >60 years                    | 0   | 1  |       |        |        |
| **Size of tumor**            |     |    |     |        |        |
| Large                        | 15  | 9  | 0.455 | 0.28–10.09 |
| Small                        | 3   | 3  |       |        |        |
| **Location of tumor**        |     |    |     |        |        |
| Intracanal and Extracanal    | 13  | 6  | 0.197 | 0.56–12.02 |
| Extracanal                   | 5   | 6  |       |        |        |
| Intracanal                   | 0   | 0  |       |        |        |

*Age groups were analyzed using chi-square 2× 2 table (age of ≤ 40 years and > 40 years)

**Tumor-location groups were analyzed using chi-square 2× 2 table (intracanal + extracanal and extracanal)
3.2 Discussion

The difficulty in obtaining an exact number of subjects was due to the low number of CPA tumor cases in CMH, incomplete audiometry and BERA examinations, and the difficulty to obtaining secondary data of MRIs performed in other hospitals, which therefore was excluded from this study. This study involved 30 subjects, consisting of 24 female and 6 male subjects. Its results were in accordance with CPA tumor research conducted by Harner, which involved 380 female subjects and 341 male subjects [6]. A study by Yadav et al. stated that menangiomias is the second most frequent CPA tumor which is more likely to occur in females with a female to male ratio 2:1 [9]. However, in a study on neurona acoustic tumors conducted by Shih, Sepehrnia, and Borghesi-Razavi, more male subjects were observed [6, 9–11]. The largest group of subjects in this study were 41- to 60-year-olds, which consisted of 17 people with a mean age of 41.07±11.24 years. This was in accordance with a study conducted by Shih et al., which obtained a mean age of 50±14 years. The literature stated that CPA tumors commonly occur over the age of 40. Nadol observed a sample with a mean age of 50 years and found that there was a positive correlation between age and hearing loss in CPA tumor patients, although it was not statistically significant [10,12].

The most common clinical complaints in this study were hearing loss in 25 subjects, followed by tinnitus in 22 subjects. The other clinical complaints were headache (23 subjects), followed by balance disorder (23 subjects), facial numbness (13 subjects), and facial paresis (8 subjects).This was in accordance with a study conducted by Shih, which found the chief complaints were hearing loss (50%), tinnitus (40%), vertigo (26.7%), ataxia (16.7%), facial paresis (13.3%), and headache (33.3 %) [10]. A study conducted by Schmidt found that, in 58 acoustic neuroma tumor patients, as much as 52% of patients complained of progressive hearing loss, 17% complained of sudden deafness, 14% complained of tinnitus, 9% complained of balance disorder, and 3% complained of facial paresis [13]. Robinette stated that there was a high risk of neuroma acoustic tumors if patients experienced some classic symptoms, such as asymmetric hearing loss accompanied by tinnitus, and Sheehan Disability Scale (SDS) scores<30% [10,13,14].

A normal hearing threshold on the ipsilateral side of the tumors was found in 11 subjects, and the highest prevalence (90%) of abnormal audiometric results were found with the 11 subjects who had very severe sensorineural hearing loss on the ipsilateral side of their tumors. Sensorineural impairment was found on the contralateral side of the lesions in 11 patients. The mean value of pure tone audiometry results on the ipsilateral side of tumor lesions was 48.75 dB and 15 dB on the contralateral side. Johnson, as cited by Stucken, performed an audiology examination of 500 acoustic neuroma patients receiving a pure tone threshold ranging from 5–130 dB (no response), with a mean threshold of 66.5 dB. Of the patients, 65% were found to have hearing loss at high frequencies, and 44% of examined patients were able to achieve 62% or more. Meanwhile, the other 56% of patients scored 60% or less of NDT [15,16]. Caye-Thomasen et al. observed 156 intracanal neuroma acoustic patients and found a mean pure-tone hearing threshold of 51 dB with an average NDT of 60% on the ipsilateral side of the lesions, compared with a20-dB hearing threshold and NDT of 96% on the contralateral side.

In this study, the distribution of BERA imaging on the ipsilateral side of lesions showed that 18 subjects had no waveform (60%), 11 subjects had abnormal BERA results (36.7%), and 1 subject had normal BERA results. Marangos found that, in a total of 309 CPA tumor patients, there was 50.2% with no waveform, 31.4% with abnormal BERA results, and only 18.4% with normal BERA results [17]. Musiek, Josey, and Glasscock (as cited by Hood) also stated that, in 61 CPA tumor patients, 30% of BERA results showed no waveform, 44% formed only a partial wave (wave I or V), and 26% of BERA results showed a complete wave but with an abnormal latency period. Because the results of most subjects showed no waveform in the BERA examination, the latency period data of wave V on the ipsilateral side could not be assessed. Thus, the assessment of the difference in wave I-V latency period on the ipsilateral side and wave V and wave I-V latency period between the ears could not be analyzed [18].
From the 30 subjects in this study, 11 subjects had ipsilateral audiometry results in the normal hearing threshold, and 10 subjects had abnormal or undetected BERA results. This was in accordance with a study by Musiek, Josey, and Glasscock (as cited by Hood), which had found that 15 out of 16 CPA tumor patients with normal hearing thresholds had an abnormal BERA result [19]. The literature stated that BERA examination is not meant to describe hearing function as accurately as a behavioral audiometric test, but it is rather intended to see neural synchronization function. In this study, there were 29 subjects who experienced hearing loss on the side of the lesion and showed a disturbed BERA result, 19 of which also had a decreased threshold. There were 18 out of 29 subjects who also complained about hearing loss on the contralateral side of their lesions. This is due to the fact that the contralateral side also interferes in BERA wave formation, although the audiometric results showed that these patients’ hearing thresholds were normal. Shih stated that the occurrence of abnormality on the contralateral side of lesions in patients with tumor sizes of 2 cm was 50% and increased to 94.4% in tumors larger than 2 cm [10].

The average size of the largest tumor diameter in this study was 42.76±11.21 mm. Samii classification was used in this study because the size of CPA tumor in patients sent to CMH were generally large, so the classification of tumor sizes less than 1 cm was not necessary for this study [18]. There were 24 subjects categorized in the large tumor group (more than 20×30 mm). This is in accordance with the Shih et al.’s study, which obtained a mean tumor size of 2.48±1.31 cm and where only 40% of tumors were less than 2 cm [10]. Meanwhile, Harner obtained a mean tumor size of 2.6 cm [6,10,18]. Tumors were mostly intracanal that extended to extracanal tumors. There was no tumor lesion that was only intracanal. This was because patients who visited CMH had large-sized tumors, so a small-sized tumor was rarely detected. This was also in accordance with the study conducted by Nadol, who divided the location of lesions limited to the CPA area, CPA lesions that extended to be intracanal, or only intracranial lesions [12].

Regarding the clinical complaints, hearing loss, tinnitus, balance disorder, and headache were found in more than 50% of total subjects, such that the data was clinically important but not statistically different. In Schmidt’s study, it was found that progressive hearing loss increased with tumor sizes of more than 1.5 cm [13]. There was a 100% occurrence of asymmetric hearing loss in patients with tumor sizes less than 1 cm and a 96% occurrence in tumor sizes more than 1.5 cm. Berrettini found 100% hearing loss in patients with small-sized (<1 cm) and medium-sized (1–3 cm) neuroma acoustic tumors, and 87.5% hearing loss in large-sized neuroma acoustic tumors (>3 cm) [20]. Balance disorders mostly occurred with large tumors. There was a significant correlation between the size of tumors with headache and trigeminal hyposthesia (facial numbness) [20]. This study found that there was a significant correlation (p = 0.047) between intracanal tumors that extended to be extracanal and hearing loss. Berrettini stated that tumors located in the medial side (66.6%) provided the least clinical symptoms of hearing loss compared to tumors located in lateral side or in the middle (100%) [20]. Medial tumors contributed the most to facial numbness (66.6%), compared to tumors located in the middle (10.3%). Balance disorder was also the most common symptom in medial tumors (83.3%) [20].

A study conducted by Nadol showed that there was a significant correlation (p = 0.001) between pure tone audiometry and tumor size in MRIs [12]. A study conducted by Shih also showed that there was a correlation between threshold reduction in pure tone audiometry and the size of tumors [10]. The increasing size of tumors would also increase the average hearing threshold. Berrettiniet al. found that a small tumor allowed for better hearing function (34 dB) compared to a medium tumor (53 dB) or a large tumor (53dB), but this effect was not statistically significant [10,12,20]. Tumors that were both intra- and extracanal were risk factors for hearing loss on the ipsilateral and contralateral sides of the lesion. If the intra- and extracanal tumors grew towards the anterior fossa posterior (pons), there would be a greater possibility of hearing loss because the hearing pathway in the pons area could be disturbed as the result of tumor aggravation. Berrettini found that hearing loss in medial tumors (36 dB) was lighter than in lateral (43 dB) or middle (56 dB) tumors, although this was not statistically significant [20].
This study found that both small- and large-sized tumors in the CPA area clinically show a disturbed BERA image, especially when the ipsilateral pons area was pushed by the tumor. A large-sized CPA tumor also showed a disturbed BERA on the contralateral side as much as 62.5%, compared to patients with small tumors, which showed a disturbed BERA 33.3% of the time. It can be concluded that BERA can detect the existence of both small- and large-sized tumors in the CPA. Koors’ research reported BERA’s sensitivity in detecting tumor sizes less than 1 cm as 85.8%. Meanwhile, tumors bigger than 1 cm were detected 95.6% of the time [8]. Hall stated that the lowest BERA sensitivity (less than 80%) was found in acoustic tumors with sizes less than 1 cm, and 100% sensitivity was found in tumors with sizes more than 2.5 cm [1]. Shih’s research found that there was a significant difference between the size of a tumor and the BERA wave image [10]. In 30 subjects, 100% of all subjects had an abnormal latency period of wave V on the ipsilateral side and a latency period of wave I-V on the ipsilateral side, and 23 subjects had an abnormal BERA result on the contralateral side. Abnormal BERA results on the contralateral side of the lesions were considered to be significantly different in tumors bigger than 2 cm [1,8,10].

There was one patient with a normal BERA and audiometry result on the ipsilateral side, although the tumor size was relatively large (35.3×34.9×42.3 mm). This was because the tumor was extracanal and did not push towards the auditory nerve as an intracanal tumor would, and the tumor grew into the cerebellum such that the nucleus in the pons area was still functioning without having been pushed by the tumor. The sensitivity of BERA would increase in tumors that extended to the CPA area (extracanalicular) than in intracanalicular tumors. There would be a greater possibility of disturbed BERA results and audiometry results if an intracanal tumor extended to be an extracanal tumor, especially if it pushed the pons to the contralateral side. The limitations of this study were its use of secondary data; the number of subjects, which did not fill out the required number; and the uneven distribution of patients. As the result of secondary data, there were some incomplete medical records, and some of the audiometry and BERA results were also incomplete. Other limitations include the size of tumors, because most CPA tumor patients in CMH had large tumors, thus BERA waves were mostly not formed, and their latency period could not be assessed.

4. Conclusion
In this study, the characteristics of CPA tumor patients in the ENT polyclinic of CMH were mostly female, with an average age of 41–60 years. The most common complaints they had were asymmetrical hearing loss accompanied by other complaints, such as tinnitus, headache, and sometimes balance disorder, facial numbness, or facial paresis. Pure tone audiometry examination, was found that most patients had a very severe sensorineural type of asymmetry hearing loss on the ipsilateral side of the lesion. The BERA results of this study showed that 29 out of 30 subjects showed disturbed BERA imaging (abnormal or no waveform) on the ipsilateral side of the lesions, with 18 subjects showing a BERA disturbance on the contralateral side. The hearing threshold in normal audiometry might provide disturbed BERA imaging, although the size of the tumors was still small. Therefore, CPA tumor patients should receive both examinations, since they have different but complementary roles.

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