

Role of Diffusion-Weighted Image in Differentiation between Epidermoid Cyst and other Cerebellopontine Angle Masses

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Abstract

Background: Many masses can present in the cerebellopontine angle (CPA), and the magnetic resonance imaging (MRI) is essential in the diagnosis and differential diagnosis of these masses, and a complimentary advanced MRI technique such as diffusion-weighted image (DWI) is needed as to differentiate between epidermoid and arachnoid cyst. **Objective:** This study aimed to find out the role of DWI in differentiate between epidermoid cyst and other CPA masses. **Materials and Methods:** By using data collection form electronic medical record, we collect demographics; choosing 40 patients; 23 of them are male and 17 are female. They were complaining of signs and symptoms of neurological disorders. By subjecting the patients to MRI sequences including T1; T2; DW; apparent diffusion coefficient (ADC); and postcontrast imaging to find out the role of DWI in differentiate between epidermoid cyst and other CPA masses. The study carried on from September 2017 to July 2018 in the institution Al-Hilla general teaching hospital in the diagnostic radiology department at MRI unit. **Results:** The resultant patient sample regarding final diagnosis; and regarding signal intensity (SI) of each particular mass; constricting on DW and ADC value; and then comparison has been done between SI of epidermoid cyst and each particular lesion to define the role of DWI in differential diagnosis between epidermoid cyst in one hand and other CPA masses. **Conclusion:** MRI can be considered the most useful method to improve the sensitivity of CPA lesion detection and a complimentary advanced MRI technique such as DWI is needed as to differentiate between epidermoid and arachnoid cysts.

Keywords: Arachnoid cyst, diffusion-weighted image, epidermoid cyst, magnetic resonance imaging, tumors

INTRODUCTION

The cerebellopontine angle (CPA) is the area between the cerebellum and the pons^[1] where the CPA cistern located; it is one of the subarachnoid cisterns which contains cerebrospinal fluid, cranial nerves; arachnoid tissue with associated vessels. The contents of CPA is anterior inferior cerebellar artery; flocculus of cerebellum; cerebellar nuclei (CN) VII; CN VIII; and foramen of Luschka of the fourth ventricle.^[2]

Tumors in the CPA are the most common neoplasms in the posterior fossa, forming 5%–10% of intracranial neoplasm. In most of cases, CPA masses are benign, and most of them are vestibular schwannomas (VSs) (acoustic neuromas), and the most common nonacoustic CPA neoplasm are meningiomas followed by epidermoids (primary cholesteatomas). While metastatic lesion or primary malignancies forming <2% of tumors in the CPA.^[3] In addition to other less frequently occurring ependymoma and arachnoid cysts and others.

Epidermoid cyst is an inclusion cyst. It is of ectodermal origin,^[4] and it is a benign congenital lesion. It represents about 1% of all intracranial tumors.^[5,6] They are located most frequently in the CPA (40%–50%). The epidermoid cyst insinuates between structures in the CPA and widely infiltrate around adjacent nerves and vessels.^[7]

VS is a primary intracranial tumor; usually developed in middle-aged and elderly peoples; it arising from myelin-forming cells (Schwann cells) of the vestibulocochlear nerve (8th cranial nerve). These tumors are firm; usually encapsulated; cystic degeneration can occur in the larger tumor.^[7]

Meningioma is tumor of meningeal arachnoid cells; typically occurs in middle-aged female; they are benign in the majority

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Access this article online

Quick Response Code:



Website:
www.medjbabylon.org

DOI:
10.4103/MJBL.MJBL_74_18

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How to cite this article: Farhan DA, Abdulsttar OA. Role of diffusion-weighted image in differentiation between epidermoid cyst and other cerebellopontine angle masses. *Med J Babylon* 2018;15:238-42.

of cases.^[7] It is extra-axial; with spherical or lobular outline. They are ideally tumor with broad-based dural attachment, and if they are large enough, they displace the cortical grey matter inward. Occasionally, meningioma may exhibit infiltrating growth pattern over the dura, termed meningioma en plaque; and these meningioma en plaque forming sheet or thin carpet along convexity dura; tentorium; or falx.^[8]

Ependymomas express low-grade tumor arising from the epithelial lining of the ventricles of the brain and central canal of the spinal cord; cerebral hemisphere; cerebellum; brainstem and the tip of filum terminal. The incidence of tumor is higher in pediatric age group (approximately 17%).^[7] Ependymoma can arising in the CPA area from ependymal rests.^[9] On magnetic resonance imaging (MRI) ependymoma often contain small cysts which may be multilocular gives it heterogeneous appearance.^[7]

Arachnoid cyst is extracerebral cyst, particularly occurs in middle and posterior fossa; in suprasellar area and posterior to the third ventricle; they present in infants and children more usually than in adult; although septated arachnoid cysts can occur, they are usually unilocular. On MRI, they are of cerebrospinal fluid (CSF) Signal intensity (SI); and have no enhanced capsule.^[7]

MATERIALS AND METHODS

Sample size and study design

This study is performed after taking verbal consent from all the patients. They are referred for evaluation in Al-Hilla teaching hospital, Babylon, Iraq. By using data collection form electronic medical record, we collect demographics; choosing 40 patients; 23 of them were male and 17 were female.

They were complaining of signs and symptoms of neurological disorders. By subjecting the Patients to MRI sequences including T1; T2; DW; apparent diffusion coefficient (ADC); and postcontrast imaging. The final diagnosis of the 40 patients by MRI are: 18 patients had acoustic Schwannoma (45%), and it was the most common lesion, the second-most common lesion was meningioma noted in 9 patients (22.0%), 8 patients had epidermoid cyst (20.0%), 3 patients had arachnoid cyst (7.5%), and 2 patients had ependymoma (5%).

Place and date of study

The study carried on from September 2017 to July 2018 in the institution Al-Hilla general teaching hospital in the diagnostic radiology department at MRI unit.

Magnetic resonance imaging device

The MRI imaging was performed by Philips MR system Achiva 1.5 T Netherlands (release 3.2.1.02010-6-9) and MR system Intera 1.5T (release 2.5.3.02007-9-28). By using brain coil in supine position: T1W axial; T2W axial image TR 3000; TE 120 s; matrix 148/532; and FOV 170 mm.

The axial diffusion-weighted image (DWI) and ADC maps in addition to postcontrast administration images of the brain were

achieved on all patients by using a 1.5-T superconducting MR scanner. All patients were screening for any contraindications to the MRI examination, like cardiac pacemakers, was done.

Gadolinium–diethylenetriaminepentaacetic acid (Magnevist) was the contrast material used in the study; the dose was 0.2 ml/kg body weight, and there were no detected reactions to contrast material injection in our study.

Axial DWI performed for all patients using single shot echo-planar spin-echo sequence EPI (3.400/100 ms [TR/TE]), matrix 192×192 , the slice thickness was 5 mm, gap 1.5 mm with a duration of 120 s, and $b = 0$, $b = 500$, and $b = 1000$ applied in the X, Y, and Z directions.

The ADC map and value was obtained by postprocessing of ADC maps which was concluded by using the standard software supplied on the machine console.

By using the region of interest in the center of CPA lesion; the lowest ADC values were measured, rather avoiding necrotic and cystic areas. Calculation of standard mean ADC values was done automatically and expressed in $10^{-3} \text{ mm}^2/\text{s}$. To differentiate the nonrestricted from restricted diffusion areas; the cutoff value of $1 \times 10^{-3} \text{ mm}^2/\text{s}$ was used.

Image analysis

The interpretation of MR images is done by academic radiologist during reporting of outpatient in MRI unit. In our study, a variety of CPA masses has been diagnosed: Schwannoma, meningioma, epidermoid cyst, arachnoid cyst, and ependymoma.

Statistical analysis

We collect the frequency distribution of data; analyzing the relationship between the particular lesion and MRI findings especially on DWI and ADC using Chi-square test. Statistical analysis was carried out using Statistical package for social sciences (SPSS) version 20 (IBM SPSS Statistics, IBM company, USA). Categorical variables were presented as frequencies and percentages. Continuous variables were presented as (means $\pm$ standard deviation). Independent samples *t*-test was used to compare means between two groups. $P < 0.05$ was considered statistically significant.

RESULTS

Patient sample regarding age distribution

The 40 patients in this study represented age groups ranging from 2 to 67 years, mean age 37-year-old [Table 1].

Patient sample regarding final diagnosis

This study included 40 patients and they were classified into five groups based on their final diagnosis; the Schwannoma tumor group included 18 patients (45%) (13 male and 5 female patients); the group with meningioma included 9 patients (22.5%) (1 male and 8 female patients); and the group with epidermoid cyst included 8 patients (20%) (6 male and 2 female patients); the group with arachnoid cyst

included 3 patients (7.5%) (2 males and 1 females); and the group with ependymoma included 2 patients (5%) (1 male and 1 female patients).

Magnetic resonance imaging findings

On T1-weighted image, isointense in 22 (55%) patients, 13 of them were Schwannoma (72.2%) of Schwannoma lesions; 9 of them were meningioma (100%) of meningioma lesions. Hypointense in 18 (45%) patients, 8 of them were epidermoid cyst (100%) of epidermoid lesion; 5 of them were Schwannoma (27.8%) of Schwannoma lesions; 3 of them were arachnoid cysts (100%); 2 of them were ependymoma (100%).

On T2-weighted image, isointense in 16 (40%) patients, 10 of them were Schwannoma (55.6%) of Schwannoma masses; 6 of them were meningioma (66.7%) of meningioma lesion. Hyperintense in 24 (60%) patients; 8 of them were epidermoid cyst (100%) of epidermoid lesions; 8 of them were Schwannoma (44.4%) of Schwannoma lesions; 3 of them were meningioma (16.7%) of meningioma lesions; 3 of them were arachnoid cysts (100%), and 2 of them were ependymoma (100%) [Table 2].

Patients sample regarding signal intensity of the lesion on diffusion-weighted image and apparent diffusion coefficient

The CPA mass appearance on DWI was isointense (mild restriction) in 18 patients (45%); 11 patients of them was Schwannoma (61%); 7 patients were meningioma (77.8%). Homogenously hyperintense in 10 patients (25%); 2 patients of them were meningioma (22.2%); and 8 of them were epidermoid cyst (100%).

We should elucidate that it was difficult to delineate the extensions and borders of the epidermoid lesions on conventional MR sequences; while it appeared bright on DWI and could be delineated clearly from dark CSF.

The DWI was partially hyperintense in 9 patients (22.5%); either in shape of ring hyper-intensity with central hypointense area in 7 patient with Schwannoma (38.9%) of Schwannoma patients; and in shape of partial hyperintense (restrict diffusion in soft tissue part of the lesion) in 2 patients with ependymoma (100%) of ependymoma cases, and hypointense in 3 patients (7.5%); all of them was arachnoid cyst; (100%) of arachnoid lesions.

On ADC, the mean ADC was high value (free diffusion) in 3 patients (7.5%); the mean ADC value was $3.41 \times 10^{-3} \text{ mm}^2/\text{s}$; all of them was arachnoid cyst (100%) of arachnoid lesion.

The ADC was low value relative to CSF in homogeneous fashion in 28 patients (70%); with different mean ADC value; the mean ADC value was $(1.161 \times 10^{-3} \text{ mm}^2/\text{s})$ in 11 patients with Schwannoma (61.1%) of Schwannoma lesion; the mean ADC value was $(0.96 \times 10^{-3} \text{ mm}^2/\text{s})$ in 7 patients with meningioma (77.8%) of meningioma lesion; the mean ADC value was $0.88 \times 10^{-3} \text{ mm}^2/\text{s}$ in 2 patients with meningioma (22.2%) of meningioma lesion; the mean ADC value was $0.727 \times 10^{-3} \text{ mm}^2/\text{s}$ in 8 patients with epidermoid cyst (100%) of epidermoid lesion.

The mean ADC was low value in partial part of lesion (nonhomogeneously) in 9 patients (22.5%); the ADC was low value in ring shape with central part of high value in 7 patients with Schwannoma (38.9%) of Schwannoma lesion; the mean ADC value was $2.277 \times 10^{-3} \text{ mm}^2/\text{s}$ in the central part (free diffusion area) of lesion, and the mean ADC value was $1.117 \times 10^{-3} \text{ mm}^2/\text{s}$ in the peripheral part of lesion (restricted diffusion area).

The ADC was low value in soft-tissue part of the lesion in 2 patients with ependymoma (100%) of ependymoma lesion; the mean ADC value in the soft tissue of ependymoma was $1.27 \times 10^{-3} \text{ mm}^2/\text{s}$ [Table 3].

Regarding the appearance of CPA mass after intravenous (IV) contrast, lesions showed different patterns after contrast administration: As a homogeneous enhancement in 19 (47.5%) patients, a heterogeneous enhancement in 10 (25.0%) patients, and no enhancement in 11 (27.5%) patients studied.

A heterogeneous enhancement after IV contrast was in 8 patients (44.4%) with acoustic Schwannoma and 2 patients with ependymoma (100%) of ependymoma lesions; no patient with meningioma, and a homogeneous enhancement in 10 patients with acoustic Schwannoma (55.6%), but it was in 9 patients of meningioma (100%). No enhancement in 8 patients with epidermoid cyst (100%) of epidermoid lesion; and 3 patients with arachnoid cyst (100%) of arachnoid lesions.

DISCUSSION

MRI has traditionally been considered the pivotal imaging test for CPA lesions, providing clinically important information on neurological disorders.^[10]

Regarding SI on T1- and T2-weighted image, schwannomas were shown by T1-weighted images as isointense in 13 patients (72.2%) and hypointense in 5 patients (27.8%); so schwannoma is iso-or hypointense relative to pons on T1-weighted image.

On T2-weighted images as hyperintense in 8 patients (44.4%) and isointense in 10 patients (55.6%); so, it is isointense or hyperintense relative to pons (often with heterogeneity) on T2-weighted image, while meningioma on T1, was isointense to slight hypointense relative to gray matter in 9 patients (100%) of meningioma lesion in our study.

On T2, it is isointense in 6 patients (66.7%) and hyperintense in 3 patients (33.3%); so, meningioma is iso- or hyperintense relative to gray matter on T2-weighted image.

Epidermoid was hypointense on T1-weighted image; and hyperintense on T2-weighted image in 8 patients (100%) (it is of CSF SI). Arachnoid cyst was hypointense on T1; hyperintense on T2 in 3 patients (100%) (it is also of CSF SI).

Ependymoma was hypointense on T1-weighted image; hyperintense on T2-weighted image in 2 patients (100%) with heterogeneity on both T1- and T2-weighted images.

After contrast enhancement: Both epidermoid (100%) and arachnoid cyst (100%) not enhanced, while Schwannoma enhanced; heterogeneously in 8 patients (44.4%) and homogeneously in 10 patients (55.6%).

Meningioma-enhanced homogeneously in 9 patients (100%); with no heterogeneity and ependymoma-enhanced heterogeneously (the soft-tissue component of lesion is enhanced) in 2 patients (100%). The nonhomogeneity noticed in the lesion may be due to vascularity of the lesion; hemorrhage or cystic degeneration.

Regarding sample size regarding SI on DW image and ADC value, On DW image, the Schwannoma was isointense (mildly restricted) in 11 patients (61%); and the mean ADC value of these 11 patients was $(1.161 \times 10^{-3} \text{ mm}^2/\text{s})$ which confirm the mild restriction.

The Schwannoma was hyperintense in ring shape (restrict diffusion) with internal area of hypointensity (free diffusion) in 7 patients (38.9%) with mean ADC value in the internal free diffusion area was $2.277 \times 10^{-3} \text{ mm}^2/\text{s}$ and the mean ADC value in the peripheral restricted diffusion area was $1.117 \times 10^{-3} \text{ mm}^2/\text{s}$.

Moreover, the meningioma on DW image was isointense (mild restriction) in 7 patients (77.8%) and the mean ADC value of these 7 lesions was $0.96 \times 10^{-3} \text{ mm}^2/\text{s}$. While the other 2 cases of meningioma (22.2%) were hyperintense (restrict diffusion) on DW image with mean ADC value was $0.88 \times 10^{-3} \text{ mm}^2/\text{s}$.

Epidermoid cyst on DW image was homogeneously hyperintense in 8 patients (100%) (restrict diffusion) with mean ADC value was $0.727 \times 10^{-3} \text{ mm}^2/\text{s}$, it is higher than mean ADC value of brain tissue but significantly lower than that of CSF.

The arachnoid cyst was hypointense in 3 patients (100%); no restriction of diffusion, with mean ADC value, was $3.41 \times 10^{-3} \text{ mm}^2/\text{s}$. Ependymoma was partially hyperintense on DW image (the soft tissue component restrict diffusion) with mean ADC value of this restricted diffusion area was $1.27 \times 10^{-3} \text{ mm}^2/\text{s}$.

Epidermoid cyst in comparison with acoustic Schwannoma; meningioma; arachnoid cyst; and ependymoma by associated MRI findings indicated that epidermoid cyst has CSF SI on T1 and T2 lesions; and it not enhanced after IV contrast.

While other mentioned lesions have SI different than CSF on T1 and on T2 (either higher or lower SI) and they enhanced after IV contrast homogeneously or heterogeneously; except for arachnoid cysts which like epidermoid cysts have CSF SI on T1 and T2; and they did not enhance after contrast administration.

Meningioma in other hand had a dural base in 3 patients (33.3%) and enhancing dural tail in 6 patients (66.7%), whereas epidermoid cyst; acoustic Schwannoma; arachnoid cysts and ependymoma were not.

On the other hand, there is observed extension into the internal auditory canal (IAC) in acoustic Schwannoma, but not in

Table 1: Distribution of patients according to study variables (age and gender)

Study variables	n (%)
Age (years)	39.25±15.98 (2-67)
Gender	
Male	17 (42.5)
Female	23 (57.5)
Total	40 (100.0)

Table 2: Distribution of study participants according to the results

Study variables	n (%)
T1W1	
Hypointense	18 (45.0)
Isointense	22 (55.0)
Total	40 (100.0)
T2W1	
Hyperintense	24 (60.0)
Isointense	16 (40.0)
Total	40 (100.0)
After contrast administration	
Heterogeneous CE	8 (20.0)
Homogeneous CE	19 (47.5)
Not enhanced	11 (27.5)
Partial enhancement	2 (5.0)
Total	40 (100.0)
DW1	
Hyperintense	10 (25.0)
Hypointense	3 (7.5)
Isointense	18 (45.0)
Partial hyperintense	2 (5.0)
Hyperintense peripheral ring with hypointense central area	7 (17.5)
Total	40 (100.0)

Table 3: The mean differences of ADC value according to radiological diagnosis

Study variables	Duration	n	Mean±SD	P
ADC value	Epidermoid cyst	8	$0.72 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.00$	<0.001*
	Acoustic Schwannoma	18	$1.14 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.02$	
ADC value	Epidermoid cyst	8	$0.72 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.00$	<0.001*
	Meningioma	9	$0.98 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.06$	
ADC value	Epidermoid cyst	8	$0.72 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.00$	<0.001*
	Arachnoid cyst	3	$3.41 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.00$	
ADC value	Epidermoid cyst	8	$0.72 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.00$	<0.001*
	Ependymoma	2	$1.27 \times 10^{-3} \text{ mm}^2/\text{s} \pm 0.00$	

*means significant. SD: Standard deviation

epidermoid; meningioma; arachnoid cysts or ependymoma. Ependymoma is heterogeneously hypointense on T1; hyperintense on T2; and the soft tissue part is enhanced after

contrast administration (heterogeneous enhancement); which is not a feature of epidermoid cyst. Hence, differentiation between epidermoid cysts in one hand and meningioma; acoustic Schwannoma or ependymoma on the basis of their MRI appearances is effortless; as meningiomas usually form a broad base against petrous bone,^[11] and have homogeneous avid enhancement;^[12] and these 2 features are not found together in epidermoid cyst; and not even acoustic Schwannoma; arachnoid cyst or ependymoma.

In addition, Schwannoma have a component inside IAC and after contrast administration; heterogeneous enhancement is observed. These features are not found in epidermoid cyst; and also these features not found together in meningioma; arachnoid cyst; or ependymoma.

The main difficulty is in differentiation between epidermoid cyst and arachnoid cyst because both are cystic lesion of CSF SI; and both not enhanced after contrast administration.

Regarding comparison between epidermoid cysts and other CPA lesions regarding SI on DW image and ADC value, results found that 8 cases (100%) of epidermoid cysts were brightly hyperintense on DWI with low-ADC values; with mean ADC value was $0.727 \times 10^{-3} \text{ mm}^2/\text{s}$, it is higher than mean ADC value of brain tissue; but significantly lower than that of CSF; indicating restriction of diffusion; in contrast to arachnoid cysts which was hypointense on DWI in (100%) of cases with high mean ADC value ($3.41 \times 10^{-3} \text{ mm}^2/\text{s}$) indicating free diffusion. The analysis of the values of ADC indicates a significant difference between epidermoid and arachnoid cysts ($P < 0.001$).

Results also found that Schwannoma showed mild restriction (isointense) in (61.1%) with mean ADC value was $1.161 \times 10^{-3} \text{ mm}^2/\text{s}$, and ring restriction of diffusion with internal free diffusion area in the remaining (38.9%) with mean ADC value in restricted diffusion area was $1.117 \times 10^{-3} \text{ mm}^2/\text{s}$.

In comparison with meningioma which was iso-intense (mild restriction) in (77.8%) with mean ADC value was $0.96 \times 10^{-3} \text{ mm}^2/\text{s}$, and hyperintense in remaining (22.2%); and the mean ADC value of these hyperintense meningioma lesions was $0.88 \times 10^{-3} \text{ mm}^2/\text{s}$.

In comparison with ependymoma which was hyperintense in soft-tissue part of the lesion (partially restrict diffusion) and the mean ADC value of restricted diffusion area was $1.27 \times 10^{-3} \text{ mm}^2/\text{s}$.

Hence, it is clear that it was easy to differentiate between epidermoid cyst and arachnoid cyst on diffusion-weighted image; this differentiation was difficult on conventional MRI sequences even after IV contrast.

The epidermoid cyst was the only lesion that appears brightly hyperintense on DW; while other 3 lesions (Schwannoma; meningioma and ependymoma) appear either isointense (mild restriction) or partially hyperintense and even then they have higher mean ADC values than epidermoid indicating mild restriction; the difference of mean ADC value was significant between epidermoid cyst and other CPA lesions ($P < 0.001$).

CONCLUSION

MRI is considered as perfect method to improve sensitivity of detection of CPA lesions, and a DWI which is complementary advanced MRI technique may be needed as to differentiate between arachnoid cysts and epidermoid cyst; in fact, epidermoid cyst is well differentiated from other masses in CPA area on DWI (especially arachnoid cyst) and that is mainly because it has low mean ADC value and bright hyperintensity on DWI. MRI is an excellent method to differentiate between masses in the CPA by showing the shape; anatomical site of origin, SI, and way of enhancement (or no enhancement) after contrast administration.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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