DIAGNOSTIC ACCURACY OF COMPUTED TOMOGRAPHY IN THE PRE-OPERATIVE EVALUATION OF POSTERIOR FOSSA TUMOURS IN CHILDREN

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Abstract

Objective: To evaluate the diagnostic accuracy of computed tomography (CT) in the pre-operative evaluation of posterior fossa tumours in children.

Materials and Methods: CT scan of brain was done on 30 consecutively selected children with clinical suspicion of posterior fossa tumours and they were followed up to the final diagnosis by histopathology. The diagnostic accuracy, sensitivity, specificity, positive and negative predictive values of the procedure was calculated for different lesions.

Results: Out of the 30 patients, 17 (56.67%) had medulloblastoma, 8 (26.67%) were diagnosed as astrocytoma, 3 (10%) as ependymoma and 2 (6.66%) as brain stem glioma. 28 cases were accurately diagnosed by CT and 2 were misdiagnosed. The sensitivity, specificity, accuracy, positive predictive value and negative predictive value of CT were: 88.89%, 100%, 96.67%, 100% & 95.54% respectively for astrocytoma; 100%, 92.86%, 96.67%, 94.12% & 100% respectively for medulloblastoma; 66.67%, 96.3%, 93.33%, 96.3% & 66.67% respectively for ependymoma and 100% each for brainstem glioma.

Conclusion: CT is a highly sensitive and specific procedure for the diagnosis of posterior fossa tumours in children. So it can be regarded as a primary imaging modality of different pediatric posterior fossa tumours.

Keywords: Diagnostic accuracy, computed tomography, posterior fossa tumours.


Introduction

Brain tumours are the most common neoplasm in children next to leukemia with an incidence of approximately 2.5 per 100,000 per years.¹ Seventy percent of childhood CNS tumors arise in posterior cranial fossa.² The most common lesions are intra-axial tumors such as cerebellar astrocytomas, medulloblastomas, brain stem gliomas and ependymomas Extra axial tumour such as chordomas and schwannomas are rare but not uncommon.

From the mid and the late 1970s, CT emerged as the primary diagnostic screening modality for the detection of intracranial pathology.³ CT is highly accurate in delineation and characterization of new and recurrent tumours.⁴⁻⁵ It assess the site of primary lesion, size, extent of involvement, precontrast density (cystic or solid), post-contrast enhancement, regularity of borders, and presence of calcification. CT also demonstrates the presence of edema, deformity and displacement of the fourth ventricle, cisternal deformity, bone erosion and widening of the cerebral ventricles as reflected by an increased cerebro-ventricular index.⁶⁻⁷ Vascular structures can

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be further defined with the help of contrast and vascular structures other than vessels can be
determined.

CT has made a significant impact on the
differential diagnosis of intracranial tumours,
particularly those which developed in the
posterior cranial fossa in infants and children.
Subarachnoid spread (supratentorial, infratentorial & spinal subarachnoid space) can
be seen in medulloblastoma on the initial CT
and on post operative follow-up. Again early CT
diagnosis depends on displacement of the
fourth ventricle and compression and distortion
of cisterns. Mass effect and cisternal
compression or obliteration can be appreciated
in nearly every case of brain stem glioma.
Although bone artifacts have been an obstacle
to the optimal demonstration of posterior fossa
contents, the diagnosis obtained with CT is
reasonably accurate. MRI has its advantage
of being radiation free, multiplaner imaging
facility hence a lesion can be seen in three
planes and accurate localization of the lesion
can be done, better soft tissue characterization
and can clearly demonstrate peritumoral
edema, but its disadvantage includes its high
cost and paucity of its availability. MRI is only
available in limited number of centers in many
developing countries like Bangladesh. For this
reason MRI is not yet widely used. It also
requires long time for acquisition of the data
and very difficult to use for restless patients
particularly in neonates and infants and even
in uncooperative children and cannot be done
in patients having metallic implants for which
CT is the modality of choice. Hence, CT has
become the most commonly used primary
radiologic investigation for posterior cranial
fossa tumors. Iodinated contrast media is used
to visualize all types of posterior cranial fossa
tumors.

In posterior fossa tumors, coronal images are
often extremely helpful for evaluating the
relationship of a tumor to the tentorium and
the foramen magnum. Coronal images are also
helpful in the evaluation of small lesions
situated near dura or bone. Reformatted sagittal
images may aid in evaluation of tumors of the
midline structures such as the third ventricle.

Newer multi-slice helical CT scanners are
capable of providing highly collimated sub
millimeter thickness sectional images in
extremely short acquisition times and thus
areas of hyperostosis or bone destruction,
intratumoral calcification and early
intratumoral or peritumoral hemorrhage are
more completely defined with greater certainty
on CT than on MRI. CT is often more specific than MR imaging for
preoperative tumour diagnosis. For example,
small round cell tumours such as germinomas
and medulloblastomas are isodense or
hyperdense compared with brain parenchyma
prior to administration of contrast agent,
whereas astrocytomas of childhood are almost
always hypo dense. Thus, in general,
germinomas can be confidently differentiated
from astrocytomas with use of CT. Making this
differentiation on the imaging study alone is
often not possible with MR imaging. Similarly,
the presence of calcification, which can be
helpful in the preoperative diagnosis of
ependymoma and teratomas, is less easily
detected by MR imaging than by CT.

There have been many works on the role of CT
in the diagnosis of posterior cranial fossa tumor
like medulloblastoma, cerebellar astrocytoma,
ependymoma, brain stem glioma, cerebell-
opontine angle (CPA) tumour, but however few
works have been done including all types of
posterior cranial fossa tumors specially in
children. Such types of study have not been
done yet in our country. Hence, certainly this
work will serve as a baseline study for other
researchers. After having multicenter study a
definite level will be achieved for a conclusive
recommendation regarding CT evaluation of
pediatric posterior fossa tumours. The present
study was thus designed to assess the efficacy
of CT for evaluation of different pediatric
posterior fossa tumours.

Materials and Methods
This prospective study was carried out from July
2006 to February 2007 in the Department of
Radiology & Imaging, Dhaka Medical College
Hospital (DMCH) and Bangabandhu Sheikh
Mujib Medical University (BSMMU) Hospital on
consecutively selected 35 patients ranging
from 1 to 15 years of age who were admitted into the Department of Neurosurgery of the respective hospitals with clinical suspicion of posterior fossa tumours and were referred for CT scan of brain. CT scan of brain was performed in all cases. Among 35 cases, 2 cases were diagnosed as arachnoid cyst, 1 case as Dandy-Walker variant; 1 patient had clinical signs of infection and a low density lesion in the cerebellum compatible with cerebellitis and another patient with leukemia had a hyperdense homogeneously enhanced lesion at the petrous apex. Histopathological examination was not done in these 5 cases. Hence, these 5 cases were excluded from this study. The rest 30 patients underwent surgery and were followed up to histopathological diagnosis. Then CT diagnoses were compared with histopathological diagnoses. Statistical analysis was done to see the diagnostic accuracy of CT for the diagnosis of posterior fossa tumors by calculating sensitivity, specificity, accuracy, positive and negative predictive values for different lesions separately.

Prior to commencement of this study, the research protocol was approved by the appropriate authority and written informed consent was obtained from the patients or their parents. CT scan of brain was performed from caudal to cephalad level with 15 to 20 degree angulation to the canthomeatal line both before and after the I.V contrast agent (Iopamidol-370) with 5mm to 10mm slice thickness at 120 Kv and 150 mA and were viewed in axial and if needed in coronal slices. CT scans were done after proper counseling of the patient and after proper sedation of restless children.

**Observations and Results**

The age of the patients ranged between 1 to 15 years with the mean age of 9.07 years. Highest incidence was found in the age group of 10 to 12 years. 20 were male (66.67%) and 10 were female (33.33%). The most common symptom was headache which was observed in 27 patients (90%). 21 patients (70%) had vomiting and 10 patients (33.3%) had gait disturbance. Blurring of vision was noted in 8 patients (26.7%). Convulsion was present in 4 patients (13.3%). Weakness of limb was observed in 3 patients (10 %). Vertigo was found in 12 patients (40%). Enlarged head was present in 1 patient (3.33%) and 2 patients (6.67%) had altered consciousness.

**Table-I**  
*CT characteristics of the posterior fossa tumours*

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Medulloblastoma (n = 17)</th>
<th>Astrocytoma (n = 8)</th>
<th>Ependymoma (n = 3)</th>
<th>Brain stem glioma (n = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borders</td>
<td>Regular</td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td></td>
<td>Irregular</td>
<td>17</td>
<td>100</td>
<td>1</td>
</tr>
<tr>
<td>Calcification</td>
<td></td>
<td>2</td>
<td>11</td>
<td>1</td>
</tr>
<tr>
<td>Peritumoral oedema</td>
<td></td>
<td>15</td>
<td>88</td>
<td>5</td>
</tr>
<tr>
<td>Compressed fourth ventricle</td>
<td></td>
<td>17</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>Location within fourth ventricle</td>
<td></td>
<td>-</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td></td>
<td>15</td>
<td>88</td>
<td>6</td>
</tr>
<tr>
<td>Density</td>
<td>Mixed</td>
<td>2</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Hypodensity</td>
<td>-</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Hyperdensity</td>
<td>10</td>
<td>58</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Isodensity</td>
<td>5</td>
<td>29</td>
<td>1</td>
</tr>
<tr>
<td>Enhancement</td>
<td>Heterogeneous</td>
<td>3</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Homogeneous</td>
<td>14</td>
<td>82</td>
<td>1</td>
</tr>
</tbody>
</table>
Table II
CT and histopathological diagnoses of the posterior fossa tumours

<table>
<thead>
<tr>
<th>Diagnoses</th>
<th>No. and percentage of patients diagnosed by CT</th>
<th>No. and percentage of patients diagnosed by histopathology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medulloblastoma</td>
<td>17 (56.67%)</td>
<td>16 (53.33%)</td>
</tr>
<tr>
<td>Astrocytoma</td>
<td>8 (26.67%)</td>
<td>9 (30%)</td>
</tr>
<tr>
<td>Ependymoma</td>
<td>3 (10%)</td>
<td>3 (10%)</td>
</tr>
<tr>
<td>Brainstem glioma</td>
<td>2 (6.66%)</td>
<td>2 (6.67%)</td>
</tr>
<tr>
<td>Total</td>
<td>30 (100%)</td>
<td>30 (100%)</td>
</tr>
</tbody>
</table>

Table III
Measures of diagnostic performance of CT

<table>
<thead>
<tr>
<th>Index</th>
<th>Cerebellar astrocytoma</th>
<th>Medulloblastoma</th>
<th>Ependymoma</th>
<th>Brainstem glioma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>88.89%</td>
<td>100%</td>
<td>66.67%</td>
<td>100%</td>
</tr>
<tr>
<td>Specificity</td>
<td>100%</td>
<td>92.86%</td>
<td>96.3%</td>
<td>100%</td>
</tr>
<tr>
<td>Accuracy</td>
<td>96.67%</td>
<td>96.67%</td>
<td>93.33%</td>
<td>100%</td>
</tr>
<tr>
<td>Positive predictive value</td>
<td>100%</td>
<td>94.12%</td>
<td>96.3%</td>
<td>100%</td>
</tr>
<tr>
<td>Negative predictive value</td>
<td>95.45%</td>
<td>100%</td>
<td>66.67%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Out of the 30 cases, CT diagnosed 28 cases correctly and 2 cases were misdiagnosed. CT misdiagnosed one case of astrocytoma as ependymoma and one case of ependymoma as medulloblastoma. Measures of diagnostic performance of CT in different posterior fossa tumors are shown in table III.

Fig. 1: NECT of brain showing mixed density cerebellar astrocytoma having nodular calcification.

Fig. 2: CECT of brain showing heterogeneously enhancing Cerebellar astrocytoma.
Fig.-3: NECT of brain showing hyperdense medulloblastoma.

Fig.-4: CECT of brain showing enhancing medulloblastoma.

Fig.-5: NECT Scan of brain showing isodense ependymoma with calcification.

Fig.-6: CECT Scan of brain showing enhancing ependymoma.
**Fig.-7:** NECT of brain showing hyperdense medulloblastoma.

**Fig.-8:** CECT of brain showing enhancing medulloblastoma.

**Fig.-9:** NECT Scan of brain showing mixed density ependymoma.

**Fig.-10:** CECT Scan of brain showing enhancing ependymoma.

**Discussion**

Computed tomography has revolutionized the cross sectional imaging, it provides detailed anatomical outline without adjacent structures interfering with the visualization of each other. It is the primary imaging modality in the evaluation of brain tumour. In most cases, the exact diagnosis should be made by histopathological examination but it is important for treatment planning that the appropriate depiction of tumour extension and tissue characterization can be made by CT.

On CT images, the typical juvenile pilocytic astrocytoma (JPA) appears as a smoothly marginated, hypodense cyst like mass with a well defined, less hypodense tumour nodule on one wall. The nodule may contain one or more areas of dense calcification. The cyst fluid is less hypodense than the CSF (15-25 HU) because of the high protein concentration. Typically, after intravenous administration of a contrast agent, dense homogeneous contrast enhancement of the tumor nodule, but not of the other walls of the cyst, is seen. On CT scan,
low grade diffuse cerebellar astrocytoma appears most commonly as poorly margined areas of decreased attenuation. Contrast enhancement is usually absent. On CT scan, low grade diffuse cerebellar astrocytoma appears most commonly as poorly margined areas of decreased attenuation. Contrast enhancement is usually absent.

On non-contrast CT images, medulloblastomas appear as rounded or oblong, mainly homogeneous, isodense to slightly hyperdense masses centrally located in the inferior vermis and cavity of the fourth ventricle. Obstruction of the fourth ventricle, inferior aqueduct or both with resulting enlargement of the third and lateral ventricles is commonly seen on CT at the time of clinical presentation. Punctate or nodular intratumoral calcifications are identified in 10% to 20% of cases. Hypodense intratumoral foci of necrosis and cysts are found in up to 50% of medulloblastoma. After intravenous injection of contrast medium, moderate to intense homogenous enhancement of the solid tumor mass is the rule in these tumours, although approximately 10% fail to demonstrate contrast enhancement on CT.\(^3\)

The CT diagnosis of brainstem tumor is based on two factors: a) the appearance of the CSF structures adjacent to the brain stem, and b) the parenchymal density before and after contrast enhancement. Appreciation of the distortion or obliteration of the fourth ventricle and/or the adjacent cisterns is of utmost importance. A large proportion of the tumours are isodense relative to the normal brain parenchyma and present as enlargement of the brainstem, on occasion occurring with hydrocephalus.\(^{11}\)

Diffuse enlargement of all or part of the brainstem is the most common finding in CT. These tumours appear on non-contrast CT as poorly margined isodense or slightly hypodense masses. Approximately 50% of brainstem gliomas exhibit some degree of contrast enhancement on CT and MR images following intravenous injection of contrast media. Enhancement is usually patchy and heterogeneous and does not appear to correlate with tumour histology.

In non-contrast CT, ependymomas appear as hypodense or isodense, heterogeneous, midline, rounded masses within the fourth ventricle that partially or completely obliterate it. The tumour is typically well defined by a prominent hypodense halo of peritumoral oedema. Aggregates of calcification, usually small and round but sometimes quite large, are found in up to half of these lesions. Following intravenous contrast injection, the solid portions and cyst walls of the tumour mass exhibit moderate but heterogeneous enhancement. Extension into the lateral recesses, cerebellopontine cisterns or vallecula is most accurately delineated on post contrast CT.\(^3\)

Various reports on posterior cranial fossa tumours in children confirm that medulloblastoma, cerebellar astrocytoma, brain stem glioma and ependymoma are the common lesions. In this present study, common tumors were medulloblastoma (56.67%), astrocytoma (26.67%), ependymoma (10%) and brain stem glioma (6.66%). These findings were close to the study of Chang et al.\(^{12}\) who found medulloblastoma 40%, followed by astrocytoma 23%, brain stem glioma 21% and ependymoma 11%. However, in our study incidence of ependymoma is greater than brain stem glioma. Medulloblastomas were more common in the series of Kingsley and Kendall\(^8\) and Segall et al.\(^{13}\) which are similar to the present study. Astrocytomas were the most frequent tumors in the series of Reider-Grosuasser et al.\(^7\), as well as in the series of Naidich et al.\(^{14}\). However, our figure showed that astrocytomas were second to medulloblastomas. According to the reports of Lee et al.\(^{15}\) and Kingsley and Kendall\(^8\), medulloblastoma is more frequent in boys, who account for 61.5-88%, cerebellar astrocytoma and brain stem glioma involve both sexes equally, but ependymoma shows a female preponderance of 80 %. This study results were somewhat different: boys predominated in the medulloblastomas (56%), brain stem glioma (100%) and ependymomas (66%), while cerebellar astrocytoma involved both sexes equally with a slight (55%) female predominance.
In this study, in non-contrast CT (NECT) astrocytomas were hypodense in 62%, isodense in 12% cases, and mixed density in 25% cases. Calcification was present in 12% cases. Chang et al.\textsuperscript{12} showed that astrocytoma was hypodense in 57%, isodense in 23%, mixed density in 13% and hyperdense in 7% cases. Calcification was present in 17% cases. In this study, cases showed contrast enhancement which was supported by Chang et al.\textsuperscript{12} In NECT 58% of medulloblastoma were hyperdense, 29% were isodense. Hydrocephalus was seen in 69% cases. Homogeneous contrast enhancement was present in 82% cases. These findings were similar to Weisburg\textsuperscript{16} who have mentioned 30% of medulloblastoma were isodense, 70% hyperdense and 100% cases hydrocephalus in precontrast scan, showed homogenous contrast enhancement in 90% cases.

Most of the ependymomas were in the fourth ventricle, therefore being midline\textsuperscript{12} and another reports of Segall et al.\textsuperscript{13} showed about three fifths of ependymomas have extended through the lateral recess of the fourth ventricle and the adjacent tissue into the cerebellopontine angle cistern on one or both sides; in our study one third tumors were laterally located. According to the reports of Kingsley and Kendall\textsuperscript{8} and Segall et al.\textsuperscript{13}, calcification was found most often in ependymoma (44-50%) and less often in other tumors (medulloblastoma 7.1-13.3%, astrocytoma 9%). In our study, the frequency of calcification (ependymoma 66%, medulloblastoma 11% and astrocytoma 12%) was close to their reports. In this study, peritumoral edema was seen with decreasing frequency in medulloblastomas, ependymomas, cerebellar astrocytomas and brain stem gliomas. These findings were similar to the reports of Chang et al.\textsuperscript{12}.

In this study it was found that measures of diagnostic performance of CT in different posterior fossa tumours are high with the overall accuracy of CT as diagnostic modality ranged between 93% and 100%. From this present finding, it is conceivable that CT is one of the accurate diagnostic modality in evaluation of pediatric posterior fossa tumours.

**Conclusion:**
CT scan is useful modality in the evaluation of pediatric posterior fossa tumours. It can be regarded as a primary imaging modality in the diagnosis of different pediatric posterior fossa tumour and validated the related previous study findings regarding its efficacy. However, further study with larger study population involving several investigators at multiple centers may give more precise results.

**References:**


