Characteristics of Brain Imaging in Intracranial Tumor Patients at Neurology Ward Dr. Hasan Sadikin General Hospital Bandung 2017–2019

Putri Nur Amalia Dewi,[1] Asep Nugraha Hermawan,[2] Cep Juli,[2] Paulus Anam Ong,[2] Sofiati Dian[2]

[1]Faculty of Medicine, Universitas Padjadjaran, Indonesia, [2]Department of Neurology, Faculty of Medicine Universitas Padjadjaran/Dr. Hasan Sadikin General Hospital, Bandung, Indonesia

Abstract

Background: Brain imaging is the main modality in establishing the diagnosis of intracranial tumors. Therefore, by using appropriate imaging modalities, lesions can be identified and this is useful in determining management and monitoring of the therapeutic process. This study aimed to describe the use of imaging modalities and the characteristics of imaging findings in diagnosing intracranial tumor patients.

Methods: This cross-sectional descriptive study obtained data from medical resumes at the Neurology Ward of Dr. Hasan Sadikin General Hospital Bandung, collected by total sampling method. Data on patients with intracranial tumors who underwent imaging examinations in January 2017–December 2019 were taken, including demographical and imaging characteristics data, divided by tumor type.

Results: Of 206 data, the imaging modalities used were contrast CT scan (45.6%), non-contrast CT scan (34.5%), multimodality imaging (13.6%), contrast magnetic resonance imaging (MRI) (3.9%), non-contrast MRI (2.4%), and magnetic resonance spectroscopy (MRS) (0.5%). The most common primary tumor was a solitary lesion (89.4%) located in the right hemisphere in 38.1% of subjects. Metastatic tumors were found mostly as multiple lesions (63.4%) located in both supratentorial and infratentorial in 25.8% of the subjects. Perifocal edema was found in 75% of patients in both tumor types.

Conclusions: Contrast CT scan is the most frequently used imaging modality. The most common radiological finding is perifocal edema. Primary tumors are commonly found in solitary numbers, and are located in supratentorial on the right hemisphere. Metastatic tumors are commonly found in multiple numbers and are located both in supratentorial and infratentorial.

Keywords: Brain imaging, imaging modality, intracranial tumor

Introduction

Intracranial tumors or brain tumors are neoplastic lesions inside the cranium due to uncontrolled and progressive cell growth or space-occupying lesions (SOL) in terms of imaging.[1] According to data from the Global Cancer Observatory, the incidence of intracranial tumors ranks 15th of all tumor diseases with an incidence of 1.5% worldwide.[1] Intracranial tumors are the 13th cause of death of all tumor/cancer cases in Indonesia.[1] This is largely due to delays in diagnosis and treatment. If detected at an early stage, appropriate treatment can be done earlier to improve the prognosis. Those can be pursued through selecting the appropriate imaging method. Intracranial imaging is useful to help in diagnosing intracranial tumors, to determine management and to monitor the therapy process.[2] Therefore, knowledge of the characteristics of imaging is important in managing intracranial tumor patients.

Dr. Hasan Sadikin General Hospital is a National Referral Hospital and cases of tumors or cancers including intracranial tumors are referred from various regions in West Java, Indonesia. Many imaging modalities are available and have an important role in the diagnosis and management of intracranial tumor cases. This study aimed to describe the use of imaging modalities and the characteristics of imaging findings in diagnosing intracranial tumor patients.

Correspondence: Putri Nur Amalia Dewi, Faculty of Medicine Universitas Padjadjaran, Jalan Raya Bandung-Sumedang Km. 21, Jatinangor, Sumedang, West Java- Indonesia, E-mail: putri17031@mail.unpad.ac.id

Methods

This was a descriptive study with a cross-sectional design. The subjects were patients aged >18 years between January 2017–December 2019, presented in Neurology Ward Dr. Hasan Sadikin General Hospital Bandung, who had a final diagnosis of intracranial tumors and brain imaging has been performed. Data were collected from medical resumes in the Department of Neurology by the total sampling method. The study has been approved by the Research Ethics Committee of Universitas Padjadjaran with ethical clearance number 791/UN6.KEP/EC/2020.

Patients with missing medical resume data, incomplete or missing head imaging results, inaccessible, or duplicate data were excluded. Demographic data and imaging characteristics from radiological experts were analyzed and divided into primary and metastases intracranial tumors.

Results

During the study period, 275 cases were presented, but only 206 subjects had complete data. Patients who were admitted to the hospital had a mean age of 50.06 (± SD 12.62) with a greater proportion of female patients (55.3%). The general characteristics of the age and sex of subjects were listed in Table 1. Of all the subjects, it was found that primary intracranial tumors (54.9%) were more prevalent than metastatic tumors (45.1%) based on the final clinical diagnosis.

Contrast CT scan was the most often used modality in both groups, followed by non-contrast CT (Table 2). It was also the most widely used modality of choice in identifying lesions in any location (Table 3). In the use of multimodality imaging, there was a difference in the preference for using a combination of modalities between the primary and metastatic group.

The first two most common radiological findings in both groups were similar, perifocal edema and midline shift, followed by other findings as described in Table 2. However, the number of lesions and the location found had differences in the primary and metastatic groups.

Discussions

This study has found that female patients are predominant, in both the primary intracranial tumor (54%) and metastatic (57%) groups, conforming to the Central Brain Tumor Registry of the United States (CBTRUS) data from 2013–2017.[3] Meningioma lesions have the potential to significantly influence growth in women due to progesteron receptor expression.[3] However, this study was limited to showing the number of meningioma cases from all primary tumors, thus, the proportion of incidence cannot be confirmed. The high incidence of metastatic brain tumors in women might be caused by the high incidence of breast cancer in Indonesia.[1] In this study, 24 of 93 metastatic intracranial tumor patients were breast cancer patients. A literature study showed that intracranial metastases can occur in 16–30% due to overexpression of HER2.[4]

Within each modality, there are advantages as well as limitations in identifying lesions in a particular location. In this research, contrast CT-Scan (45.6%) was the most widely used

Table 1 Characteristics of Intracranial Tumor Patients at Dr. Hasan Sadikin General Hospital 2017–2019

Characteristic	Subject (n=206)
Age, mean±SD	50.06±12.62
Gender, n(%)	
Male	92 (44.7)
Female	114 (55.3)
Imaging modality, n (%)	
Non-contrast CT	71 (34.5)
Contrast CT	94 (45.6)
Non-contrast MRI	5 (2.4)
Contrast MRI	8 (3.9)
MRS	1 (0.5)
Multimodality	28 (13.6)

Notes: CT= Computed tomography, MRI= Magnetic resonance imaging, MRS= Magnetic resonance spectroscopy

Table 2 Imaging Characteristics of Intracranial Tumor Patients

Characteristics	Primary Tumors (n=113)	Metastatic Tumors (n=93)
Imaging modality, n (%)		
Non-contrast CT	38 (33.6)	33 (35.5)
Contrast CT	45 (39.8)	49 (52.7)
Non-contrast MRI	5 (4.4)	-
Contrast MRI	6 (5.3)	3 (3.2)
MRS	1 (0.9)	-
Multimodality	19 (15.9)	8 (8.6)
Non-contrast CT and MRS	8 (7.1)	1 (1.1)
Non-contrast CT and contrast MRI	6 (5.3)	1 (1.1)
Non-contrast CT and non-contrast MRI	-	3 (3.2)
Contrast CT and MRS	1 (0.9)	2 (2.2)
Contrast CT and non-contrast MRII	2 (1.8)	-
Contrast CT and contrast MRI	-	1 (1.1)
Contrast MRI and MRS	-	1 (1.1)
Location, n (%)		
Supratentorial	105 (92.9)	66 (71)
Right hemisphere	43 (38.1)	21 (22.6)
Left hemisphere	34 (30.1)	21 (22.6)
Bilateral	7 (6.2)	20 (21.5)
Others	21 (18.6)	4 (4.3)
Infratentorial	6 (5.3)	3 (3.2)
Supratentorial and infratentorial	2 (1.8)	24 (25.8)
Number, n (%)		
Solitary	101 (89.4)	34 (36.6)
Multiple	12 (10.6)	59 (63.4)
Radiological findings,n (%)		
Perifocal edema	85 (75.2)	70 (75.3)
Midline shift	62 (54.9)	31 (33.3)
Non-communicating hydrocephalus	23 (20.4)	8 (8.6)
Intracranial hemorrhage	16 (14.2)	12 (12.9)
Calcification	12 (10.6)	5 (5.4)
Ring enhancement	5 (4.4)	9 (9.7)
Communicating hydrocephalus	5 (4.4)	2 (2.2)
Intratumoralhemorrhage	3 (2.7)	0 (0)
Meningeal enhancement	2 (1.8)	1 (1.1)
Hyperostosis	2 (1.8)	-
Septal enhancement	2 (1.8)	-

Notes: CT= Computed tomography, MRI= Magnetic resonance imaging, MRS=Magnetic resonance spectroscopy

modality in imaging studies for both primary (39.8%) and metastatic (52.7%) tumor types as well as for lesions located in supratentorial (46.2%), infratentorial (44.4%), or both (42.3%).

Using a contrast CT scan is more advantageous than a single CT scan without contrast. Based on a retrospective study conducted in South Africa,[5] there is 3.28% of intracranial pathology that failed to be detected on the use of non-contrast CT without being followed by a contrast CT scan, for example, if there is blood-brain barrier damage.[5] Although a non-contrast CT scan can reduce operational costs, risk of allergic reactions, and risk of contrast-induced acute kidney injury, it requires careful assessment of the history of the disease.[5]

Magnetic resonance imaging (MRI) is rated as the modality of choice with high

Table 3 Distribution of Imaging Modality based on Location

Imaging Modality	Supra-tentorial (n=171)	Infra-tentorial (n=9)	Supra-tentorial and Infratentorial (n=26)
Non-contrast CT, n (%)	62 (36.3)	1 (11.1)	8 (30.8)
Contrast CT, n (%)	79 (46.2)	4 (44.4)	11 (42.3)
Non-contrast MRI, n (%)	2 (1.2)	3 (33.3)	-
Contrast MRI, n (%)	6 (3.5)	-	3 (11.5)
MRS, n (%)	1 (0.6)	-	-
Multimodality, n (%)	21 (12.3)	1 (11.1)	4 (15.4)

Notes: CT= Computed tomography, MRI= Magnetic resonance imaging, MRS= Magnetic resonance spectroscopy

contrast and spatial resolution for delineating intracranial tumor lesions compared to CT.[6] This is due to the working principle of MRI which utilizes electromagnetic signal emission at the level of the hydrogen atom nucleus in the human body.[6] According to the *Panduan Penatalaksanaan Kanker Otak Tahun 2016* from the Ministry of Health of the Republic of Indonesia,[2] MRI should be the right method of choice to provide a good picture, especially for infratentorial lesions. This is contrary to this study in which the identification of infratentorial lesions is still dominated by the use of contrast CT scan. CT scan is still the standard radiological examination and as an initial screening tool due to its availability and relatively low operating costs compared to MRI.[2,6]

Magnetic resonance spectroscopy (MRS) can also be the modality of choice that serves to measure the metabolites of tumor tissue so that anatomical, physiological, and metabolic information is obtained at one time.[7] It has the same working principle as MRI so that it will produce MRI and MRS images on examination. In this study, the use of MRS appeared to be combined with the use of CT scans. Another advantage, MRS is a non-invasive modality.[8] As with MRI, the availability of MRS is limited in hospitals in Indonesia and cannot be performed on patients with metal implants, so its use is limited.[8]

Imaging studies can provide characteristic information such as location, number of lesions, and radiological findings, so that tumor lesions can be identified. In primary intracranial tumors, this study shows that tumor lesions have been found in a solitary form (89.4%) and located in the right hemisphere (38.1%), whereas in metastatic intracranial tumors, the lesions are more frequent in multiple forms (63.4%), located in both supratentorial and infratentorial (25.8%). The location varies depending on histopathological type of the primary tumor. In general, many primary tumors are supratentorial.[6] For example, glioma is often found in the cerebral hemispheres (frontal and temporal lobe) and meningioma is most common in supratentorial parasagittal.[6] Almost all primary tumor lesions are found in solitary numbers, multiple lesions are a very rare condition.[10] It is thought that multiple lesions that occur sequentially are caused by irritation by the perifocal edema of the first lesion, leading to proliferation of neoplastic cells in astrocytes or arachnoid cells.[10]

Metastatic lesion are formed due to neoplastic cells that spread hematogenously and extravasates in the perivascular space or brain parenchyma.[11] This mechanism allows the formation of metastatic tumors tend to produce multiple lesions, as many as 70–80% of patients with metastatic intracranial tumors have multiple lesions.[11] However, metastatic lesions have a predilection location intracranial depending on the primary tumor type.[12] Breast cancer has a predilection location in the posterior fossa whereas lung cancer tends to be scattered throughout the intracranial area.[12] So far, there have been no studies that have proven significantly the predilection location of intracranial metastatic tumors.[12]

The results of this study indicate that the appearance of perifocal edema is the most common feature found on imaging examinations of patients with intracranial tumors, followed by midline shift, and non-communicating hydrocephalus. Perifocal edema can be found in both primary and metastatic intracranial tumors, and in this study, almost the same frequency was found, 75.2% and 75.3%, respectively. The

pathophysiology of perifocal edema in primary and metastatic intracranial tumors has different characteristics. Perifocal edema in metastasis cases is vasogenic edema, which is formed by increased production of factors that increase blood vessel permeability, such as vascular endothelial growth factor (VEGF).[13] In primary tumors, perifocal edema is not only caused by vasogenic mechanisms but is also characterized by extensive infiltration of surrounding tumor cells.[13]

The midline shift image in primary intracranial tumors was found to be more (54.9%) than in metastatic tumors (33.3%). This is due to the location of the tumor. Besides, the study found that the mean and median tumor volume and peritumoral edema volume in primary intracranial tumors were greater than in metastatic tumors.[14] There is a strong correlation between volume and length of the shift in primary intracranial tumors, so that the midline shift will be significantly greater than in metastatic tumors.[13]

Non-communicating hydrocephalus was more common in primary tumors (20.4%) than metastases (8.6%). Non-communicating hydrocephalus results from obstruction along the cerebrospinal fluid (CSF) pathway between the lateral ventricles and the outlet of the fourth ventricle; whereas communicating hydrocephalus results from a disruption of CSF absorption, which causes accumulation of CSF throughout the ventricular system.[15] Intracranial tumor lesions located near the posterior fossa area can cause obstruction in the fourth ventricle area so that the appearance of non-communicating hydrocephalus is more common.[15] However, the mechanism of hydrocephalus is not always caused by a brain tumor. Therefore, information about co-morbidities and other medical conditions is needed so that the relationship between lesions and the incidence of hydrocephalus can produce accurate data.

The limitations of the study are the incomplete data available, especially on radiological expertise and patient-specific tumor types according to the World Health Organization (WHO). Further research on imaging characteristics, such as radiological findings based on age, location of the lesion, and type of intracranial tumor can be developed with more complete and accurate data considering the lack of research on these variables.

In conclusion, CT scan is still the modality of choice for imaging brain tumors at Dr. Hasan Sadikin General Hospital during the 2017–2019 period. The most common radiological finding is perifocal edema. Based on the group of tumor types, primary tumor lesions have been found in solitary numbers and located in the right hemisphere, whereas metastatic intracranial tumors have been found in multiple numbers, located both supratentorial and infratentorial.

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