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Contribution of Magnetic Resonance Imaging (MRI) in the Diagnosis of Brain Metastases

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Abstract

Objective: To assess the value of MRI in the diagnosis of brain metastases due to the main primary tumours in patients who have undergone MRI at the CNSS. **Methods:** This is a retrospective, descriptive study of 3 years and 7 months duration from January 2019 to July 2023 involving 24 cases. We included in our study, all records of patients whose brain MRI was interpreted as being in favour of brain metastases. The examinations were performed using a TOSHIBA (CANON) MRI scanner with a power of 1.5 Tesla. The parameters studied were age, sex, circumstances of discovery, type of primary cancer, location of lesions and MRI complications. Data were collected and analysed using Kobocollect and SPSS 22 software. **Results:** Out of a total of 2021 cases of brain MRI performed, brain metastases represented 24 cases or 1.20%. The average age of our patients was 51 years with extremes of 29 and 72 years. No gender predominance was noted. HTIC syndrome and motor deficits were the most common symptoms with 37.50% and 20.83% respectively. The discovery of brain metastases was synchronous with that of the primary cancer in 75% of cases. Brain metastases were metachronous in 25% of cases and were indicative of a previously latent neoplasia in 12.5% of cases. A predominance of bronchopulmonary cancer was noted in 33.33% of cases. The lesions were single in 25% of the patients and multiple in 75%. Their location was above tentorial in 75% of the patients, while in 08% of the cases they were below tentorial and in 17% of the cases above and below tentorial at the same time. The most common complications were perilesional edema in 96% of cases, followed by mass effect in 50%. **Conclusion:** In terms of neuroimaging, MRI is the gold standard for diagnosing brain metastases. However, due to its cost and technical inaccessibility in a disadvantaged context, brain MRI is rarely used and yet this non-invasive technique compared to other neurosurgical procedures that are not very accessible in Guinea and often unavailable with limited resources allows for a more precise diagnosis in situations where doubt about the nature of a non-specific brain lesion persists.

Subject Areas

Oncology

Keywords

Brain Metastases, MRI, Primary Tumors, CNSS

1. Introduction

Brain metastases (BM) are secondary neoplastic foci that develop at a distance from the initially affected site (primary tumor) and whose growth is autonomous and independent of that of the primary tumor. These lesions represent the most common malignant brain tumors in adults [1]. It is estimated that 20 to 40% of patients with primary neoplasia will develop MC during the course of their illness [1]. Their incidence has been increasing steadily in recent years, due to progress in diagnostic techniques and the increased survival of cancer patients thanks to better control of the systemic disease [1]. Median survival of untreated patients is 1 - 2 months [2]. Their initial diagnosis is essentially based on neuroradiology, with MRI as the reference examination, whose contrast sensitivity gives it superior performance to CT scanning in most brain pathologies and makes it possible to establish the early diagnosis of small lesions as well as their precise topographic characterization [3]. This contrast sensitivity makes it possible to distinguish between different categories of soft tissues and to specify the anatomy and location of lesions [3]. MRI is prescribed as part of the assessment of a known primary cancer, or symptoms of a secondary lesion revealing an unknown primary [3]. In the latter case, diffusion, perfusion and spectroscopy sequences make a great contribution to the differential diagnosis of abscesses and primary brain tumors which present identical aspects to the classic sequences [4]. The final diagnosis is made by histopathological analysis of biopsies or excision samples dependent on immunohistochemistry techniques and invasive neurosurgical procedures that are not easily accessible and often unavailable in resource-limited countries [5].

2. Method

We report a series of 24 cases of brain metastases (CM). The examinations were performed using a 1.5 Tesla MRI device.TOSHIBA brand.The inclusion criterion was all patient records whose brain MRI was interpreted as being in favor of brain metastases.

Were not retained in our workrecords of patients presenting with other neurological or neurosurgical pathologies on brain MRI.

The technique consisted of performing a topogram in the axial and sagittal plane; T1-weighted spin echo (SE) sequences in the coronal and sagittal planes, T2-weighted turbo spin echo (TSE) sequences in the coronal plane, and T1-weighted spin echo (SE) sequences with fat saturation (Fat Sat) after injection of gadolinium in all three planes. The slice thickness during MRI scanning was less than or equal to 3 mm.

3. Result

During our study period, 2021 brain MRIs were performed. Brain metastases accounted for 24 cases or 1.20%. The mean age of our patients was 51 years with extremes of 29 and 72 years. No gender predominance was noted. HTIC syndrome and motor deficits were the most common symptoms with 37.5% and 20.8% respectively (**Table 1**).

Table 1. Distribution of patients according to the circumstances of discovery.

Circumstances of discovery	Number of patients	Proportion (%)
HTIC syndrome	9	37.5
Signs of focus	5	20.8
Epileptic seizures	2	8.3
Cerebellar syndrome	2	8.3
Frontal syndrome	1	4.2
Blindness	1	4.2
PEIC on the scanner	2	8.3
Extension report	2	8.3
Total	24	100

The discovery of brain metastases was synchronous with that of the primary cancer in 75% of cases. Brain metastases were metachronous in 25% of cases and revealed a previously latent neoplasia in 12.5% of cases. A predominance of bronchopulmonary cancer was noted in 33.3% of cases (**Table 2**).

On MRI, 45% of the lesions had taken up the contrast in an annular manner, 30% of the lesions had taken up the contrast in a heterogeneous manner, and the uptake was nodular in 25% of the lesions. The lesions were single in 25% of the patients and multiple in 75%. Their location was above tentorial in 75% of the patients, while in 8% of the cases they were below tentorial and in 17% of the cases above and below tentorial at the same time.

The most common complications were perilesional edema in 96% of cases, followed by mass effect in 50% (**Table 3**).

Table 2. Distribution of patients according to the type of primary cancer.

Primary cancer	Number of patients	Proportion (%)
Lung cancer	8	33.3
Breast cancer	5	20.8
Cervical cancer	2	8.3
Kidney cancer	2	8.3
Colorectal cancer	1	4.2
Prostate cancer	1	4.2
Endometrial cancer	1	4.2
Unidentified cancers (PDV)	4	16.7
Total	24	100

Table 3. Distribution of patients with MC according to MRI complications.

Complications of MC	Number of patients	Proportion (%)
Perilesional edema	23	96
Hemorrhage	2	8
Necrosis	3	13
Hydrocephalus	1	4
Mass Effect	12	50
Commitment	8	33

4. Discussion

Several studies report an incidence in the general population ranging from 2.8 to 11.5 per 100,000 inhabitants [6]. In the United States, the annual frequency is estimated at about 170,000 new cases. They occur in approximately 10 to 30% of cancer patients [7] [8]. Posner JB *et al.* reviewed a US autopsy series of 2375 patients with cancers, which included lymphomas and leukemias, and reported an almost identical frequency (24%) [9]. They would occur in 25% of cases according to Takakura K *et al.* in a Japanese autopsy series of 3359 patients with a solid primary tumor [10]. In a series carried out in Marrakech Pratic F on a total of 800 brain tumors, 3.75% of MC were found [11]. A frequency of 2.9% of MC (20 cases) in 682 tumors diagnosed between 2010 and 2017 was reported in a study by Doualeh AK (34). In the Sanogo KBM study, 92 cases of MC were collected from 2681 cancer patients, which represents 3.43% [12]. The low incidence of our study generally matches the numerical weakness of the African series in its tumor pathologies, this being explained by the absence of a well-maintained cancer registry and by the insufficiency of the health coverage of the populations which do not facilitate access to care and diagnostic means. And could also be due to the diagnostic difficulties due to the limited means and management of cancerous diseases with a higher mortality in underdeveloped countries caused by poverty and illiteracy of the population. In addition, these lesions occur in the context of systematic cancerous disease. The neurological expression may be masked, leading to the death of patients before their diagnosis. The majority of MCs occur between 40 and 60 years of age, with the exception of MCs of melanoma, sarcoma and germ cell tumors which affect younger subjects. MCs are much rarer after the age of 70 (less than 5% of MCs [13]; these results could be explained by more rapid death of elderly patients (before the appearance or revelation of MC) and less frequent autopsies [14]. In the series carried out in Marrakech Pratic F, the age varied between 26 years for the youngest and 66 years for the oldest, with an average age of 51 years and 06 months [11]. Zatouli F finds an average age of 54 years and 8 months, with extremes ranging from 37 years to 68 years [15]. For Nataf F and col the average age was 52 years and 8 months [16]. A study of 195 patients with brain metastases (Simionescu MD et al) found that 74.5% of patients were between 40 and 60 years of age. The extreme ages were 18 and 80 years. (36). In the Doualeh AK series the average age was 47 years [17]. In the Sanogo KBM study the mean age of onset was 48 years with a predominance of the age group [30 - 50 years] [12]. These data are generally consistent with the average age of our patients. The sex ratio varies according to the published series. The frequency of MC is identical in men and women (sex ratio is 1) [18]. A retrospective study conducted by Ghosh SK *et al.* on 72 patients with CD from November 2010 to October 2012 did not find any gender predominance [19]. Which is consistent with our results. However, the sex predominance depends largely on the primary tumor. Thus, the most frequent brain metastases in men are of pulmonary origin, while in women, the highest percentage is in the breast. In the Doualeh AK series, the predominance was clearly female, corresponding to 69% with a sex ratio of 0.43 (34). A predominance of the male sex is noted in the Pratic F series carried out in Marrakech, with 83.3% and a sex ratio of 5 [11]. The nature of the primary was a determining factor in the absence of predominance of one sex over the other in our study. The frequency of primary tumors causing MC varies according to the studies, but all agree that bronchopulmonary cancers and breast cancers are the two largest providers of MC, followed by gastrointestinal cancers, kidney cancers and melanomas. These five cancers cause more than 70% of MCs [18]. If we are interested in the ability of a given cancer to develop MCs, the tumors with the greatest tropism for the brain and its envelopes are melanomas (70%), choriocarcinomas (40%), lung cancers (30% to 50%) and breast cancers (20%) [20]. The literature showed a similar distribution to our study with the predominant cancers being bronchopulmonary cancer (33.33%), followed by breast cancer (20.83%). The occurrence of brain metastases is suspected in any patient with cancer who presents with neurological symptoms. Compared to our study, Doualeh AK found that 80% of patients presented with inaugural (revealing) MC and 20% of MC were metachronous [17]. In the Sanogo KBM series, MCs were synchronous in

54.3% of cases and metachronous in 45.7% of cases; they had not recorded any cases of inaugural (revealing) metastases [12]. The time taken to detect MCs compared to the discovery of the primary cancer varies. It is linked to the location and origin of the primary tumor. In general, this time is approximately 5 to 7 months for lung cancers and 17 to 42 months for breast cancers [21] and 2.2 to 3.8 years for melanoma [22].

In small cell lung carcinomas in complete remission, the cumulative risk of brain metastases at 3 years is 58%. In treated stage III non-small cell lung carcinomas, the risk of brain metastases at 1 year is 18%. In metastatic non-small cell lung carcinomas, 30 to 40% of brain metastases are synchronous. The median time to onset of metachronous brain metastases is approximately 14 months [22]. After breast cancer diagnosis, median times to brain metastases vary by histological subtype, ranging from 27.5 months for cohorts with triple-negative tumors to 35.8 months for cohorts with HER2-overexpressing tumors, 47.4 months for cohorts with luminal A tumors, and finally 54.4 months for cohorts with luminal B tumors [22]. For kidney cancers, gastrointestinal cancers, melanomas, the average delay varies from 1 to 5 years. Symptoms and clinical signs depend on the location of the metastases and are not specific. Nataf F *et al.* found HTIC syndrome in 41% of his patients [16], and in the series of Posner JB *et al.*, headaches are present in 53% of patients [9]. In the Sanogo KBM study, HTIC syndrome was the most frequent mode of revelation because it was found in 64% of patients; in 34.8% of cases, it was found alone and in 29.4% of cases it was associated with other signs [12]. In the Doualeh AK case series, headaches represent 90% of the reasons for consultation accompanied by vomiting [17]. These data are consistent with what we found in our study. Deficit signs are present initially in 18 to 40% of cases and in 67% at diagnosis [23]. Zatouli F found a figure of 47.6%, while Posner JB *et al.* found 40% [9] [15]. Sanogo KBM observes 24% and Doualeh AK 55% of patients showing signs of neurological deficit [12] [17]. That said, motor deficits represent, along with headaches, the most frequent revealing signs. Other manifestations can occur acutely, such as language disorders, paresthesias, and isolated homonymous lateral hemianopia. Epileptic seizures constitute the initial presentation in 12 to 39% of cases [9] [24] [25]. They are more common in cases of melanoma MC, where they can occur in up to 50% of cases [26]. The French series of Chamberlain AL *et al.* report that 50% of patients had an acute onset of symptoms with an inaugural epileptic seizure in 39% of cases, and that 50% had a progressive onset with headaches associated with focal neurological deficits in 20% of cases [27]. Zatouli F found a cerebellar syndrome of 14.28%, Posner JB and col 20% [9] [15]. This disorder may be secondary to a cerebellar or brainstem tumor, but sometimes pseudocerebellar symptoms may be related to a large frontal MC, hydrocephalus and much more rarely a parietal lesion. In our series, 8.33% of patients presented signs of cerebellar syndrome. Other revealing manifestations may be an alteration of higher functions: Their incidence varies considerably depending on the series, from 9 to 52% of cases [23]. These may be isolated memory disorders, apraxia, and difficulty in dressing, reading, calculating while other intellectual functions seem preserved. An inaugural language disorder is observed in 1 to 10% of cases, but it generally has no localizing value [28]. Brain CT and MRI provide valuable information regarding MCs: their number, size, appearance, and distribution. In clinical routine, radiological assessment of metastases is mainly done by visual analysis of **Figures 1-4** [29]. Lesions may range from radiologically silent microscopic deposits to masses several centimeters in diameter. Contrast enhancement is commonly seen and may be intense, punctate, nodular, or annular. Hemorrhage may also be a feature and occurs more frequently in certain underlying primary pathologies [30]. The degree of peritumoral edema varies from virtually none to (more commonly) extensive surrounding edema. MRI has superior sensitivity to CT for identification of small lesions, particularly in the posterior fossa, and double/triple dose contrast, delayed imaging, and the use of magnetization transfer to suppress background signal from nonenhancing tissues may further improve the sensitivity of lesion detection [30]. MRI has a higher sensitivity than CT scan, and its sensitivity after gadolinium injection is higher than that of CT scan performed after a double dose and delayed sections [31]. It allows for better exploration of the posterior fossa, and is the method of choice for highlighting intracerebral lesions measuring 3 - 5 mm. It also allows visualization of possible meningeal involvement, assessment of tumor extension and the impact on the surrounding brain parenchyma [32]. A study on the evolution of imaging techniques (CT versus MRI) from the American Academy of Neurology in Boston published in 2008 on 481 CBPC shows a rate of MC that goes from 10% with CT to 24% with MRI. On CT, all MC detected were symptomatic, while on MRI, 11% were asymptomatic [33]. Nouakchott experienced about 127 cases MRI was requested in the presence of a normal CT scan (57%) and it showed a PEIC in 34 patients (26.78%) [5]. The number of MCs varies greatly depending on the origin of the series: autopsy or scannographic. Overall, single MCs would represent approximately 30% of cases in autopsy studies [34]. Studies using scanners show a higher frequency of solitary MCs (50%) [35]. Nataf F *et al.* count 88.4% of unique MCs, Zatouli F finds 57.14% of unique MCs against 42.85% multiple (38, 39). Studies using scanners by Delattre JY *et al.* found after examining 288 CT scans, that brain metastases are unique in 49% of cases, that there are two lesions in 21%, and three in 13% [35]. A study by Swift PS and col on 728 CT scans gave results: single MC in 44% of cases, 2 lesions in 24%, 3 lesions in 10%, 4 lesions in 8%, 5 - 10 lesions in 10% of cases [36]. Our study found more multiple lesions in our patients and this can perhaps be explained more by the use of MRI which is more efficient in detecting these lesions. The number also varies according to the primary cancer. Thus, kidney cancers, small pelvis cancers (uterus, prostate) and gastrointestinal cancers more readily give rise to single metastases, while lung cancers and melanomas are most often multiple. This has been demonstrated by two studies: one CT-scan conducted by Delattre JY *et al.* and the other autopsy conducted by Takakura K [10] [35] *et al.* noted that half of the patients in their series with melanoma MCs have more than five locations. The distribution of brain metastases in the brain depends on the blood flow in each compartment: 80% are supratentorial, 15% are cerebellar and 5% are located in the brainstem [36]. It should be noted, however, that retroperitoneal and pelvic tumors (uterus, prostate, rectum) more often give rise to metastases in the posterior fossa [36]. Leptomeningeal MCs are more typical of breast cancers and to a lesser extent of melanomas and small cell lung cancers. In our series, supratentorial localization was found in 75% of cases, infratentorial in 8% of cases, while in 17% of cases the lesions were both supratentorial and infratentorial. Daoud S et al (Experience of the neurosurgery department of the University Hospital Center of Oran on MC): found the localizations were supratentorial 56%, infratentorial 33%, supra and infratentorial 11% [37]. Delattre JY *et al.* found 80% of supratentorial localizations and 20% of subtentorial localizations [35]. The frontal and parietal lobes are more often affected than the temporal and occipital lobes [35] [38]. A topographical study found a significant predilection for the temporo-occipital region and the junction territories of the three main cerebral arteries. These data are consistent with the results we have obtained. Almost all MCs with a diameter greater than 5 mm are visualized on CT. However, MRI remains the method of choice for highlighting intracerebral lesions of 3-5 mm in size, and it allows visualization of possible meningeal involvement. However, microscopic brain metastases cannot be seen in radiology, which is why MRI does not allow formal exclusion of all brain metastases. In our series, analysis of metastatic lesions noted a tumor size ranging from 4 mm to 80 mm, with an average size of 42 mm. As indicated in the guide to the proper use of medical imaging examinations, MRI is the method of choice for detecting brain metastases. On T1-weighted sequences, the signal of metastases is generally identical or slightly lower than that of the gray matter. A hyposignal is observed in the case of intratumoral necrosis or perilesional edema; a hypersignal reflects the presence of hemorrhage or melanin [31]. On T2-weighted spin echo and FLAIR sequences, metastases are typically hyperintense relative to the gray matter. FLAIR is more sensitive than T2-weighted spin echo for detecting small cortical locations close to the CSF; the FLAIR signal is generally less intense than that of perilesional edema [32]. MRI with gadolinium injection should be systematic during the preoperative assessment of apparently single MCs. Indeed, in 10 to 20% of cases it allows the detection of other locations that went unnoticed by the scanner [31]. In case of multiple lesions, the T2 appearance may simulate the hyperintensity foci observed in the white matter, particularly in elderly subjects; if no enhancement is observed after injection of Gadolinium chelates, the probability that these are metastases is low [31]. Some metastases are in hypointense or isosignal; these are lesions secreting mucin (gastrointestinal adenocarcinoma), tumors with high cell density (high nucleocytoplasmic ratio) or hemorrhagic lesions [32]. In T2 gradient echo, hyposignals are found in the case of intratumoral hemorrhage and/or calcifications. MRI after injection of contrast product is the most sensitive technique for the detection of intracranial metastases even of very small size (of the order of 2 mm)

[39]. Small metastases that are not accompanied by edema may also be overlooked if no injection is performed. The appearance of the lesions is variable: intense, nodular, ring-shaped or mixed enhancement. In our study, the most common aspect encountered is the hyposignal found in 45% of cases; after injection of PDC, annular contrast uptake is the most frequent and constitutes 45% of the lesions, while 30% of the lesions had taken it heterogeneously, and the uptake was nodular in 25% of the lesions. Other magnetic resonance imaging techniques have been developed, in particular diffusion imaging, perfusion imaging and spectroscopy to allow the differential diagnosis of MC compared to other lesions. When the cancer is known, the radiological appearance, MRI or CT scan, is generally sufficient in the clinical context [40]. The situation is different when the brain metastasis precedes the discovery of the cancer. The primary tumors most frequently revealed by MC are bronchial cancers (60% to 90%) followed by digestive cancers (8% to 10%) [40]. Breast cancers are much more rarely revealed by MC and the place of mammography in the systematic assessment remains debated if palpation of the breasts and chest X-ray do not show secondary locations [40]. In our study, the assessment to search for the primary allowed it to be found in 12.5% of cases. When the MC reveals an unknown cancer, a systemic assessment is necessary. In addition to a very complete clinical examination, it includes a chest X-ray supplemented by a chest CT scan, an ultrasound or an abdominopelvic CT scan. The negative assessment should lead to the immediate proposal of a brain biopsy (or excision) for diagnostic purposes. The clinical examination, in particular of the breasts and skin, allows the other examinations to be directed. Examinations such as digestive fibroscopies or systematic mammography are less useful in the absence of clinical orientation. If the explorations remain negative, it is necessary to consider the excision of the brain lesion, if it is surgically accessible, or its biopsy which will allow confirmation of the diagnosis of metastasis and an element of histological orientation [23].

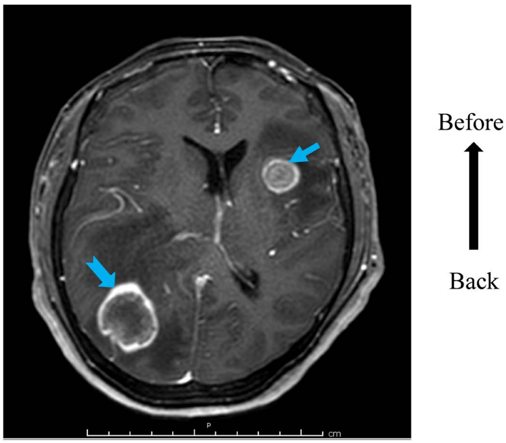

Figure 1. Brain metastases (Arrows) at the house of a 55-year-old patient with colorectal cancer. T1-weighted MRI axial slice showing 2 brain lesions in the left frontal lobe (➡) and the other in the right occipital lobe with surrounding perilesional edema (➡). Enhancement of the lesions in an annular and heterogeneous manner.

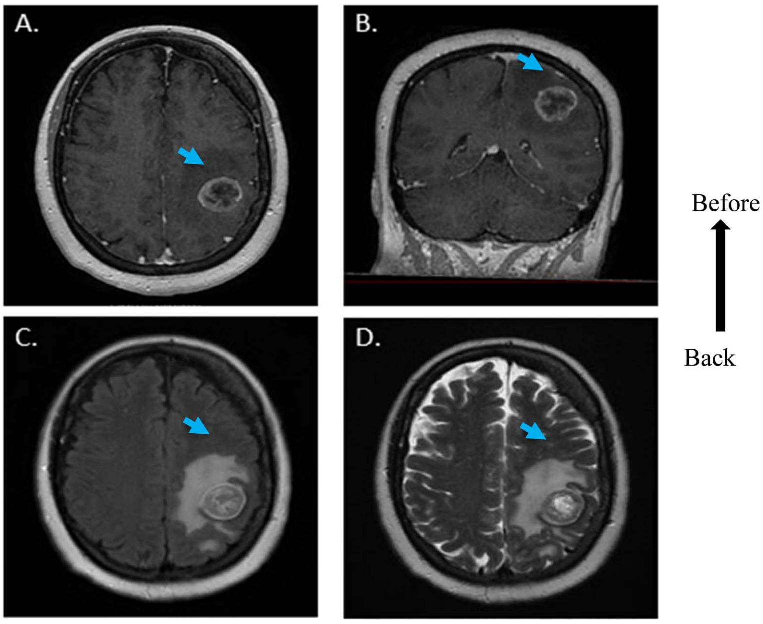

Figure 2. Suspicion of brain metastasis discussed in the face of an abscess on CT scan 43-year-old patient consulted for convulsive seizures without known primary cancer. (A) MRI T2 sequence axial section: hyperintense left parietal lesion; (B) T1 sequence + gadolinium: Annular enhancement, central necrosis; (C) diffusion b1000: Diffusion acceleration in the form of a hyposignal; (D) ADC mapping: high apparent diffusion coefficient in the form of a hypersignal; Diagnosis of MC (red arrows) and cervical cancer discovered later.

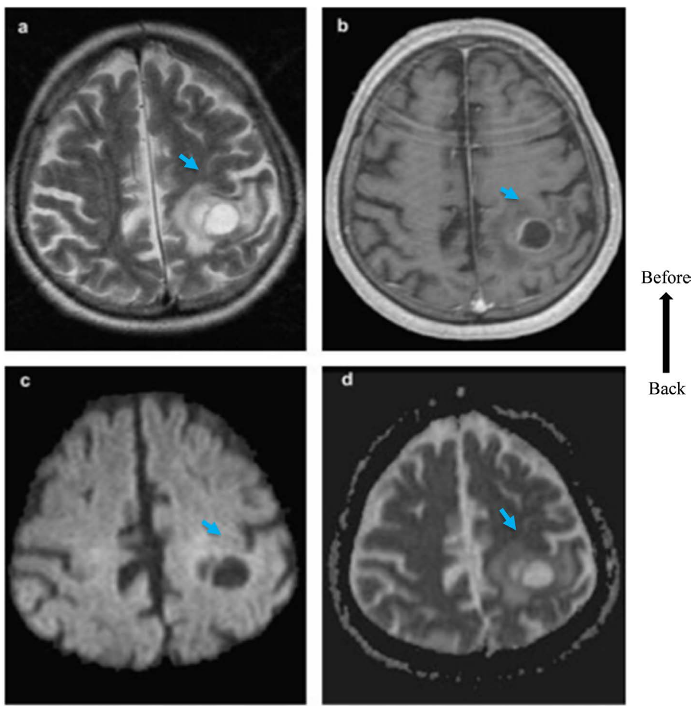

Figure 3. Left parietal metastasis (red arrows) of breast cancer in a 47-year-old patient who consults for a PEIC on brain scan. (a) Axial T1 sequence after injection of Gadolinium (annular enhancement, central necrosis and perilesional edema around); (b) Coronal T1 sequence after injection of Gadolinium; (c) Axial T2 FLAIR sequence (hyperintense and heterogeneous lesion); (d) Axial T2 sequence (hyperintense and heterogeneous lesion).

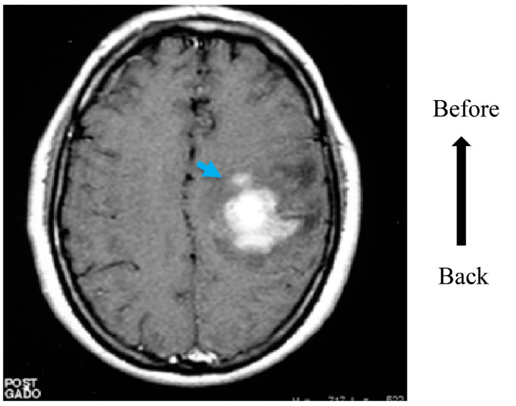

Figure 4. MC (Arrow) single revealing in a 72-year-old patient without known primary cancer. T1-weighted MRI axial slice performed after injection of gadolinium. Nodular contrast uptake of the left fronto-parietal lesion. Hemorrhagic with perilesional edema. Mass effect and slight shift to the right of the midline. After exploration, renal cancer is discovered later.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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