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CT and MRI findings in patients with neuroinfections

Wyniki badań obrazowych mózgu (tomografii komputerowej i rezonansu magnetycznego) chorych na neuroinfekcje

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Summary

Background: Although in most patients a diagnosis of neuroinfection is not based on the results of brain imaging, there is a trend to perform MRI or CT on any patient in whom such infection is suspected. However, in selected cases, especially in patients with brain abscess or with herpetic encephalitis, brain CT and/or MRI are essential for diagnosis. Therefore we decided to analyze the results of computed tomography and magnetic resonance imaging of the brains of patients with neuroinfections and to assess the usefulness of these imaging methods in clinical practice.

Material/Methods: Brain imaging (CT and/or MRI) was performed in 106 cases (62 purulent and 44 aseptic meningoencephalitis patients). The results were analyzed in subgroups of patients with different etiology of neuroinfection.

Results: In 40 of the 58 patients (68.9%) with purulent meningoencephalitis on whom computed tomography was made, the image revealed the pathology. In the remaining 18 cases (31.1%) the results were normal. In all 4 patients on whom only MRI was done, the results were abnormal (4/4, 100%). Among the 41 patients with aseptic meningoencephalitis on whom computed tomography was done, the pathology was found in 11 (26.8%). Of the 20 patients who underwent brain MRI, the pathology was depicted in 12 (12/20, 60.0%). In 4 of the 24 patients (16.7%) with aseptic meningoencephalitis on whom only computed tomography was done, the results were abnormal. In 2 of the 3 patients (66.7%) on whom MRI was done as the only radiological examination, the results were abnormal. The pathology was found on the radiograms of 11 of the 17 patients (64.7%) in whom both imaging methods were used. In the remaining 6 of these 17 cases (6/17, 35.3%) neither CT nor MRI revealed any abnormality. Altogether, of the 44 patients with aseptic meningoencephalitis in whom brain imaging was performed, pathology was depicted in 17 (38.7%).

Conclusions: 1. The high percentage of abnormal CT and MR images in patients with meningoencephalitis warrants the use of brain imaging in patients with severe clinical course of the disease and in patients in whom diagnosis is difficult. 2. Imaging techniques are most efficient in patients with herpes simplex and tuberculous encephalitis. 3. Our observations suggest that in patients with aseptic neuroinfection, magnetic resonance is of greater value than computed tomography imaging.

Key words: brain imaging • neuroinfection • aseptic meningoencephalitis • purulent meningoecephalitis

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Background

Despite the continuing progress of diagnostic techniques and therapy, the risk of serious sequelae of central nervous system infections, like death or neurological invalidism, remained high. In recent years, in our Department, mortalities of purulent and aseptic meningoencephalitis were 30% and 8%, respectively.

Development of imaging techniques and increase of their availability, create the opportunity of depicting the central nervous system in majority of meningoencephalitis patients. Although in most of the patients the diagnosis of neuroinfection is not based on the results of brain imaging, there is a trend to perform the MRI or CT in each patient in whom the presence of such infection is suspected [1–3].

However in selected cases, especially in patients with brain abscess or with herpetic encephalitis, the brain CT and/or MRI are essential for diagnosis [3–6].

Brain imaging is crucial for differential diagnosis in patients in whom the diagnosis is uncertain. The radiology helps to differentiate neuroinfections from: brain tumors, ischaemic focuses and multiple sclerosis. It is also useful in diagnosis and monitoring of disease sequelae such as brain abscess, hydrocephalus and subcortical atrophia [1,3,7]. Sometimes, it is also possible to disclose the pathogenesis of the purulent meningoencephalitis (otogenic and post-traumatic) [2,8].

Therefore we decided to analyze the results of brain computed tomography and magnetic resonance imaging of patients with neuroinfections, and to assess their usefulness in clinical practice.

Table 1. Etiology of purulent meningitis in the study group.
Tabela 1. Etiologia ropnych zapaleń opon mózgowych w badanej grupie chorych.

Etiology	Number of patients	Percentage of patients
Streptococcus pneumoniae	22	24.7
Neisseria meningitidis	6	6.7
Enterococcus faecalis	3	3.4
Pseudomonas aeruginosa	3	3.4
Staphylococcus epidermidis	3	3.4
Haemophilus influenze	1	1.1
Klebsiella pneumoniae	1	1.1
Streptococcus pyogenes	1	1.1
Unknown	49	55.0
Total	**89**	**100.0**

Material and methods

From January 1996 to August 2002 in Department of Infectious Diseases and Hepatology, Medical University of Lodz, Poland, 198 adults were treated for meningoencephalitis. In 96 of them (96/198; 48.9%) the purulent and 102 (102/198; 51.1%) aseptic infection were diagnosed. Complete clinical data were derived from files of 166 patients.

Patients

Purulent meningoencephalitis was diagnosed in 89 of 166 patients (89/166; 53.6%). There were 59 males and 30 females among them. The mean age of patients was 48.3 years (range: 15–88 years). Aseptic meningoencephalitis was diagnosed in 77 of 166 patients (36 males and 41 females). The mean age of patients with aseptic meningoencephalitis was 35.0 years (range: 15–75 years). Etiology of purulent and aseptic meningoencephalitis is presented in table 1 and 2.

Table 2. Etiology and the diagnostic criteria of aseptic encephalomeningitis in the study group.
Tabela 2. Etiologia i kryteria rozpoznania aseptycznych zapaleń opon mózgowo-rdzeniowych i mózgu w badanej grupie chorych.

Etiology	No. of patients	Percentage of patietns	Diagnostic criteria
Unknown	48	62.3%	negative results of each specific test
Herpes simplex encephalitis	8	10.3%	typical clinical course, increase of anti-HSV antibodies titer in serum and/or in cerebrospinal fluid presence of focal changes on brain images
Nueroborreliosis	7	9.1%	increase of specific antibodies titers in serum and in cerebrospinal fluid
Tuberculous encephalitis.	6	7.8%	results of BACTEC or PCR microbiologic examination of cerebrospinal fluid good response to tuberculostatic treatment if results of microbiologic assessment did not revealed the presence of pathogen but the clinical course was typical for tuberculosis
Listeria monocytogenes encephalitis.	3	3.9%	increase of specific antibodies titer in serum
Mumpsencephalitis	3	3.9%	clinical course of mumps
Tick borne encephalitis	2	2.6%	increase of specific antibodies titer in serum

In 106 cases brain imaging were done. Patients were qualified to computed tomography and/or magnetic resonance imaging when: (1) the clinical course of the disease was severe and consequently the presence of additional pathology was suspected, (2) the diagnosis of neuroinfection was uncertain and brain imaging was necessary for differential diagnosis, (3) the deterioration of patient state occurred during clinical course of the disease and radiologic features of complications were to be searched.

Methods

We assessed the percentage of patients with purulent and aseptic meningoencephalitis in whom brain CT and MR imaging were performed during the clinical course of the disease. We assessed the percentage of cases where the results of CT and MRI revealed the pathology. We also assessed the percentage of patients from both subgroups in whom brain imaging substantially contributed in making final diagnosis or helped to disclose the disease etiology. Brain imaging studies were performed during the acute and /or convalescent stage of illness. CT and MR imaging were performed 2 to 10 days and 5 to 22 days, respectively, after the onset of the disease. All patients underwent spin-echo T1- weighted (repetition time [msec]/echo time [msec]: 500–800/20–25), fast spin echo T2- weighted (2,200–2,500/60–90) and fluid-attenuated inversion recovery MRI sequences.

We evaluate the usefulness of second examination with the use of alternative imaging method (CT vs. MRI) in patients in whom brain imaging was already made.

Comparisons between both subgroups of patients (purulent or aseptic meningoencephalitis) were performed using t-Student test. A P-value < 0.05 was considered significant.

Results

The use of brain imaging in studied subgroups

Purulent meningoencephalitis patients

In subgroup of 89 patients with purulent meningoencephalitis, in 27 cases (27/89; 30.3%) it was possible to challenge the diagnosis without the use of radiologic examination. In remaining sixty two patients brain imaging was considered necessary and in consequence all these (62/89; 69.6%) patients underwent the radiologic examination during the first week after admission to hospital. In 58 of 89 patients (65.2%) with purulent meningoencephalitis computed tomography was made. In all cases it was the only imaging method used. In 4 patients (4/89; 4.5%) MRI was done. Similarly in all these 4 cases MRI was done exclusively.

Aseptic meningoencephalitis patients

In subgroup of 77 patients with aseptic meningoencephalitis, in 33 cases (33/77; 42.9%) it was possible to make the diagnosis without the use of radiologic examination. Remaining forty four patients (44/77; 57.1%) underwent the brain imaging. Forty one patients (41/77; 53.2%) underwent CT of the brain and 20 patients (20/77; 26.0%) underwent the MRI.

In 24 of 77 patients (31.2%) with aseptic meningoencephalitis computed tomography was performed as an only imaging method. In 3 patients (3/77; 3.9%) MRI was done exclusively. In 17 patients both methods were used (17/77; 22.1%); in each of these cases the computed tomography was done as a first examination and MRI was performed later to verify the results of CT imaging.

In 38 patients the first imaging was done during the first week after admission to the hospital. In remaining 6 cases the first brain imaging was done in forth week after admission. In all these 6 patients the computed tomography was the only method of brain imaging used.

In 17 patients in whom both methods of examination were used, the MRI was done no later than a week after the CT imaging.

Depicted brain pathology

Purulent meningoencephalitis patients

In 40 of 58 patients (68.9%) with purulent meningoencephalitis in whom computed tomography was made, the imaging revealed the pathology. In remaining 18 cases (32.1%) the results were normal. In all 4 patients in whom MRI were done solely, the results were abnormal (4/4; 100%).

Altogether, in 60 patients with purulent meningoencephalitis in whom brain imaging were done, pathology was depicted in 42 of them (70.0%). The details of results of CT and MRI in this subgroup of patients are presented in Table 3. The results of computed tomography depending on etiology of purulent meningoencephalitis are presented in Table 4.

In patients in whom MRI of the brain was done exclusively, in 1 patient MRI revealed the focus of inflammation in petrous pyramid. In this patient the neuroinfection was caused by *Streptococcus pneumoniae*. In remaining 3 patients in whom MRI was done and pathology were found, the etiology of neuroinfecion remained unknown.

Aseptic meningoencephalitis patients

In 41 patients in whom computed tomography was done, in 11 (26.8%) the pathology was found. In 20 patients who underwent brain MRI, the pathology was depicted in 12 of them (12/20; 60.0%).

In 4 of 24 patients (16.7%) in whom computed tomography was done exclusively, the results were abnormal. In 2 of 3 patients (66.7%) in whom MRI were done as only radiololgic examination, the results were abnormal. The pathology was found on radiograms of 11 patients among these 17 patients (64.7%) in whom both imaging methods were used. In remaining 6 of these 17 cases (6/17; 35.3%) both CT and MRI did not reveal any abnormality (see Figure 1).

Table 3. Results of CT and MR imaging in the group of patients with purulent and aseptic meningoencephalitis.
Tabela 3. Wyniki tomografii komputerowej i rezonansu magnetycznego u chorych na ropne i aseptyczne zapalenia opon mózgowych i mózgu.

Type of neuroinfection	Purulent meningoencephalitis		Aseptic meningoencephalitis	
Imaging / Results of imaging	Computed tomography	Magnetic resonance	Computed tomography	Magnetic resonance
No changes	18	0	30	8
Focal laesions	18	0	5	9
Brain oedema	2	0	3	0
Hydrocephalus	4	0	3	1
Brain atrophia	9	0	0	0
Post-traumatic changes in scull	3	0	0	0
Focus of inflammation in petrous pyramid	2	3	0	0
Demyelinization	0	0	0	2
Brain abscess	2	0	0	0
Empty-saddle syndrom	0	1	0	0

Table 4. Results of CT imaging in the group of patients with purulent meningoencephalitis depending on etiology.
Tabela 4. Wyniki tomografi komputerowej mózgu w grupie chorych na ropne zapalenia opon mózgowych i mózgu w zależności od etiologii choroby.

Results of CT	Etiology	No of patients	Total
No changes	Unknown	12	**18**
	S. pneumoniae	3	
	N. meningitidis	2	
	E. foecalis	1	
Hypodense damage	S. pneumoniae	8	**13**
	Unknown	5	
Hyperdense damage	S. pneumoniae	3	**3**
Isodensity	Unknown	2	**2**
Brain atrophia	Unknown	9	**9**
Hydrocephalus	S. pneumoniae	2	**4**
	Unknown	1	
	H. influenzae	1	
Post-traumatic changes in scull	Unknown	2	**3**
	P. aeruginosa	1	
Focus of inflammation in petrous pyramid	S. pneumoniae	1	**2**
	Unknown	1	
Brain oedema	Unknown	2	**2**
Brain abscess	S. pneumoniae	1	**2**
	Unknown	1	

Altogether, in 44 patients with aseptic meningoencephalitis in whom brain imaging were done, pathology was depicted in 17 of them (38.7%). The details of results of CT and MRI in this subgroup of patients are presented in Table 3.

The results of brain imaging depending on etiology of aseptic meningoencephalitis are presented in Tables 5 and 6. In group of 17 patients in whom MRI was done after CT brain imaging, in 7 cases the MRI revealed new signs of brain pathology, such as focal changes and demyelinization, which were not seen of CT pictures.

Discussion

Brain imaging was performed in majority of our patients. Almost 70% of patients with purulent meningoencephalitis

and almost 60% of patients with aseptic infection underwent CT and/or MRI. The radiology revealed the signs of pathology in considerable percentage of cases.

In purulent neuroinfection patients who underwent brain imaging, pathology was depicted in 70% of cases. Computed tomography in this subgroup of patients was especially useful. It was the method used predominantly and revealed pathology in 67.9% of patients who were examined with this technique. Although the MRI revealed CNS pathology in 100% of cases, the method was used only exceptionally. Therefore we cannot discuss the usefulness of MRI in patients with purulent meningoencephalitis. We can say, however, that whenever we decided to use the MRI to verify our clinical hypothesis, the method was very efficient.

In aseptic meningoencephalitis patients who underwent brain imaging, pathology was seen of CT and MRI scans in 38.7% of cases. Although the computed tomography was used in majority of patients its value was much smaller than in group of patients with purulent meningoencephalitis. CT revealed the abnormalities in only 26.8% of all patients with aseptic neuroinfection whereas in patients with purulent neuroinfection the results of brain CT were abnormal in 67.9% of cases. The difference was statistically significant ($P<0.05$). The value of CT is even smaller in the subgroup of patients with aseptic neuroinfection in whom CT were used exclusively. In such patients CT revealed brain pathology signs in only 16.7% of cases.

MRI was used in 20 patients with aseptic meningoencephalitis and therefore we were able to evaluate its usefulness in this subgroup of patients. The method revealed pathology in 60.0% of patients subjected to the examination. The subgroup of 17 patients in whom both CT and MRI were used is especially interesting as we were able to compare

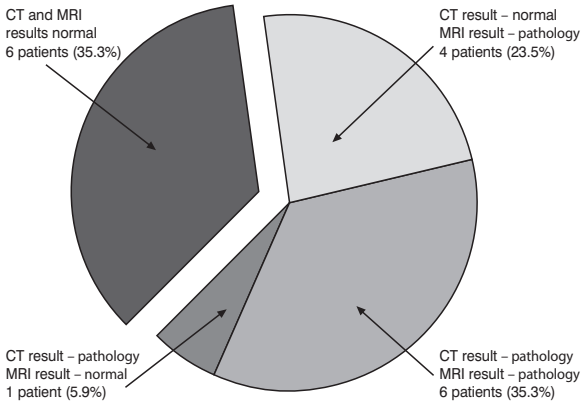

Figure 1. Results of brain imaging in patients with aseptic meningoencephalitis.

Rycina 1. Wyniki badań obrazowych mózgu u chorych na aseptyczne zapalenia opon mózgowych i mózgu.

the usefulness of both imaging techniques. Pathology was found in 11 patients from this subgroup, however CT revealed pathologic signs which were not seen on MRI scans in only one case. In 10 of 11 cases, pathology was depicted by MRI. Conversely, MRI revealed pathology in 4 patients in whom CT scans were normal. Therefore we had an impression that making both CT and MRI in patients with aseptic meningoencepahlitis was not necessary. Moreover, considering the calculated efficacy of CT (26.8%) and MRI (60.0%) in depicting brain pathology in our patients with aseptic meningoencephalitis, we could probably limit our diagnostic workup to MRI only.

Our observation concerning the value of CT in depicting brain pathology in patients with purulent meningoencephalitis is similar to reported by Kepa et al [3]. CT revealed the signs of brain pathology in almost 70% of their patients.

Table 5. Results of CT imaging in the group of patients with aseptic meningoencephalitis depending on etiology.

Tabela 5. Wyniki tomografii komputerowej mózgu w grupie chorych na aseptyczne zapalenia opon mózgowych i mózgu w zależności od etiologii choroby.

Results of CT imaging	Etiology	No. of patients	Total
No changes	Unknown	21	**30**
	Herpses simlex encephalitis	2	
	Neuroborreliosis	2	
	Tuberculous encephalitis	2	
	Tick borne encephalitis	2	
	Mumpsencephalitis	1	
Hyperdense damage	Herpses simlex encephalitis	4	**5**
	Unknown	1	
Hydrocephalus	Tuberculous encephalitis	3	**3**
Brain oedema	Herpses simlex encephalitis	1	**3**
	Mumpsencephalitis	1	
	Unknown	1	

Table 6. Results of MRI in the group of patients with aseptic meningoencephalitis depending on etiology.
Tabela 6. Wyniki rezonansu magnetycznego mózgu w grupie chorych na aseptyczne zapalenia opon mózgowych i mózgu w zależności od etiologii choroby.

Result of magnetic resonance imaging	Etiology	No. of patients	Total
No changes	Unknown	5	**8**
	Herpes simplex encephalitis	1	
	Neuroborreliosis	1	
	Tick borne encephalitis	1	
Hyperintensive damage	Herpses simlex encephalitis	4	**5**
	Tuberculous encephalitis	1	
Hypointensive damage	Unknown	4	**4**
Demyelinization	Unknown	2	**2**
Hydrocephalus	Tuberculous encephalitis	1	**1**

Focal hypodense lesions and brain atrophia was found in CT of 23.2% and 16.0% of our purulent meningoencephalitis patients, respectively. In studied group focal hypodense lesions were observed mainly in patients with pneumococcal and with unknown etiology. Atrophic changes were found only in patients with meningoencephalitis of unknown etiology. It is questionable, whether changes seen of CT were the sequel of the disease or were present concurrently with the neuroinfection. The hypodense lesions were probably regions of focal ischaemia caused by brain infection. The cortical and subcortical atrophia found in CT of purulent neuroinfection patients had appeared probably before the onset of infection, were caused by toxic or mechanical brain injuries. This changes could have facilitated the development of meningoencephalitis.

Hypodense lesions have been described in patients with purulent meningoencephalitis, but the *H. influenze* and *N. meningitidis* were the etiologic factors [3,9–11]. It is possible that in patients with purulent neuroinfection of unknown etiology, *H. influenze* and *N. meningitidis* were the undetected pathogens. Brain atrophia was reported in purulent meningoencephalitis patients but its incidence (9%–11.5%) was lower than in our material [3,12].

Magnetic resonance imaging although used exceptionally in purulent meningoencephalitis patients in our study, proved to be very useful. It revealed the presence of inflammation in petrous pyramid, the source of the neuroifection, in three cases. These patients underwent surgery and the sources of inflammation were removed and otogenic neuroinfection easily cured with antibiotics. Although many authors reported the role of brain imaging in diagnosis of sinusitis as a source of purulent meningoencephalitis [13–15] that was not a case in our patients.

In patients with aseptic meningoencephalitis, the hyperdense lesions were the main finding on computed tomography. Hyperdense lesions were present in 4 of 5 patients with herpes simplex encephalitis. The CT findings were very helpful in making the diagnosis as they suggested the herpes simplex etiology. The remaining patient is especially interesting as despite the typical for herpes simplex encephalitis radiology findings, intense diagnostic workup including serological tests and polymerase chain reaction of cerebrospinal fluid did not reveal the etiologic agent.

Hydrocephalus was seen on CT scans of patients with tuberculous encephalitis only. We found this complication in all 3 of our 6 tuberculous encephalitis patients in whom CT was done. Our observation is similar to presented by others. Pagliano et al. reported the group of 10 children with tuberculous infection. Hydrocephalus was seen in 8 of them on CT and MRI [16].

Brain swelling was rarely found on CT scans of aseptic meningoencephalitis patients. It is possible that anti-edematous treatment started in our patients on admission, successfully prevented the development of this complication.

T-2 weighted MRI confirmed the presence of hyperintense lesions in patients with herpes simplex meningoencephalitis. It also revealed the presence of hyperintense lesions in one patients with tuberculous meningoencephalitis, the presence of hypointense lesions in 4 patients and foci of demielinisation in 2 patients with aseptic meningoencephalitis of unknown etiology. There are numerous literature reports concerning the presence of focal lesions in patients with viral meningoencephalitis caused by Ebstein-Barr virus, varicella zoster and herpers zoster viruses, rotaviruses, virus of Japanese encephalitis [17–23]. Focal lesion were observed mainly in thalamus, brain stem, hipocampus, basal ganglia and white matter [17,18,21–23]. The cases of Japanese encephalitis virus coinfections with herpers virus and Ebstain-Barr virus were also reported. In these cases the presence of hyperintense periventricular lesions on T-2 weighted MRI was the main finding [24]. Periventricular inflammatory lesions followed by development of hydrocephalus were observed in patients with cytomegalovirus encephalitis [25].

Despite the focusing our diagnostic workup on these pathogens as the possible causative factors, we were not able to diagnose the active infection of such etiology. Nevertheless

we suppose that aseptic neuroinfections of unknown etiology in our patients were caused by one of the discussed viruses.

In two patients with aseptic meningoencephalitis of unknown etiology brain imaging depicted foci of demielinisation. Such lesions were reported in patients infected with parvovirus B19 [26]. Unfortunately, we had no diagnostic tool to verify the hypothesis of infection with this pathogen.

No radiological signs of brain pathology were found in two patients with neuroboreliosis who underwent brain imaging. In remaining 4 patients with neuroboreliosis there were no indications to perform CT or MRI. Tarasow et al. [27] reported pathological findings, mainly atrophic lesions, on MRI scans of 36% of neuroboreliosis patients. It is also possible that some patients had neruoboreliosis but we included them to unknown etiology group as we were unable to diagnose the disease.

In summary, we found that brain imaging in patients with neuroinfections is very helpful and improve our diagnostic abilities. In many cases the radiologic findings suggest the possible etiology, making further diagnostic workup easier. New imaging technique with diffusion-weighted MRI is promising, offering the higher sensivity in herpes simplex encephalitis than conventional MRI [28].

Conclusions

1. The high percentage of abnormal CT and MR images in patients with meningoencephalitis warrants the use of brain imaging in patients with severe clinical course of the disease and in patients in whom diagnosis is difficult.

2. Imaging techniques are most efficient in patients with herpes simplex and tuberculous encephalitis.

3. Our observations suggest that in aseptic neuroinfecion patients, magnetic resonance is of a greater value than computed tomography imaging.

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