

TOPICAL REVIEW

Clinical manifestations of neurosarcoidosis

Titlic M^{1,2}, Bradic-Hammoud M³, Miric L², Punda A⁴*Department of Neurology, Split University Hospital, Split, Croatia. marina.titlic@gmail.com*

Abstract: Sarcoidosis is a chronic disease of unknown aetiology. Neurosarcoidosis is registered in 5 % of patients with sarcoidosis. Clinical manifestations of sarcoidosis are numerous and diverse. Manifestation of Neurosarcoidosis includes partial- and grand-mal seizures, low-grade fever, headache, increased intracranial pressure, visual disturbances, diabetes insipidus, amenorrhea-galactorrhoea syndrome and pituitary failure, hypogonadotropic hypogonadism, hyperprolactinemia, unilateral and bilateral facial palsy, infiltration of meninges (aseptic meningitis) and nerve roots, leptomeningitis, pachymeningitis with cranial neuropathies, pseudotumor, mild cognitive disorder, psychosis, delirium, dementia, disorientation, amnesia, progressive visual deterioration and proptosis, axonal polyneuropathies, mononeuropathies, chronic polyradiculoneuritis, peripheral neuropathy, cranial nerve abnormalities, radiculopathies, peripheral neuropathy, mononeuritis multiplex, progressive numbness and deep sensation disturbance in bilateral lower extremities, hemiplegia, hyperreflexia with pathological reflexes and hypesthesia, upward gaze palsy, spinal cord compression, dysarthria, dysphagia, weakness, episodes of blurred vision, diplopia, intracerebral hemorrhage, neuro-ophthalmic manifestations, intranuclear ophthalmoplegia, dysorientation, vasculitis presenting with strokes, intracranial hypothalamic lesion, paresthesia, hemiparesis, myelopathy in the cervico-thoracic region, lumbar pain, sensory level and inability of lateral gaze (Tab. 2, Ref. 60). Full Text (Free, PDF) www.bmj.sk.

Key words: sarcoidosis, neurosarcoidosis, hydrocephalus and intracranial hemorrhage.

Sarcoidosis is an inflammatory chronic disease of unknown aetiology characterised by non-caseating epithelioid granulomas, presence of T lymphocytes, mononuclear phagocytes, and non-caseating epithelioid granulomas in the tissues (1, 2). The organs most often involved are the lungs, but any other organ may be affected as well, with or without concomitant lung involvement. Yet, the lungs are involved in about 90 % of patients. The typical appearance is bilateral hilar lymphadenopathy with or without lung parenchymal infiltrates, but a wide range of chest radiographic patterns may be observed. In cases of liver involvement, cirrhosis and portal hypertension develop, occurring in fewer than 1 % of cases (3–5).

Many non-neoplastic neurological disease can mimic brain neoplasms on neuroimaging or on histological examination, including multiple sclerosis, stroke, pyogenic abscess, toxoplasmosis, tuberculosis, cysticercosis, fungal infections, syphilis, sarcoidosis, Behcet disease, radiation necrosis, venous thrombosis, and others (6). The assessment of pathological an final diagnosis is based on particularly important new diagnostic techniques, such as diffusion-weighted MRI, perfusion-weighted

MRI, magnetic resonance spectroscopy, single-photon emission tomography, and positron emission tomography, but also histological examination including immunohistochemistry and molecular genetics, as well as laboratory diagnosis based on serum and cerebrospinal liquor examination (6–10).

According to numerous researches, neurosarcoidosis (central and peripheral) is found in about 5–15 % patients with systemic sarcoidosis (11, 12).

The subjective of the study is to review the possible clinical manifestations of neurosarcoidosis.

Review of literature

We performed a systematic review of peer-reviewed publications identified through MEDLINE databases (searched through September 2008). The search terms were neurosarcoidosis and sarcoidosis, and the search was limited to clinical trials and articles in English. The search was extended by review of bibliographies from pertinent original reports of data and review articles. Unpublished trials and data presented only in abstract form were not included. The authors report numerous different clinical manifestations of neurosarcoidosis (Tab. 1).

The authors present numerous localisations of brain and spinal cord lesions in patients with neurosarcoidosis. Particular neurosarcoidosis diagnoses are based upon pathohistological findings in biopsy samples. The probable diagnosis is based upon clinical signs, laboratory diagnosis and magnetic resonance (MRI) findings. MRI of brain and spinal cord show nu-

¹Department of Neurology, Split University Hospital, Split, Croatia, ²University of Split School of Medicine, Split, Croatia, ³Private Clinic, Zagreb, Croatia, and ⁴Department of Nuclear Medicine, Split University Hospital, Croatia

Address for correspondence: M. Titlic, MD, Dept of Neurology, University Hospital Split, Spinčiceva 1, 21 000 Split, Croatia. Phone: +385.21.556426, Fax: +385.21.556675

Tab. 1. Clinical manifestations of neurosarcoidosis.

Study author(s)	Symptoms
Favre J et al ¹³ Tamagno G, Murialdo G ¹¹	partial seizure low-grade fever, headache, visual disturbances, amenorrhea-galactorrhea syndrome and pituitary failure due to an infiltrative lesion involving the hypothalamus and the pituitary stalk
Moore FG et al ¹⁴	bilateral facial palsy, infiltration of meninges and nerve roots
Shin JH et al ¹⁵ Prüter C et al ¹⁶	central diabetes insipidus mild cognitive disorder
Friedman SH, Gould DJ ¹⁷ Ozerova LV et al ¹⁸ Kodama M et al ¹⁹	psychosis, delirium, dementia fever, headache, thirst dementia
Tobias S et al ²⁰ Murialdo G, Tamagno G ²¹	progressive visual deterioration and proptosis amenorrhea-galactorrhea syndrome with hypogonadotropic hypogonadism
Vannemreddy PS et al ²² Ferry D et al ²³	intractable headache axonal polyneuropathies, mononeuropathies, chronic polyradiculoneuritis
Said G et al ²⁴ Teirstein A ²⁵	facial diplegia, peripheral neuropathy cranial nerve abnormalities, leptomeningitis, seizures, mass lesion of brain and spinal cord, pituitary dysfunction, neuropathies
Kidd D et Beynon HL ²⁶	pachymeningitis with cranial neuropathies, hydrocephalus, encephalopathy and hypothalamic dysfunction, radiculopathies, peripheral neuropathy, mononeuritis multiplex
Kort L et al ²⁷ Mahadewa TG et al ²⁸	pseudotumour progressive numbness and deep sensation disturbance in bilateral lower extremities
Nakagaki H et al ²⁹	hemiplegia, hyperreflexia with pathological reflexes and hypesthesia
Hamada H et al ³⁰ Tabuena RP et al ³¹	upward gaze palsy diabetes insipidus, hypogonadism, hyperprolactinemia
Spencer TS et al ³²	seizures, spinal cord compression, increased intracranial pressure
Trabelsi L et al ³³ Nishie M et al ³⁴	amenorrhea, galactorrhea dysarthria, dysphagia, weakness, multiple cranial nerve palsy
Karouache A et al ³⁵ Sponsler JL et al ³⁶	peripheral neuropathy, meningitis partial seizures
Miscusi M et al ³⁷ Yamaguchi S et al ¹² Huang EH et al ³⁸ Jain V et al ³⁹	acute intracranial hypertension intracerebral hemorrhage neuro-ophthalmic manifestations bilateral facial paralysis
Maeda K et al ⁴⁰ Brisman JL et al ⁴¹ Schlienger JL et al ⁴² Baussart B et al ⁴³	dysorientation, amnesia, dementia vasculitis presenting with strokes diabetes insipidus, gonadotropic deficiency aseptic meningitis, intracranial hypothalamic lesion
Hodge MH et al ⁴⁴	paresthesias, dysarthria, right facial droop, hemiparesis
Rózsa A et al ⁴⁵	myelopathy in the cervico-thoracic region, internuclear ophthalmoplegia
Bihan H et al ⁴⁶	diabetes insipidus, hyperprolactinemia, gonadotropin deficiency, hyperprolactinemia
Perdigao S et al ⁴⁷	lumbar pain, gait and sphincter disturbances, spastic paraparesis, hyperreflexia, sensory level, episodes of blurred vision
Tumilán LM et al ⁴⁸ Westhout FD, Linskey ME ⁴⁹	delirium, seizures papilledema, diplopia, headache, psychotic symptoms
Walid MS et al ⁵⁰	incapability of lateral gaze

Tab. 2. Localisation of neurosarcoidosis lesions shown by MRI.

Study author(s)	MRI of brain/spinal cord
Moore FG et al ¹⁴ Kodama M et al ¹⁹ Murialdo G, Tamagno G ²¹ Mahadewa TG et al ²⁸ Nakagaki H et al ²⁹ Hamada H et al ³⁰ Tabuena RP et al ³¹ Spencer TS et al ³²	meninges and lumbar nerve roots multiple lacunar infarctions hypothalamus and/or pituitary gland medulla oblongata parietooccipital lobes third and fourth ventricles pituitary stalk inflammatory lesion in the brain and spinal cord, leptomeningeal enhancement, hydrocephalus, intracranial hemorrhage
Trabelsi L et al ³³ Sponsler JL et al ³⁶	pituitary tuberculoma amygdala, anterior hippocampus, mesial temporal neocortex
Miscusi M et al ³⁷ Baussart B et al ⁴³ Hodge MH et al ⁴⁴	fourth ventricle lesion hypothalamic lesion, aseptic meningitis white matter, basal ganglia infarction, dural and leptomeningeal enhancement
Rózsa A et al ⁴⁵ Bihan H et al ⁴⁶	spinal cord hypothalamic-pituitary, parenchymal brain and spinal cord
Perdigao S et al ⁴⁷ Westhout FD, Linskey ME ⁴⁹	medullary involvement deep white matter, cerebral aqueduct, diffuse meningeal enhancement
Walid MS et al ⁵⁰ Byard RW et al ⁵¹ Marangoni S et al ⁵² Suzuki M et al ⁵³ Takano K ⁵⁴ Bruns F et al ⁵⁵	pons, fourth ventricle hypothalamic white matter lesions, spinal mass lesion pituitary gland hypothalamus, pituitary gland temporodorsal in the hemisphere, basal ganglia
Fels C et al ⁵⁶	periventricular and white matter lesions, multiple or solitary supra- and infratentorial brain lesions, leptomeningeal enhancement, involvement of brain nerves and intramedullary lesions
Iizuka T, Sakai F ⁵⁷	hypothalamus, pituitary gland, leptomeninges, cranial nerves
Hesselmann V et al ⁵⁸ Ketonen L et al ⁵⁹	fourth ventricle ventricular enlargement, diffuse periventricular white matter changes

merous neurosarcoidosis lesions in numerous clinical manifestations (Tab. 2).

Discussion

The cause of appearance of sarcoidosis and manifestation of neurosarcoidosis are unclear. Central and peripheral neurosarcoidosis incidence varies significantly from one research to another, and is deemed to be from 5 to 15 %. The central sarcoidosis incidence is about 5 % (11, 47, 60). The clinical manifestations of neurosarcoidosis are numerous, including cranial neuropathy, facial palsy, optic nerve or other cranial nerve involvement, peripheral neuropathy, or manifestations of the central nervous system affecting the hypothalamus, pituitary gland, cerebral cortex, cerebellum, meninges and spinal cord, etc. (13–50, 60).

The variety of possible manifestations of neurosarcoidosis significantly hinder the Assessment of diagnosis and differential

diagnosis. Therefore, in addition to sound knowledge of its clinical manifestations, knowledge of additional diagnostic procedures is of importance.

Presently, the diagnosis is based on neuroradiological and laboratory tests. Magnetic resonance imaging (MRI) of the brain is presently the basic neuroradiological diagnostic method for central, but also for spinal neurosarcoidosis (44, 60). MRI represents the key method in localising the brain and spinal cord lesions: hypothalamus and/or pituitary gland, pituitary tuberculoma, pituitary stalk, cranial nerves, amygdalae, anterior hippocampus, medial temporal neocortex, deep white matter, basal ganglia, spinal cord, medullary involvement, medulla oblongata, lumbar nerve roots, multiple lacunar infarctions, parietooccipital lobes, third and fourth ventricles, cerebral aqueduct, pons, temporodorsal in the hemisphere, periventricular and white matter lesions, multiple or solitary supra- and infratentorial brain lesions, inflammatory lesion in the brain and spinal cord, dural and leptomeningeal enhancement, hydrocephalus and intracranial hemorrhage.

Additional diagnostic methods include x-rays of the bones, angiotensin converting enzyme (ACE) in the serum and the cerebrospinal liquor, cerebrospinal liquor treatment and the Kveim test (19, 60). Sometimes, when possible and required, in order to reach an utmost precise diagnosis, the positron emission tomography (PET) scan is used (36).

In certain cases the final diagnosis is made by biopsy (43, 47).

According to data stated above, conclusion can be made that in addition to laboratory diagnosis, sound knowledge of clinical manifestations of neurosarcoidosis forms the basis for further differential diagnostic evaluation of potential neurosarcoidosis.

References

- Motta M, Alongi F, Bolognesi A, Cozzarini C, Di Muzio N, Fazio F. Remission of refractory neurosarcoidosis treated with brain radiotherapy: a case report and a literature review. *Neurologist* 2008; 14 (2): 120–124.
- Schelhorn J, Smesny U, Fitzek C, Brodhun M, Witte OW, Terborg C. Differential diagnosis of solitary neurosarcoidosis. *Nervenarzt* 2005; 76 (8): 984–987.
- Nunes H, Brillet PY, Valeyre D, Brauner MW, Wells AU. Imaging in sarcoidosis. *Semin Respir Crit Care Med* 2007; 28 (1): 102–120.
- Ricci A, Mariotta S, Saltini C, Falasca C, Giovagnoli MR, Mannino F, Graziano P, Sciacchitano S, Amenta F. Neurotrophin system activation in bronchoalveolar lavage fluid immune cells in pulmonary sarcoidosis. *Sarcoidosis Vasc Diffuse Lung Dis* 2005; 22 (3): 186–194.
- Gupta S, Faughnan ME, Prud'homme GJ, Hwang DM, Munoz DG, Kopplin P. Sarcoidosis complicated by cirrhosis and hepatopulmonary syndrome. *Can Respir J* 2008; 15 (3): 124–126.
- Omuro AM, Leite CC, Mokhtari K, Delattre JY. Pitfalls in the diagnosis of brain tumors. *Lancet Neurol* 2006; 5 (11): 937–948.
- Duzova A, Bakkaloglu A. Central nervous system involvement in pediatric rheumatic diseases: current concepts in treatment. *Curr Pharm Des* 2008; 14 (13): 1295–1301.
- Ng D, Jacobs M, Mantil J. Combined C-11 methionine and F-18 FDG PET imaging in a case of neurosarcoidosis. *Clin Nucl Med* 2006; 31 (7): 373–375.
- Nozaki I, Hamada T, Ikeda T. A case of sarcoidosis in which sarcoid granulomas were observed only in the heart. *Nippon Ronen Igakkai Zasshi* 2005; 42 (3): 364–367.
- Ito Y, Nakazato Y, Tomioka R, Tamura N, Shimazu K. A suspicious case of central neurosarcoidosis, manifesting as a progressive gait disturbance with a lesion in the central gray matter of the midbrain, accompanying an elevated level of angiotensin converting enzyme in the cerebrospinal fluid. *Rinsho Shinkeigaku* 2007; 47 (8): 512–515.
- Tamagno G, Murialdo G. Amenorrhea-galactorrhea syndrome as an uncommon manifestation of isolated neurosarcoidosis. *Ann Ital Med Int* 2001; 16 (4): 260–266.
- Yamaguchi S, Kuroda S, Kobayashi H, Maruichi K, Kubota K, Ito T, Iwasaki Y. CNS sarcoidosis presenting with intracerebral hemorrhage: case report. *No Shinkei Geka* 2006; 34 (8): 839–842.
- Favre J, Curty B, Steel T, Baltuch G, Genné D, Kernan J, Fankhauser H. Recurrent nocardial brain abscesses treated by repeated stereotactic aspirations. *J Clin Neurosci* 1998; 5 (1): 97–100.
- Moore FG, Andermann F, Richardson J, Tampieri D, Giaccone R. The role of MRI and nerve biopsy in the diagnosis of neurosarcoidosis. *Can J Neurol Sci* 2001; 28 (4): 349–353.
- Shin JH, Lee HK, Choi CG, Suh DC, Kim CJ, Hong SK, Na DG. MR imaging of central diabetes insipidus: a pictorial essay. *Korean J Radiol* 2001; 2 (4): 222–230.
- Prüter C, Kunert HJ, Hoff P. ICD-10 mild cognitive disorder following meningitis due to neurosarcoidosis. *Psychopathology* 2001; 34 (6): 326–327.
- Friedman SH, Gold DJ. Neurosarcoidosis presenting as psychosis and dementia: a case report. *Int J Psychiatry Med* 2002; 32 (4): 401–403.
- Ozerova LV, Vasil'ev SN, Shemetun ON. Cerebral sarcoidosis: clinical aspects and course. *Probl Tuberk* 2002; 7: 20–23.
- Kodama M, Umegaki H, Mogi N, Iguchi A, Takeda A. An elderly case with sarcoidosis whose symptom of dementia was effectively treated by steroid. *Nippon Ronen Igakkai Zasshi* 2002; 39 (6): 648–653.
- Tobias S, Prayson RA, Lee JH. Necrotizing neurosarcoidosis of the cranial base resembling an en plaque sphenoid wing meningioma: case report. *Neurosurgery* 2002; 51 (5): 1290–1294.
- Murialdo G, Tamagno G. Endocrine aspects of neurosarcoidosis. *J Endocrinol Invest* 2002; 25 (7): 650–652.
- Vannemreddy PS, Nanda A, Peddy PK, Gonzalez E. Primary cerebral sarcoid granuloma: the importance of definitive diagnosis in the high-risk patient population. *CLin Neurol Neurosurg* 2002; 104 (4): 289–292.
- Ferriby D, Stojkovic T, De Seze J, Hurtevent JF, Vermersch P. Chronic polyradiculoneuritis disclosing sarcoidosis. *Rev Neurol (Paris)* 2002; 158 (3): 357–360.
- Said G, Lacroix C, Platé-Bordeneuve V, Le Page L, Pico F, Presles O, Senant J, Remy P, Rondepierre P, Mallecourt J. Nerve granulomas and vasculitis in sarcoid peripheral neuropathy: a clinicopathological study of 11 patients. *Brain* 2002; 125 (2): 264–275.
- Teirstein A. Neuromuscular sarcoidosis. *Semin Respir Crit Care Med* 2002; 23 (6): 505–512.

26. Kidd D, Beynon HL. The neurological complications of systemic sarcoidosis. *Sarcoidosis Vasc Diffuse Lung Dis* 2003; 20 (2): 85—94.
27. Kort L, Boncoeur MP, Delage-Corre M, Moufid A, Denes E, Couratier P. Isolated neurosarcoidosis without systemic signs. *Rev Neurol (Paris)* 2003; 159 (4): 455—457.
28. Mahadewa TG, Nakagawa H, Watabe T, Inoue T. Intramedullary neurosarcoidosis in the medulla oblonga: a case report. *Surg Neurol* 2004; 61 (3): 283—287.
29. Nakagaki H, Furuya J, Nagata T, Kotorii S, Nagano S, Higashino T, Yoshikai S, Nakanishi K, Yamada T. An elder case of neurosarcoidosis associated with brain infarction. *Rinsho Shinkeigaku* 2004; 44 (2): 81—85.
30. Hamada H, Hayashi N, Kurimoto M, Umemura K, Hirashima Y, Endo S. Isolated third and fourth ventricles associated with neurosarcoidosis successfully treated by neuroendoscopy—case report. *Neurol Med Chir (Tokyo)* 2004; 44 (8): 435—437.
31. Tabuena RP, Nagai S, Handa T, Shigematsu M, Hamada K, Ito I, Izumi T, Mishima M, Sharma OP. Diabetes insipidus from neurosarcoidosis: long-term follow-up for more than eight years. *Intern Med* 2004; 43 (10): 960—966.
32. Spencer TS, Campellone JV, Maldonado I, Huang N, Usmani Q, Reginato AJ. Clinical and magnetic resonance imaging manifestations of neurosarcoidosis. *Semin Arthritis Rheum* 2005; 34 (4): 649—661.
33. Trabelsi L, Majdoub-Rekik N, Bouaziz H, Mnif-Feki M, Hammami B, Maaloul I, ben Jmaa M, Abid M. Pituitary tuberculosis: a case report. *Ann Endocrinol (Paris)* 2005; 66 (4): 340—346.
34. Nishie M, Mori F, Suzuki C, Ogawa M, Kurahashi K, Kaimori M, Wakabayashi K. Disseminated intraparenchymal microgranulomas in the brainstem in central nervous system sarcoidosis. *Neuropathology* 2005; 25 (4): 361—364.
35. Karouache A, Mounach J, Aziz N, Bouraza A, Satte A, Ouhabi H, Rafiq R, Boutaleb N, Mossadaq R. A report of 9 cases of neurosarcoidosis. *Rev Neurol (Paris)* 2005; 161 (11): 1091—1101.
36. Sponsler JL, Werz MA, Maciunas R, Cohen M. Neurosarcoidosis presenting with simple partial seizures and solitary enhancing mass: case reports and review of the literature. *Epilepsy Behav* 2005; 6 (4): 623—630.
37. Miscusi M, Polli FM, Missori P, Delfini R. Ghost lesions in patient with cerebral-isolated neurosarcoidosis. A case report. *J Neurosurg* 2006; 50 (1): 17—20.
38. Huang EH, Yeo KT, Lim WK, Chau CY, Hwang WY. Concurrent intermediate uveitis and an enhancing intracranial lesion as the initial manifestation of sarcoidosis. *Ann Acad Med Singapore* 2006; 35 (4): 266—269.
39. Jain V, Deshumkh A, Gollomp S. Bilateral facial paralysis: care presentation and discussion of differential diagnosis. *J Gen Intern Med* 2006; 21 (7): C7—10.
40. Maeda K, Kita Y, Uehara S, Yamasaki O, Rikimaru M, Saji N, Tabuti M, Furumoto M. A case of isolated CNS sarcoidosis with diffuse confluent high intensity lesions at bilateral deep white matter. *No To Shinkei* 2006; 58 (7): 605—610.
41. Brisman JL, Hinduja A, McKinney JS, Gerhardstein B. Successful emergent angioplasty of neurosarcoid vasculitis presenting with strokes. *Surg Neurol* 2006; 66 (4): 402—404.
42. Schlienger JL, Delemer B, Vinzio S. Impact of systemic disease on the pituitary gland. *Ann Endocrinol (Paris)* 2006; 67 (4): 316—324.
43. Baussart B, Lepeintre JF, Tadié M. Endoscope-assisted biopsy for the diagnosis of neurosarcoidosis. *Neurochirurgie* 2006; 52 (4): 371—375.
44. Hodge MH, Williams RL, Fukui MB. Neurosarcoidosis presenting as acute infarction on diffusion-weighted MR imaging: summary of radiological findings. *Amer J Neuroradiol* 2007; 28 (1): 84—86.
45. Rózsa A, Sztankanecz Y, Gács G, Magyar T. Uncommon manifestation of central nervous system sarcoidosis. *Ideggyogy Sz* 2007; 60 (1): 46—50.
46. Bihan H, Christozova V, Dumas JL, Jomaa R, Valeyre D, Tazi A, Reach G, Krivitzky A, Cohen R. Sarcoidosis: clinical, hormonal, and magnetic resonance imaging (MRI) manifestations of hypothalamic-pituitary disease in 9 patients and review of the literature. *Medicine (Baltimore)* 2007; 86 (5): 259—268.
47. Perdigo S, Arantes M, Pinheiro L, Costa M. Atypical presentation of intramedullary sarcoidosis: report of two cases. *Rev Neurol* 2007; 45 (7): 406—408.
48. Tumialán LM, Gupta M, Hunter S, Tumialán L. A 55-year-old man with liver failure, delirium and seizures. *Brain Pathol* 2007; 17 (4): 472—473.
49. Westhout FD, Linskey ME. Obstructive hydrocephalus and progressive psychosis: rare presentations of neurosarcoidosis. *Surg Neurol* 2008; 69 (3): 288—292.
50. Walid MS, Ajjan M, Grigorian AA. Neurosarcoidosis—the great mimicker. *J Natl Med Assoc* 2008; 100 (7): 859—861.
51. Byard RW, Manton, Tsokos M. Sarcoidosis and mechanisms of unexpected death. *J Forensic Sci* 2008; 53 (2): 460—464.
52. Marangoni S, Argentiero V, Tavolato B. Neurosarcoidosis. Clinical description of 7 cases with a proposal for a new diagnostic strategy. *J Neurol* 2006; 253 (4): 488—495.
53. Suzuki M, Marsui O, Ueda F, Matsushita T, Fujinaga Y, Kobayashi K, Horichi Y, Hayashi Y, Tachibana O, Yamashita J. Dynamic MR imaging for diagnosis of lesions adjacent to pituitary gland. *Eur J Radiol* 2005; 53 (2): 159—167.
54. Takano K. Sarcoidosis of the hypothalamus and pituitary. *Intern Med* 2004; 43 (10): 894—895.
55. Bruns F, Pruemer B, Haverkamp U, Fishedick AR. Neurosarcoidosis: an unusual indication for radiotherapy. *Brit J Radiol* 2004; 77 (921): 777—779.
56. Fels C, Riegel A, Javaheripour-Otto K, Obenauer S. Neurosarcoidosis: findings in MRI. *Clin Imaging* 2004; 28 (3): 166—169.
57. Iizuka T, Sakai F. Neurosarcoidosis. *Nippon Rinsho* 2002; 60 (9): 1785—1793.
58. Hesselmann V, Wedekind C, Terstege K, Schulte O, Voges J, Krug B, Lackner K. An isolated fourth ventricle in neurosarcoidosis: MRI findings. *Eur Radiol* 2002; 12 (Suppl 3): S1—3.
59. Ketonen L, Oksanen V, Kuuliala I. Preliminary experience of magnetic resonance imaging in neurosarcoidosis. *Neuroradiology* 1987; 29 (2): 127—129.
60. Tsao CY, Lo WD, Rusin JA, Henwood MJ, Boue DR. Isolated neurosarcoidosis presenting as headache and multiple brain and spinal cord lesions mimicking central nervous system metastases. *Brain Dev* 2007; 29 (8): 514—518.

Received January 7, 2009.
Accepted May 28, 2009.