



A Singular Case of Neurosyphilis Manifesting Through a Meningovascular Chronic Inflammatory Process in Association with the Occurrence of Two Aneurysms Involving the Distal A2 Segment of Both Anterior Cerebral Arteries: A Case Report and Review of the Literature

Daive Bagatti¹, Jasenka Mazibrada², Gianfranco Kim Innocente Ligarotti¹, Vittoria Nazzi¹, Angelo Franzini¹

Key words

- Anterior cerebral artery
- Biopsy
- Meningovascular inflammation
- Mycotic aneurysm
- Neurosyphilis
- Serological scar

Abbreviations and Acronyms

ACAs: Anterior cerebral arteries

CNS: Central nervous system

CSF: Cerebrospinal fluid

CT: Computed tomography

FTA-ABS: Fluorescent treponemal antibody absorption

IgM: Immunoglobulin M

MRI: Magnetic resonance imaging

TPHA: *Treponema pallidum* hemagglutination

From the Departments of ¹Neurosurgery III and ²Neuropathology, Foundation of the "Carlo Besta" Neurological Institute, IRCCS, Milan, Lombardy, Italy

To whom correspondence should be addressed:
Daive Bagatti (last year medical student)
[E-mail: davide.bagatti@libero.it]

Citation: *World Neurosurg.* (2016) 87:662.e13-662.e18.
<http://dx.doi.org/10.1016/j.wneu.2015.10.085>

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

1878-8750/\$ - see front matter © 2016 Elsevier Inc.
All rights reserved.

INTRODUCTION

Syphilis is a sexually transmitted disease caused by *Treponema pallidum*, a bacterium of the order of spirochetes, with human beings as the only host. It has been esteemed that 12 million people have been infected with syphilis in 1999, with more than 90% of the cases registered in poor countries. Recently, the drastic increase in the incidence of syphilis worldwide, especially in urban areas,¹ led clinicians to heighten their degree of suspicion, with special regard to the presence of this infection within the human immunodeficiency populations, intravenous drugs users, and homosexuals.²⁻¹⁶

Although advanced syphilis is a classic infective cause of aneurysmal disease, abnormal dilation of brain vessels in the

■ **BACKGROUND:** Although syphilis has become a rare disease in the Western world since the Second World War, it is believed to have infected 12 million people in 1999, with greater than 90% of cases occurring in the developing world. Moreover, since the year 2000, the rates of syphilis have been increasing in the United States, the United Kingdom, Australia, and Europe. Because of the mimic nature of the disease and the overall low rate of occurrence of its manifestations in advanced stages, a proper diagnosis may prove difficult.

■ **CASE REPORT:** We report the case of a 41-year-old African man affected by neurosyphilis that manifested itself through a meningovascular chronic inflammatory process, with the peculiar feature of a bilateral aneurysm of probable mycotic origin involving the distal tract of A2 segment of both anterior cerebral arteries.

■ **CONCLUSIONS:** Because of the mostly nonspecific nature of clinical manifestations of syphilis (particularly advanced syphilis) and its consequent tendency to masquerade as many other diseases, even a skilled physician may find its diagnosis quite challenging; thus, thorough clinical and radiologic investigations should be supported by serologic testing for syphilis in all cases of cognitive impairment. Mycotic intracranial aneurysms in association with neurosyphilis rarely are reported; however, they require early diagnosis and meticulous, individualized treatment. Because syphilis appears to be on the raise, further studies on the topic are warranted.

context of meningovascular syphilis rarely is reported. If untreated for a long time, syphilis can cause major damage to important organs, such as the heart and brain. New reports may be helpful in diagnosing and managing neurosyphilis in its delayed clinical manifestations.

CASE DESCRIPTION

A 41-year-old African man came under our observation because of the worsening of an initially undertreated headache, whose first appearance was traced by the patient about 10 years ago. Clinical examination showed the presence of mildly depressed mood, intense headache, tinnitus, and pain, mainly located at the middle part of the left temporal muscle and at the left temporomandibular joint, with irradiation to the cervical

ipsilateral region. Magnetic resonance imaging (MRI) and computed tomography (CT) examinations (**Figure 1A–B**) highlighted the presence of a cortical-subcortical left frontal lesion, largely represented by edema, in association with cortical calcifications and a marked leptomeningeal enhancement.

This radiologic picture led to the diagnostic hypothesis of inflammatory-infectious/granulomatous/immune-mediated leptomeningeal process, probably a leptomeningeal angiomatosis in the left frontal region associated with edema, worthy of further diagnostic insight because of its ambiguous nature. A positron emission tomography scan was then performed, which only showed a modest uptake of methionine surrounding the aforesaid big edematous interemispheric area. New MRI and magnetic resonance angiography investigations not

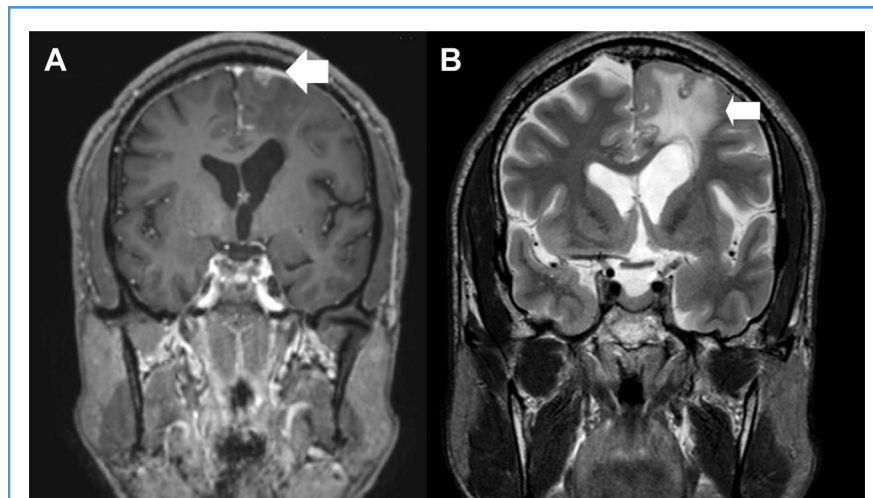


Figure 1. (A) T1-weighted coronal magnetic resonance imaging (MRI) (after contrast) and (B) T2-weighted coronal MRI (without contrast) showing a left frontoparasagittal lesion surrounded by an edematous interemispheric area. Both in the cortical and subcortical areas (arrow), a marked hyperintensity on T2-weighted sequences can be appreciated (B). After contrast, it is possible to notice marked leptomeningeal enhancement (arrowhead) in the left frontal and interemispheric regions (A).

only confirmed the presence of the aforementioned radiologic pattern but also revealed a most striking feature: the presence of 2 irregular aneurysms located in the distal tract of A2 segment of both anterior cerebral arteries (ACAs) (Figure 2A–B).

Laboratory tests also were performed: blood serum sample tested positive for *Treponema pallidum* hemagglutination (TPHA; 1:80). The fluorescent treponemal antibody absorption (FTA-ABS) test showed a minimal degree of reactivity (1+), and total antitreponemal antibodies (immune complexes = 16) were detected; antitreponemal immunoglobulin M (IgM)

was negative. Total protein levels in the cerebrospinal fluid were high (66.8 mg/dL). Then, the patient underwent new serologic tests that confirmed the presence of total antitreponemal antibodies (immune complexes ranging from 6.2 to 8.9). TPHA proved positive again (1:5120) and the Venereal Disease Research Laboratory test was weakly reactive.

The patient was finally proposed an open biopsy of his left frontoparasagittal lesion with a microsurgical technique, to which he agreed. The postoperative course was free from complications, and histopathologic investigations of the biop-

specimen provided evidence of a mainly meningovascular chronic inflammatory process involving the central nervous system (CNS), consistent with a diagnostic hypothesis of neurosyphilis (Figure 3A–F).

At postoperative follow-up, a brain CT scan and both a CT angiography and a new MRI (Figure 4) were performed, which showed a reduction of the edematous area and confirmed the presence of 2 aneurysms, of probable mycotic origin involving both ACAs. While awaiting the results of new laboratory studies of blood and cerebral spinal fluid (CSF), we consulted an infectivologist, who recommended oral antibiotic therapy with amoxicillin, possibly followed by specific antitreponemal therapy with intravenous penicillin 20 million units per day for 2 weeks, depending on the outcome of the microbiological investigations themselves. CSF testing showed a cytometry of approximately 0.3 L/mm³ and substantial negativity of other parameters (TPHA, FTA-ABS, antitreponemal IgM, and total antibodies), apart from the high value of proteins (66 mg/dL). The patient's blood serum sample still tested positive for TPHA (1:2560) and for FTA-ABS (2+); total antitreponemal antibodies (immune complexes = 4.6) were detected and antitreponemal IgM were 0.4. A serologic test for human immunodeficiency virus was negative.

In light of these results, no evidence of an actual activity of the disease in CSF was pointed out. Thus, according to the opinion of the infectivologist, there was no indication to treatment with penicillin intravenously; the patient took amoxicillin orally instead, until his discharge, and then assumed dexamethasone and rabeprazole. Currently, clinical follow up at 4 months after diagnosis does not show any impairment: the patient is now stable and doesn't complain of any neurologic deficit.

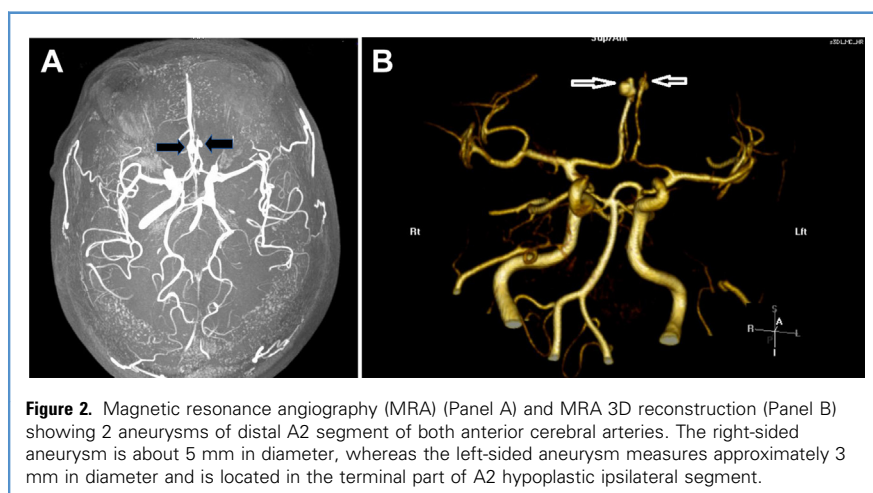


Figure 2. Magnetic resonance angiography (MRA) (Panel A) and MRA 3D reconstruction (Panel B) showing 2 aneurysms of distal A2 segment of both anterior cerebral arteries. The right-sided aneurysm is about 5 mm in diameter, whereas the left-sided aneurysm measures approximately 3 mm in diameter and is located in the terminal part of A2 hypoplastic ipsilateral segment.

MATERIALS AND METHODS

Histochemistry and Immunohistochemistry

Immunohistochemistry was performed on Carnoy-fixed and paraffin-embedded biopsy samples (4- μ m thick) with the use of the completely automated DAKO autostainer plus instrument. The following antibodies were applied: 1) Ki67 (mouse monoclonal, clone MIB-1, working dilution 1:100); 2) CD68 (mouse monoclonal,

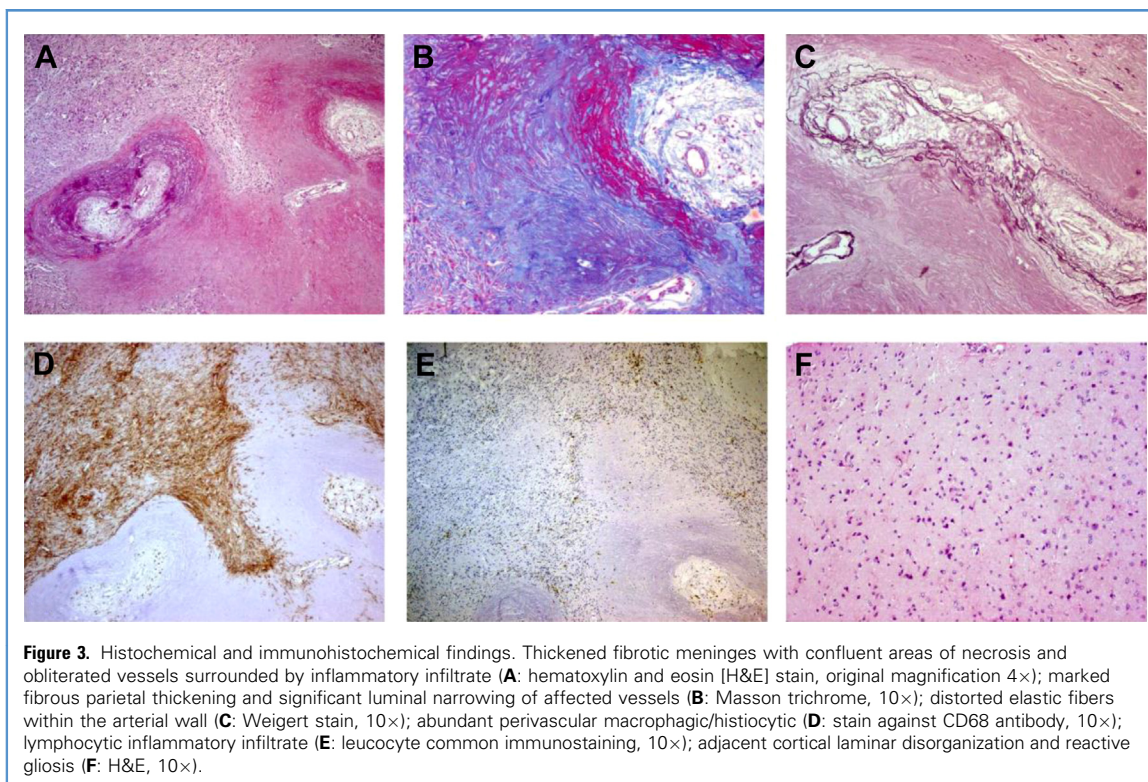


Figure 3. Histochemical and immunohistochemical findings. Thickened fibrotic meninges with confluent areas of necrosis and obliterated vessels surrounded by inflammatory infiltrate (**A**: hematoxylin and eosin [H&E] stain, original magnification 4×); marked fibrous parietal thickening and significant luminal narrowing of affected vessels (**B**: Masson trichrome, 10×); distorted elastic fibers within the arterial wall (**C**: Weigert stain, 10×); abundant perivascular macrophagic/histiocytic (**D**: stain against CD68 antibody, 10×); lymphocytic inflammatory infiltrate (**E**: leucocyte common immunostaining, 10×); adjacent cortical lamina disorganization and reactive gliosis (**F**: H&E, 10×).

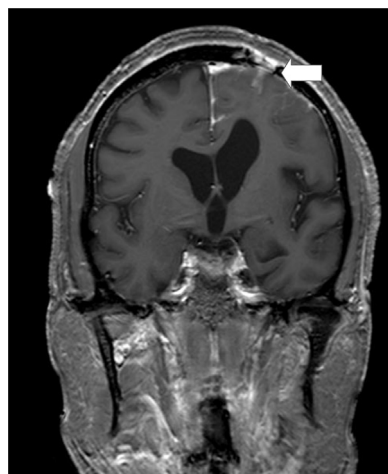


Figure 4. T1-weighted coronal magnetic resonance imaging (after contrast) performed after biopsy, showing signs of previous surgery, with left frontal craniotomy and an underlying cavity (arrow). In respect to the previous neuroimaging investigations, the absence of frontal cortical swelling is evidenced. After contrast, the leptomeningeal enhancement persists, extending along the frontal and interhemispheric areas.

clone PG-M1, working dilution 1:1000); 3) glial fibrillary acidic protein (mouse monoclonal, clone 6F2, working dilution 1:600); 4) leucocyte common antigen (mouse monoclonal, clone 2B11+PD7/26, working dilution 1:200); 5) CD20cy (mouse monoclonal, clone L26, working dilution 1:50); 6) CD45RO (mouse monoclonal, clone UCHL1, working dilution 1:50); and 7) CD138 (mouse monoclonal, clone MI15, working dilution 1:100), all provided by DAKOCytomation (Glostrup, Denmark).

RESULTS

The histologic specimen was represented by nervous parenchyma (cerebral cortex and subcortical white matter) with relative meningeal tissue appearing markedly thickened and fibrotic. The disease process affected mainly the meninges, where there was a marked fibrohistiocytic proliferation cuffing vessel walls of medium and large caliber arteries (**Figure 3A**; hematoxylin and eosin stain). The affected vessels presented perivascular infiltration of inflammatory cells, mainly lymphocytes and prominent

fibrous thickening of vascular wall (**Figure 3B**; Masson trichrome stain) with partial destruction of elastic fibers and with vascular lumen occluded or significantly reduced (**Figure 3C**; Weigert stain). There were extensive and confluent areas of necrosis in fibrous scarring within the perivascular stromal compartment, circumscribed by mixed inflammatory infiltrate consisting mainly of histiocytes (**Figure 3D**; anti-CD68 antibody stain), lymphocytes (**Figure 3E**; antileucocyte common antibody stain), predominantly of T phenotype (CD45RO positive), with occasional B cells (CD20 positive) and plasma cells. The proliferative activity, evaluated by immunostaining for MIB-1, was limited to the inflammatory cells and stromal fibroblasts. The underlying cerebral cortex presented slight distortion of laminar cortical architecture with mild atrophy and focal loss of neuronal cells with reactive gliosis (**Figure 3F**; hematoxylin and eosin stain), scarce chronic inflammatory infiltrate, and focal calcified areas. In summary, morphologic alterations were consistent with chronic inflammatory

process of predominantly meningovascular involvement and were compatible with serological data indicating neurosyphilis.

DISCUSSION

General Considerations and Diagnostic Hypothesis

Treponema pallidum typically invades the CNS in secondary and later stages of syphilis infection. When spontaneous resolution does not happen, an individual can develop different symptomatic forms of syphilis.^{16,17} Among these, syphilitic infection of the nervous system may result in one of the most insidious chronic meningeal inflammatory processes. Neurosyphilis can be divided into 2 main categories, on the basis of the extent of tissue involvement: 1) early involvement of the CNS, limited to the meninges and vessels; and 2) parenchymal involvement of brain and spinal cord.

Because of the considerable variability (with partial overlapping) of clinical manifestations, it is possible to identify the following 6 groups^{7,18}: 1) asymptomatic syphilis, with reactive nontreponemal CSF serology (Venereal Disease Research Laboratory test) results; 2) acute syphilitic meningitis, characterized by signs of meningeal irritation and cranial neuropathies usually involving cranial nerves VII, VIII, VI, and II; 3) meningovascular (arteritic) syphilis (see paragraph to follow); 4) tabes dorsalis, a slowly progressive demyelination of posterior columns of spinal cord; 5) general paresis (of the insane), otherwise known as *dementia paralytica*, a neuropsychiatric disorder based on the chronic meningoencephalitis that leads to cerebral atrophy^{7,19-21}; and 6) optic atrophy, a relatively new phenomenon that often includes anterior uveitis or panuveitis (granulomatous or non-granulomatous), retinitis, retinal vasculitis, vitreitis, and papillitis.^{6,22,23}

In particular, meningovascular syphilis occurs, on average, 7 years after the initial infection.²⁴ The pathology consists of endarteritis with perivascular inflammation that can manifest as 2 different forms, depending on the caliber of the vessels: 1) the Heubner-type, involving medium-sized vessels; and 2) the Nissl-Alzheimer type, typically affecting small-caliber vessels, for instance, the vasa vasorum of the CNS. Vascular damage leads to fibroblastic proliferation of the intima, thinning of the

media, and fibrous and inflammatory abnormalities in the adventitia, with lymphocytic and plasma cell infiltration. Aneurysmal dilation rarely is reported. Luminal narrowing predisposes patients to cerebrovascular thrombosis, ischemia, vessel occlusion, and infarction, which explains why the most common presentation of meningovascular syphilis is a stroke syndrome in a relatively young adult involving the middle cerebral artery (most common) or the branches of the basilar artery (second most common). A subacute encephalitic prodrome is present, characterized by the presence of headaches, vertigo, insomnia, and psychological abnormalities (personality changes, emotional lability, insomnia, decreased memory), followed by a gradually progressive vascular syndrome.

We can consider our patient as suffering from meningovascular neurosyphilis, which occurred several years after infection, clinically still prodromal (headache, low mood) and with the peculiar feature of a bilateral intracranial aneurysm of probable mycotic origin.

Review of Reported Cases of Mycotic Intracranial Aneurysms and Comparison with Our Patient (Pathological Pattern, Clinical Presentation, Diagnosis, Treatment, and Clinical Outcome)

The eventual role of arterial wall inflammation in the development of mycotic brain aneurysms, a phenomenon that is already known to occur in cases of syphilitic aortitis, is still debated.^{17,25} It is commonly thought that syphilis may result in a lymphoplasmacytic infiltration of the vasa vasorum with endarteritis obliterans.²⁶ Therefore, histologic features of mycotic aneurysms are reported to be lymphocytic infiltration, marked intimal proliferation and internal elastic lamina destruction.²⁷ In meningovascular syphilis, this process may lead to aneurysms years after onset of infection^{28,29} as in the case of our patient. The association of syphilis with either single or multiple intracranial aneurysms, however, is a rare condition^{17,25}: Few cases have been described in literature, mostly occurring in the carotid artery, the middle cerebral artery, the anterior cerebral artery, the anterior and posterior communicating arteries, and the basilar artery.^{17,25} To our knowledge, the occurrence of 2 aneurysms involving both ACAs has not been reported previously, although we cannot

completely rule out the possibility that it may be a coincidental finding.

Although many cases remain asymptomatic, the majority of symptomatic mycotic brain aneurysms manifest themselves through symptoms related to their rupture, such as severe unremitting localized headaches, dizziness, seizures, altered mental status, and focal neurologic deficits related to subarachnoid hemorrhage. Additional and insidious presentations for unruptured intracranial infectious aneurysms may include a subacute history of fever, chills, and malaise.³⁰⁻³⁵ In our case, no evidence of intracranial bleeding has been pointed out, and the patient belongs to the group of asymptomatic/mildly symptomatic ones.

Currently, the diagnosis of brain mycotic aneurysms and related complications is based on the use of neuroimaging as well as dedicated cerebrovascular imaging (noncontrast CT scans, contrast-enhanced CT angiography, MRI, conventional angiography), in the presence of predisposing infectious conditions, eventually highlighted by positive cultures of peripheral blood or the infected aneurysm wall (we didn't perform any biopsy sampling of the aneurysms) and CSF examination.^{30,35-39} It is noteworthy that no laboratory study has proven sufficiently sensitive or specific to serve as a single test for the definitive diagnosis of neurosyphilis.^{14,40} Treponemal tests such as The FTA-ABS and the microhemagglutination assay are very sensitive and specific tests in secondary, latent, tertiary, and quaternary syphilis and represent a useful tool to confirm the diagnosis. Today, it is quite common to observe FTA-ABS and TPHA tests producing persistently positive results (the theory of "serological scar"). In particular, serological scar is considered the persistence of reagins in low titers (of pure serum up to 1:4) after 2 years, with positive treponemic tests. Persistent high titer serology, even with normal CSF, should be followed up longer because of the possible existence of other treponema reservoirs.^{41,42}

The treatment of intracranial infectious aneurysms remains controversial and highly individualized, because of the lack of clear standards to guide clinical decision making.^{30,43} We opted for a conservative management, which is indicated for patients with unruptured aneurysms and/or with high surgical risk and consisting of

4–6 weeks of antimicrobial therapy. If cultures are unclear, empiric treatment should be initiated. Then, the patient must be followed with serial angiography to monitor the stability of the aneurysms.^{30,44} Alternatively, the definitive treatment of ruptured aneurysms relies on surgical clipping (young, symptomatic patients with accessible aneurysms), endovascular coiling (surgically inaccessible or multiple aneurysms, at high surgical risk), or trapping via either modalities.^{39,43,45-49} Despite the paucity of the studies, it seems the overall majority of patients had a positive outcome, with a few cases of further neurologic decline or death.^{30,36,37,46,47,50-56}

CONCLUSIONS

Because of the protean nature of the disease, even a skilled physician may find its diagnosis quite challenging. Thus, thorough clinical and radiologic investigations should be supported by serological testing for syphilis in all cases of cognitive impairment.²⁵ Although mycotic intracranial aneurysms in association with neurosyphilis are rare, they represent potentially life-threatening lesions that require early diagnosis and meticulous, individualized treatment; because syphilis seems to be on the rise, further studies on the topic are warranted.

REFERENCES

- Mattei PL, Beachkofsky TM, Gilson RT, Wisco OJ. Syphilis: a reemerging infection. *Am Fam Physician*. 2012;86:433-440.
- Berger JR, Waskin H, Pall L, Hensley G, Ihmedian I, Post MJ. Syphilitic cerebral gumma with HIV infection. *Neurology*. 1992;42:1282-1287.
- Chahine LM, Khoriaty RN, Tomford WJ, Hussain MS. The changing face of neurosyphilis. *Int J Stroke*. 2011;6:136-143.
- Coffin LS, Newberry A, Hagan H, Cleland CM, Des Jarlais DC, Perlman DC. Syphilis in drug users in low and middle income countries. *Int J Drug Policy*. 2010;21:20-27.
- Cohen CE, Winston A, Asboe D, Boag F, Mandalia S, Azadian B, et al. Increasing detection of asymptomatic syphilis in HIV patients. *Sex Transm Infect*. 2005;81:217-219.
- Doris JP, Saha K, Jones NP, Sukthankar A. Ocular syphilis: the new epidemic. *Eye (Lond)*. 2006;20:703-705.
- Duffy JD. General paralysis of the insane: neuropsychiatry's first challenge. *J Neuropsychiatry Clin Neurosci*. 1995;7:243-249.
- Gao L, Zhang L, Jin Q. Meta-analysis: prevalence of HIV infection and syphilis among MSM in China. *Sex Transm Infect*. 2009;85:354-358.
- Ghanem KG, Moore RD, Rompalo AM, Erbeling EJ, Zenilman JM, Gebo KA. Neurosyphilis in a clinical cohort of HIV-1-infected patients. *AIDS*. 2008;22:1145-1151.
- Karp G, Schlaeffer F, Jotkowitz A, Riesenberg K. Syphilis and HIV co-infection. *Eur J Intern Med*. 2009;20:9-13.
- Katz DA, Berger JR, Duncan RC. Neurosyphilis. A comparative study of the effects of infection with human immunodeficiency virus. *Arch Neurol*. 1993;50:243-249.
- Marra CM. Syphilis and human immunodeficiency virus infection. *Semin Neurol*. 1992;12:43-50.
- Schöfer H, Imhof M, Thoma-Greber E, Brockmeyer NH, Hartmann M, Gerken G, et al. Active syphilis in HIV infection: a multicentre retrospective survey. The German AIDS Study Group (GASG). *Genitourin Med*. 1996;72:176-181.
- Timmermans M, Carr J. Neurosyphilis in the modern era. *Neurol Neurosurg Psychiatry*. 2004;75:1727-1730.
- Zetola NM, Engelman J, Jensen TP, Klausner JD. Syphilis in the United States: an update for clinicians with an emphasis on HIV coinfection. *Mayo Clin Proc*. 2007;82:1091-1102.
- Zetola NM, Klausner JD. Syphilis and HIV infection: an update. *Clin Infect Dis*. 2007;44:1222-1228.
- Asdaghi N, Muayqil T, Scozzafava J, Jassal R, Saqqur M, Jeerakathil TJ. The re-emergence in Canada of meningovascular syphilis: 2 patients with headache and stroke. *CMAJ*. 2007;176:1699-1700.
- Nagappa M, Sinha S, Taly AB, Rao SL, Nagarathna S, Bindu PS, et al. Neurosyphilis: MRI features and their phenotypic correlation in a cohort of 35 patients from a tertiary care university hospital. *Neuroradiology*. 2013;55:379-388.
- Hutto B. Syphilis in clinical psychiatry: a review. *Psychosomatics*. 2001;42:453-460.
- Lair L, Naidech AM. Modern neuropsychiatric presentation of neurosyphilis. *Neurology*. 2004;63:1331-1333.
- Rundell JR, Wise MG. Neurosyphilis: a psychiatric perspective. *Psychosomatics*. 1985;26:287-290, 295.
- Prokosch V, Thanos S, Busse H, Stupp T. Ophthalmological symptoms as key findings in neurosyphilis – diagnosis and therapy. *Klin Monbl Augenheilkd*. 2009;226:184-188 [in German].
- Turchetti P, Pacella F, Pacella E, Mirisola C, Uccella I. An immunocompetent migrant presenting with neurosyphilis with an unusual unilateral papillitis: a case report. *Eur J Med Res*. 2012;17:3.
- Holmes MD, Brant-Zawadzki MM, Simon RP. Clinical features of meningovascular syphilis. *Neurology*. 1984;34:553-556.
- Visoná de Figueiredo NS, Moraes Angst DB, Mendes LS, Machado ME, Guimarães Rocha MS, Dozzi Brucki SM. Basilar artery aneurysm in a woman with syphilis. *JAMA Neurol*. 2015;72:720-721.
- Okuyama K, Yaginuma T, Takahashi T. The development of vasa vasorum of the human aorta in various conditions: a morphometric study. *Arch Pathol Lab Med*. 1988;112:721-725.
- Kannoth S, Thomas SV. Intracranial microbial aneurysm (infectious aneurysm): current options for diagnosis and management. *Neurocritical Care*. 2009;11:120-129.
- Coyle PK, Dattwyler R. Spirochetal infection of the central nervous system. *Infect Dis Clin North Am*. 1990;4:731-746.
- Jackman JD Jr, Radolf JD. Cardiovascular syphilis. *Am J Med*. 1989;87:425-433.
- Ducruet AF, Hickman ZL, Zacharia BE, Narula R, Grobelny BT, Gorski J, et al. Intracranial infectious aneurysms: a comprehensive review. *Neurosurg Rev*. 2010;33:37-46.
- Mincheff TV, Cooler AW. Ruptured mycotic aneurysm presenting initially with bacterial meningitis. *Am Surg*. 2008;4:73-75.
- Misser SK, Lalloo S, Ponnusamy S. Intracranial mycotic aneurysm due to infective endocarditis—successful NBCA glue embolisation. *S Afr Med J*. 2005;95:397-399, 403-404.
- Trivedi MP, Carroll C, Rutherford S. Infective endocarditis complicated by rupture of intracranial mycotic aneurysm during pregnancy. *Int J Obstet Anesth*. 2008;17:182-187.
- Tunkel AR, Kaye D. Neurologic complications of infective endocarditis. *Neurol Clin*. 1993;11:419-440.
- Yoon JO. Not just an aneurysm, but an infected one: a case report and literature. *J Vasc Nurs*. 2006;24:2-8. quiz 9-10.
- Bartakke S, Kabde U, Muranjan MN, Bavdekar SB. Mycotic aneurysm: an uncommon cause for intracranial hemorrhage. *Indian J Pediatr*. 2002;69:905-907.
- Corr P, Wright M, Handler LC. Endocarditis-related cerebral aneurysms: radiologic changes with treatment. *AJNR Am J Neuroradiol*. 1995;16:745-748.
- Hung SC, Tai CT. Infective endocarditis complicated with thalamic infarction and mycotic aneurysm rupture: a case report. *Zhonghua Yi Xue Za Zhi*. 1998;61:53-58.
- Wajnberg E, Rueda F, Marchiori E, Gasparetto EL. Endovascular treatment for intracranial infectious aneurysms. *Arq Neuropsiquiatr*. 2008;66:790-794.
- Harding AS, Ghanem KG. The performance of cerebrospinal fluid treponemal-specific antibody tests in neurosyphilis: a systematic review. *Sex Transm Dis*. 2012;39:291-297.
- Ho KK. Review on serologic diagnosis of syphilis. *Hong Kong Dermatol Venereol*. 2002;10:10-18.

42. Rotta O. Serological diagnosis of syphilis. Brazilian dermatology annals — 80 years. *An Bras Dermatol*. 2005;80.
43. Peters PJ, Harrison T, Lennox JL. A dangerous dilemma: management of infectious intracranial aneurysms complicating endocarditis. *Lancet Infect Dis*. 2006;6:742-748.
44. Phuong LK, Link M, Wijdicks E. Management of intracranial infectious aneurysms: a series of 16 cases. *Neurosurgery*. 2002;51:1145-1151; discussion 1151-1152.
45. Andreou A, Ioannidis I, Mitsos A. Endovascular treatment of peripheral intracranial aneurysms. *AJNR Am J Neuroradiol*. 2007;28:355-361.
46. Chapot R, Houdart E, Saint-Maurice JP, Aymard A, Mounayer C, Lot G, et al. Endovascular treatment of cerebral mycotic aneurysms. *Radiology*. 2002;222:389-396.
47. Erdogan HB, Erentug V, Bozbuga N, Goksedef D, Akinci E, Yakut C. Endovascular treatment of intracerebral mycotic aneurysm before surgical treatment of infective endocarditis. *Tex Heart Inst J*. 2004;31:165-167.
48. Luders JC, Steinmetz MP, Mayberg MR. Awake craniotomy for microsurgical obliteration of mycotic aneurysms: technical report of three cases. *Neurosurgery*. 2005;56(1 suppl):E201; discussion E201.
49. Sugg RM, Weir R, Vollmer DG, Cacayorin ED. Cerebral mycotic aneurysms treated with a neuroform stent: technical case report. *Neurosurgery*. 2006;58:E381; discussion E381.
50. Aspoas AR, de Villiers JC. Bacterial intracranial aneurysms. *Br J Neurosurg*. 1993;7:367-376.
51. Barrow DL, Prats AR. Infectious intracranial aneurysms: comparison of groups with and without endocarditis. *Neurosurgery*. 1990;27:562-572; discussion 572-573.
52. Brust JC, Dickinson PC, Hughes JE, Holtzman RN. The diagnosis and treatment of cerebral mycotic aneurysms. *Ann Neurol*. 1990;27:238-246.
53. Chun JY, Smith W, Halbach VV, Higashida RT, Wilson CB, Lawton MT. Current multimodality management of infectious intracranial aneurysms. *Neurosurgery*. 2001;48:1203-1213; discussion 1213-1214.
54. Dhomne S, Rao C, Shrivastava M, Sidhartha W, Limaye U. Endovascular management of ruptured cerebral mycotic aneurysms. *Br J Neurosurg*. 2008;22:46-52.
55. Frazee JG, Cahan LD, Winter J. Bacterial intracranial aneurysms. *J Neurosurg*. 1980;53:633-641.
56. Hara Y, Hosoda K, Wada T, Kimura H, Kohmura E. Endovascular treatment for an unusually large mycotic aneurysm manifesting as intracerebral hemorrhage—case report. *Neurol Med Chir (Tokyo)*. 2006;46:544-547.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 11 August 2015; accepted 24 October 2015

Citation: World Neurosurg. (2016) 87:662.e13-662.e18. <http://dx.doi.org/10.1016/j.wneu.2015.10.085>

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

1878-8750/\$ - see front matter © 2016 Elsevier Inc. All rights reserved.