OPEN LETTER

Management of intracranial tuberculous mass lesions: how long should we treat for? [version 2; peer review: 1 approved with reservations]

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Abstract

Tuberculous intracranial mass lesions are common in settings with high tuberculosis (TB) incidence and HIV prevalence. The diagnosis of such lesions, which include tuberculosis and tuberculous abscesses, is often presumptive and based on radiological features, supportive evidence of TB elsewhere and response to TB treatment. However, the treatment response is unpredictable, with lesions frequently enlarging paradoxically or persisting for many years despite appropriate TB treatment and corticosteroid therapy. Most international guidelines recommend a 9-12 month course of TB treatment for central nervous system TB when the infecting Mycobacterium tuberculosis (M. tb) strain is sensitive to first-line drugs. However, there is variation in opinion and practice with respect to the duration of TB treatment in patients with tuberculomas or tuberculous abscesses. A major reason for this is the lack of prospective clinical trial evidence. Some experts suggest continuing treatment until radiological resolution of enhancing lesions has been achieved, but this may unnecessarily expose patients to prolonged periods of potentially toxic drugs. It is currently unknown whether persistent radiological enhancement of intracranial tuberculomas after 9-12 months of treatment represents active disease, inflammatory response in a sterilized lesion or merely revascularization. The consequences of stopping TB treatment prior to resolution of lesional enhancement have rarely been explored. These important issues were discussed at the 3rd International Tuberculous
Meningitis Consortium meeting. Most clinicians were of the opinion that continued enhancement does not necessarily represent treatment failure and that prolonged TB therapy was not warranted in patients presumably infected with \textit{M.tuberculosis} strains susceptible to first-line drugs. In this manuscript we highlight current medical treatment practices, benefits and disadvantages of different TB treatment durations and the need for evidence-based guidelines regarding the treatment duration of patients with intracranial tuberculous mass lesions.

**Keywords**
tuberculosis, central nervous system, treatment duration, management, imaging, tuberculous meningitis, tuberculoma, tuberculous abscess

This article is included in the Wellcome Centre for Infectious Diseases Research in Africa (CIDRI-Africa) gateway.

This article is included in the Tuberculous Meningitis International Research Consortium collection.

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**Grant information:** This work was supported by the Wellcome Trust [098316 and 203135 to GM, 097254 to SM]. FCC was supported by National Institutes of Health/Fogarty International Center [R21TW011035]. OKS was supported by the National Institutes of Health [K23 NS084054-01]. AF was supported by the National Research Foundation SARCHI Chair in Clinical Neurosciences. GM is also supported by the South African Research Chairs Initiative of the Department of Science and Technology and National Research Foundation (NRF) of South Africa [64787]. NRF incentive funding [UID: 85858] and the South African Medical Research Council through its TB and HIV Collaborating Centres Programme with funds received from the National Department of Health [RFA# SAMRC-RFA-CC: TB/HIV/AIDS-01-2014]. The funders had no role in the study design, data collection, data analysis, data interpretation, or writing of this report. The opinions, findings and conclusions expressed in this manuscript reflect those of the authors alone. This work was supported by the Wellcome Trust through funding to the Tuberculous Meningitis International Research Consortium.

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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**How to cite this article:** Marais S, Van Toorn R, Chow FC et al. Management of intracranial tuberculous mass lesions: how long should we treat for? [version 2; peer review: 1 approved with reservations] Wellcome Open Research 2019, 4:158 (https://doi.org/10.12688/wellcomeopenres.15501.2)

**First published:** 15 Oct 2019, 4:158 (https://doi.org/10.12688/wellcomeopenres.15501.1)
Microglia in the CNS are infected by the role of the host inflammatory response in pathogenesis. The mycobacterial burden in CNS TB is low. The impressive astrocytes and vascular proliferation that evolves to develop epithelioid histiocytes, Langerhan's giant cells, lymphocytes, form tuberculomas. Tuberculomas show granulomatous inflammation with a central area of caseous necrosis surrounded by epithelioid histiocytes, Langerhan’s giant cells, lymphocytes, astrocytes and vascular proliferation that evolves to develop a thick vascular connective tissue layer.

The mycobacterial burden in CNS TB is low. The impressive pathology and evolution of lesions during TB therapy highlights the role of the host inflammatory response in pathogenesis. Micoglia in the CNS are infected by M.tb and activated microglia release many cytokines that play a crucial role in pathogenesis. TNF-α is a central molecule in the control and mediation of inflammation in CNS TB. While TNF-α is involved in granuloma formation and control of disease, elevated levels are associated with markers of increased pathology such as cerebrospinal fluid leukocytosis, higher levels of other soluble inflammatory mediators, increased M.tb load and clinical deterioration. Studies focused on the vasculature associated with tuberculomas have revealed significant vasculitis with proliferative changes in the basement membrane.

Occasionally, tubercles may coalesce or continue to progress to form a tuberculous abscess, which is a large pus-filled encapsulated lesion containing bacilli. Histopathologically, the tuberculous abscess wall shows chronic vascular granulation tissue whilst lacking the granulomatous reaction of a tuberculoma.

The clinical features of tuberculomas depend on their anatomic location in the brain, related to local mass effect, obstruction of cerebrospinal fluid pathways, and/or seizures. Supratentorial lesions are common in adults while infratentorial involvement is slightly more common in children. Patients usually present sub-acute with symptoms and signs such as headaches, seizures, depressed level of consciousness, and focal neurological deficits like chorea are rare manifestations of tuberculomas. If associated with TBM, meningeal symptoms and signs may dominate the clinical picture. Tuberculous abscesses have a more accelerated course, often presenting acutely with associated fever.

Neuroimaging is essential for identifying intracranial tuberculosis mass lesions with findings determined by the composition of the lesion. Tuberculomas have classically been categorized as non-caseating, caseating solid, and caseating liquid, that can be differentiated on computed tomography (CT) and magnetic resonance imaging (MRI). Multiple lesions are seen more often than isolated lesions though the latter is still common. Perilesional edema can be present or absent.

CT is the most frequent modality used to identify tuberculomas due to its wide availability though it has limitations in resolution. Tuberculomas typically appear as round or lobulated nodules that are hypodense or isodense to the brain parenchyma. CT with contrast most commonly shows rim enhancement of the tuberculous abscess and contrast enhancement may vary with tuberculomas have revealed significant vasculitis with proliferative changes in the basement membrane.

MRI is the preferred modality for the identification of tuberculomas due to superior resolution and better visualization of the posterior fossa relative to CT. Non-caseating granulomas are hypointense or isointense on T1-weighted imaging (T1WI) and hyperintense on T2-weighted imaging (T2WI, “T2-bright”) with
homogeneous contrast enhancement\textsuperscript{31}. Caseating solid granulomas are hypointense or isointense on T1WI and hypointense on T2WI (“T2-black”) with rim enhancement. Caseating liquid granulomas, which are rare, are hypointense on T1WI and hyperintense on T2WI with rim enhancement. Tuberculous abscesses may be indistinguishable from tuberculomas with a liquid center on standard MRI settings, but they are usually larger (>3 cm in diameter) and thin-walled in appearance\textsuperscript{31}. Miliary tuberculomas appear as multiple, small (2–3 mm), scattered lesions that typically rim enhance with contrast administration and lack perilesional edema\textsuperscript{39}.

Evidence of a satisfactory radiological response on serial brain imaging after TB treatment initiation includes a reduction in perilesional edema, decrease in lesion size and calcification (seen on CT). Other findings supportive of improvement of liquefied tuberculomas and abscesses on MRI are a decrease in T2 brightness and, subsequently, loss of T2 signal. Evolution of TB abscesses from early-stage “T2-bright” with edema to “T2-black” lesions may represent a marker for cure\textsuperscript{31}. In our experience, the resultant homogeneous “T2-black” tuberculoma (with rim T1 contrast enhancement) may persist for many months in asymptomatic patients without relapse off TB treatment. CT of such lesions usually shows gradual calcification, which most often involves the capsule.

Paradoxical reactions
Paradoxical enlargement or the development of new intracranial tuberculomas or abscesses in patients with CNS or extraneural TB on appropriate treatment is well-described\textsuperscript{8,32–44}. Such reactions typically occur within the first six months after TB treatment initiation\textsuperscript{33–42}, but may rarely be delayed for a year or more\textsuperscript{10,45–47}. Paradoxical reactions are often identified when patients present with neurological deterioration during TB treatment, prompting brain imaging. In case series of predominantly HIV-uninfected patients with CNS TB, clinical deterioration due to paradoxical tuberculoma reaction has been described in 6–29\%\textsuperscript{32–39}. However, many of these patients are asymptomatic during these episodes and the frequency of detecting paradoxical tuberculoma development or enlargement increases substantially (from 29\% to 65\%) if surveillance brain imaging is performed during the first six months of TB treatment\textsuperscript{35}. Paradoxical TB reactions are more common in HIV-infected patients, particularly in those who commence antiretroviral therapy (ART) after starting TB treatment, in which case it is referred to as paradoxical TB-immune reconstitution inflammatory syndrome (TB-IRIS)\textsuperscript{46–51}. The influence of HIV on the frequency of paradoxical tuberculoma reactions (separate from the effect of ART) has rarely been reported. One recent study of 47 HIV-infected and 14 HIV-uninfected adults with tuberculomas found no difference in the frequency of paradoxical reactions by HIV status (36\% in each group)\textsuperscript{32}. The majority of HIV-infected patients were receiving ART prior to tuberculoma presentation or did not start ART after diagnosis, precluding the development of TB-IRIS in this group. The pathogenesis of paradoxical reactions (including IRIS) remains unclear but is likely related to an aberrant immune response to TB antigens rather than failure of TB treatment\textsuperscript{43,52}. Clinical findings supporting this view are the observation that new or enlarging tuberculomas in TBM patients frequently appear in those known to be infected with drug-susceptible strains who show clinical and radiological improvement of other aspects of TBM (Figure 1)\textsuperscript{43}. Another argument is that anti-inflammatory drugs (corticosteroids and thalidomide) are

![Figure 1. Serial magnetic resonance imaging of a patient with drug-susceptible central nervous system tuberculosis who received TB treatment for 4 years.](image-url)
effective in the prevention and management of paradoxical TB reactions, including tuberculomas.63–65

Medical treatment

The mainstay of treatment of intracranial tuberculomas is similar to that of TBM and includes TB therapy and corticosteroids. The World Health Organization, Centers for Disease Control and Prevention of America and the British Thoracic Society recommend a 9–12 month course of TB treatment for CNS TB when the M.tuberculosis strain is sensitive to all drugs.64–69. However, these guidelines are based on expert opinion rather than randomized controlled trials. Specifically, no studies have compared different treatment durations in patients with intracranial tuberculomas. The morphology of the lesion plays an important role in response to therapy and a one-size-fits-all approach may therefore be inappropriate in the decision regarding tuberculoma treatment duration. This is suggested by the almost invariably good response of military tuberculomas to TB treatment (presumably non-caseous) and the frequent persistence of caseous and liquefied TB lesions (e.g. abscesses) despite TB treatment.41,52

Some guidelines suggest adjunctive systemic corticosteroids in all forms of CNS TB, including those in whom a strong suspicion of tuberculoma exists.68. Corticosteroid therapy may be of particular value when there is significant perilesional edema (resulting in symptomatology) and in cases where there is paradoxical enlargement despite optimal TB therapy.69. Corticosteroid duration should be tailored according to the radiological response of the tuberculoma and clinical wellbeing of the patient and balanced against side effects.

TB abscesses are often unresponsive to standard TB therapy with corticosteroids. Although no clinical trials exist, adjuvant thalidomide therapy (3–5 mg/kg/day) has been shown to be beneficial in patients who develop enlarging TB abscesses.41. In our experience, thalidomide can be stopped without relapse 3–9 months after initiating therapy.41,67,68,70–72. Thalidomide is generally well tolerated, with a relatively low frequency of side effects.41,68,70–72, but may lead to the development of thromboembolism and prolongation of the prothrombin time.41,68,70–72. Even after 24 months of therapy, tuberculomas may persist in 22%–46% of cases.41,52 (Figure 1).

Surgical management

There are no controlled studies to determine the role of surgery in patients with intracranial tuberculous mass lesions. However, there are general principles from clinical practice and the existing literature that can be summarized.61 Biopsy for diagnosis is considered: 1) at the outset if the definitive diagnosis is unclear, and 2) for persistence or paradoxical growth of a presumed tuberculoma despite medical treatment (for diagnostics and drug sensitivity testing). Resection of the lesion may be considered: 1) to relieve symptomatic or potentially life-threatening mass effect and/or hydrocephalus, and 2) to treat medically refractory seizures. Drainage of abscesses is considered for symptomatic mass effect or hydrocephalus, especially when large and/or in the posterior fossa. However, surgery for tuberculous mass lesions is rarely performed in TB endemic settings as the clinical and imaging information is usually sufficient to make the diagnosis. Furthermore, risks associated with surgery, especially if the lesion is located in an eloquent or difficult to access brain area, and inadequate neurosurgical facilities usually combine to preclude surgical management.

Duration of TB treatment: what happens in practice?

There is variation in opinion and practice with respect to the duration of TB treatment in patients with intracranial tuberculomas or tuberculous abscesses. A major reason for this is the lack of prospective clinical trial evidence. In rare cases where a microbiological diagnosis is achieved, it is not feasible to access repeated clinical specimens from the site of disease to ascertain whether and when culture conversion has occurred, unlike pulmonary TB where sputum M.tuberculosis can be monitored and treatment duration adjusted accordingly. Monitoring is performed clinically and with brain imaging.

The routine duration of TB treatment in intracranial tuberculoma cases include periods of 6,64,9,12,14–16,40,46,65,70,72, 9–12 months) is not warranted in patients suspected of infection with or with proven M.tuberculosis strains susceptible to first-line drugs. This position is supported by the asymptomatic

Rationale for using longer versus shorter regimens

It is currently unknown whether persistent radiological enhancement of intracranial tuberculomas after 9–12 months of appropriate treatment represents active disease, inflammatory response in a sterilized lesion or merely revascularization. The consequences of stopping TB treatment prior to complete radiological resolution of these lesions has rarely been explored. These important issues were discussed at the 3rd International TBM Consortium meeting. Most clinicians were of the opinion that the continued enhancement does not necessarily represent treatment failure and that prolonged TB therapy (beyond 9–12 months) is not warranted in patients suspected of infection with or with proven M.tuberculosis strains susceptible to first-line drugs.
<table>
<thead>
<tr>
<th>Study, First author, year published, country</th>
<th>Study design</th>
<th>Patients, n (age group)</th>
<th>Duration of ATT, Months: %</th>
<th>Steroid use, %</th>
<th>Favorable clinical outcome, %, (n/N)</th>
<th>Radiologic persistent tuberculoma(s), % (n/N): months F/U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghani, 1994, multiple</td>
<td>Case report + review</td>
<td>41 (C + A)</td>
<td>10-24: 100</td>
<td>80⁴</td>
<td>68 (25/37)</td>
<td>N/A</td>
</tr>
<tr>
<td>Anuradha, 2011, India</td>
<td>Retrospective observational</td>
<td>43 (C + A)</td>
<td>9: 100</td>
<td>100</td>
<td>26 (11/43)</td>
<td>79 (30/38): 9</td>
</tr>
<tr>
<td>Awada, 1998, Saudi Arabia</td>
<td>Retrospective observational</td>
<td>18 (C + A)</td>
<td>12-18: 100</td>
<td>67</td>
<td>N/A</td>
<td>100 (18/18): 12</td>
</tr>
<tr>
<td>Bayindir, 2006, Turkey</td>
<td>Retrospective observational</td>
<td>23 (C + A)</td>
<td>12-18: 100</td>
<td>N/A</td>
<td>100 (15/15)</td>
<td>N/A</td>
</tr>
<tr>
<td>Gupta, 1990, India</td>
<td>Prospective observational</td>
<td>31 (C + A)</td>
<td>11-12: 97</td>
<td>N/A</td>
<td>N/A</td>
<td>14 (4/29): 12</td>
</tr>
<tr>
<td>Gupta, 2003, India</td>
<td>Prospective observational</td>
<td>9 (C + A)</td>
<td>16: 11</td>
<td>89</td>
<td>44 (4/9)</td>
<td>N/A</td>
</tr>
<tr>
<td>Harder, 1983, Saudi Arabia</td>
<td>Retrospective observational</td>
<td>20 (C + A)</td>
<td>12: 61</td>
<td>75</td>
<td>35 (7/20)</td>
<td>0 (0/10): 12⁵</td>
</tr>
<tr>
<td>Idris, 2007, Sudan</td>
<td>Retrospective observational</td>
<td>16 (A)</td>
<td>18: 100⁶</td>
<td>56</td>
<td>N/A</td>
<td>13 (2/16): 18</td>
</tr>
<tr>
<td>Li, 2012, China</td>
<td>Retrospective observational</td>
<td>6 (A)</td>
<td>18: 100</td>
<td>33</td>
<td>83 (5/6)</td>
<td>N/A</td>
</tr>
<tr>
<td>Man, 2010, France</td>
<td>Retrospective observational</td>
<td>23 (A)</td>
<td>9-18: 88</td>
<td>43</td>
<td>53 (10/19)</td>
<td>75 (12/16): 9-21</td>
</tr>
<tr>
<td>Marais, 2019, South Africa</td>
<td>Retrospective observational</td>
<td>66 (A)</td>
<td>≥9: 96% 19-46: 54⁷</td>
<td>76</td>
<td>37 (20/54)</td>
<td>49 (20/41): 18 33 (14/42): 24</td>
</tr>
<tr>
<td>Nair, 2019, India</td>
<td>Retrospective observational</td>
<td>86 (C + A)</td>
<td>≥18: 100 &gt;24-120: 22</td>
<td>N/A</td>
<td>N/A</td>
<td>22 (19/86): 24</td>
</tr>
<tr>
<td>Poonnoose, 2003, India</td>
<td>Retrospective observational</td>
<td>28 (C + A)</td>
<td>≥18: 100</td>
<td>54</td>
<td>68 (19/28)</td>
<td>69 (19/28): 18 46 (13/28): 24</td>
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<tr>
<td>Ravenscroft, 2001, South Africa</td>
<td>Prospective observational</td>
<td>34 (C)</td>
<td>≥6: 100 12-6</td>
<td>N/A</td>
<td>N/A</td>
<td>44 (14/32): 6⁹</td>
</tr>
<tr>
<td>Shah, 2019, India</td>
<td>Case series</td>
<td>6 (C)</td>
<td>23-32: 100</td>
<td>83</td>
<td>83 (5/6)</td>
<td>83 (5/6): &gt;24</td>
</tr>
<tr>
<td>Tandon, 1985, India</td>
<td>Retrospective observational</td>
<td>50 (C + A)</td>
<td>12-18: 98</td>
<td>N/A</td>
<td>78 (39/50)</td>
<td>40 (20/50): N/A</td>
</tr>
<tr>
<td>Wasay, 2004, Pakistan</td>
<td>Retrospective observational</td>
<td>102 (C + A)</td>
<td>9-12: 100⁶</td>
<td>79⁶</td>
<td>34 (17/50)</td>
<td>NA</td>
</tr>
<tr>
<td>Yaramis, 1998, Turkey</td>
<td>Retrospective observational</td>
<td>4 (C)</td>
<td>12: 100 24: 50</td>
<td>100</td>
<td>100 (4/4)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Abbreviations: n, number; ATT, antituberculous therapy; N, number with known data; F/U, follow-up; C, children; A, adults; N/A, data not available; RCT, randomized controlled trial

⁠¹ All studies included HIV-uninfected patients or patients with unknown HIV status, except studies by Man et al. and Marais et al., that included 7, and 47 HIV-infected patients, respectively;

² The definition varies between studies and include descriptions such as “complete recovery”, “no neurological disability”, “asymptomatic” and unspecified “good clinical recovery”. Several studies included patients with co-existing tuberculous meningitis that might have influenced clinical outcomes.

³ Including 30 patients with available data

⁴ Including patients followed up for at least 9 months

⁵ Including patients treated medically without surgical intervention

⁶ Excluding 1 patient who died during therapy

⁷ “32” refers to number of meningeal tuberculomas in 25 patients

⁸ Including patients followed up for at least 12 months
state of many patients and the paucity of AFB on staining and sterility of tuberculoma biopsy samples obtained prior to and following TB treatment initiation \(^3,^4\). Immunohistochemical staining of excised tuberculomas also demonstrates high expression of vascular endothelial growth factor (VEGF) in the lesions with intense positivity of inflammatory mononuclear cells as well as reactive astrocytes and fibrocytes \(^5\). The VEGF-induced angiogenesis in the granuloma capsule may therefore contribute, in addition to inflammation, to the persistent and prolonged contrast enhancement frequently seen on serial brain imaging. Furthermore, one trial reports no clinical or radiological deterioration at 24 months follow-up in 20 patients with persistent intracranial tuberculomas after completion of 9 months’ TB therapy \(^6\).

A theoretical argument in favor of continuing treatment longer than 9–12 months is that drug penetration into the CNS is suboptimal and is likely even more suboptimal into the tuberculoma or tuberculotic abscess. Drug penetration into cerebrospinal fluid is poor for rifampicin, the key sterilizing drug \(^7\). Tuberculotic abscesses that, unlike tuberculomas, are teeming with bacilli may potentially act as an immune sanctuary protecting the bacilli from immune effector cells within pus \(^8\). The consequence of these factors may be that sterilization is not always achieved with 9–12 months treatment and that a longer duration may be required. The inability to obtain specimens to confirm sterilization make this an area of uncertainty. Pertinent, too, is that relapse of CNS TB could have catastrophic consequences. Furthermore, some patients need late re-initiation of immunomodulatory treatment and this should ideally be done while on TB treatment to avoid relapse resulting from iatrogenic immunosuppression. However, if treatment is continued because of residual lesions, when does the clinician stop therapy? Should this be until all contrast enhancing lesions have resolved – which can take years – or some arbitrary timepoint before then?

**Conclusion**

Intracranial tuberculoma represents a major health concern in developing countries. Routine practices often include prescription of TB therapy until lesional enhancement has resolved, which may expose some patients to an unnecessarily prolonged treatment course. Because of the lack of evidence-based guidelines and equipoise with respect to shorter versus longer duration regimens, further research is needed. In the first instance, a multi-country audit of existing practice and outcomes in terms of cure and relapse would help in defining the spectrum of current practice. Ultimately, a randomized controlled trial comparing a standardized duration of TB treatment with duration based on brain imaging would provide a definitive answer to this question.

**Ethics statement**

Images presented in Figure 1 were obtained during a retrospective study of patients who presented with intracranial tuberculoma to Inkosi Albert Luthuli Central Hospital in Durban, South Africa. The Biomedical Research Ethics Committee (BREC) of the University of KwaZulu-Natal (UKZN) approved the study (BREC class approval number BCA325/15). As this was a retrospective folder review, and data were analyzed anonymously outside of the clinical setting, the ethics committee of UKZN waived the requirement for informed consent and informed consent was not obtained.

**Data availability**

**Underlying data**

No data is associated with this article.

**Acknowledgements**

Tuberculous Meningitis International Research Consortium

Rob E. Aarnoutse; Suzanne T. B. Anderson; Nathan C. Bahr; Nguyen D. Bang; David R. Boulware; Tom Boyles; Lindsey H. M. te Brake; Satish Chandra; Felicia C. Chow; Fiona V. Cresswell; Reinout van Creveld; Angharad G. Davis; Sofiati Dian; Joseph Donovan; Kelly E. Dooley; Anthony Figaji; A. Rizal Ganiem; Ravindra Kumar Garg; Diana M. Gibb; Raph L. Hamers; Nguyen T. T. Hiep; Darma Imran; Ahmad Imron; Sanjay K. Jain; Sunil K. Jain; Byamee Seejeebhoy; Jayantee Kalita; Rashmi Kumar; Vinod Kumar; Arjan van Laarhoven; Rachel P-J. Lai; Abi Manesh; Suzaan Marais; Vidya Mave; Graeme Meintjes; David B. Meya; Usha K. Misra; Manish Modi; Alvaro A. Ordonez; Nguyen H. Phu; Sunil Pradhan; Kameshwar Prasad; Alize M. Proust; Lalita Ramakrishnan; Ursula Rohlwink; Rovina Ruslami; Johannes F. Schoeman; James A. Seddon; Kusum Sharma; Omar Siddiqui; Regan S. Solomons; Nguyen T. T. Thuong; Guy E. Thwaites; Ronald van Toorn; Elizabeth W. Tucker; Sean A. Wasserman; Robert J. Wilkinson.

**References**


52. Walker NF, Stek C, Wasserman S, et al.: The tuberculosis-associated immune...


This manuscript reviews published studies of the diagnosis and treatment of intracranial tuberculomas and provides a consensus opinion on current practices and research needs.

The authors state “The diagnosis of intracranial tuberculoma is most often presumptive and based on radiological features, supportive evidence of TB elsewhere and response to TB treatment.” Since the diagnosis of intracranial tuberculoma rests in part on exclusion of other causes of intracranial mass lesions, it is necessary for the authors to discuss neuroimaging features (including DWI/ADC) that may or may not distinguish tuberculomas and tubercular abscesses from other causes of rim-enhancing and homogenous-enhancing lesions, including metastases, sarcoidosis, lymphoma, and bacterial, fungal and parasitic infections (e.g. staphylococcus, brucella, cryptococcus, aspergillus, toxoplasma gondii, taenia solium, schistosoma). Further, the authors should discuss the possibility that lack of radiological improvement after > 12 months of anti-tuberculosis treatment could indicate that the diagnosis of tuberculoma is incorrect and should prompt consideration of alternative diagnoses.

Is the rationale for the Open Letter provided in sufficient detail?
Yes

Does the article adequately reference differing views and opinions?
Yes

Are all factual statements correct, and are statements and arguments made adequately supported by citations?
Partly

Is the Open Letter written in accessible language?
Yes

Where applicable, are recommendations and next steps explained clearly for others to follow?
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Diagnosis and treatment of central nervous system infections including tuberculosis.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.