

Pictorial Essay

Imaging findings of the infective endocarditis with neurological complications

Rattabhorn Montrisaet M.D.

Sasitorn Petcharunpaisan M.D.

From Division of Diagnostic Radiology, Department of Radiology, Faculty of Medicine, Chulalongkorn University, King Chulalongkorn Memorial Hospital, The Thai Red Cross Society, Bangkok, Thailand.

Address correspondence to R.M.(e-mail: r.montrisaet@gmail.com)

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Abstract

Neurological complications are the most serious extracardiac complications of infective endocarditis. They can be manifested as ischemic stroke, intracranial hemorrhage, mycotic aneurysms, meningitis, cerebritis and abscesses. Avoidance of anticoagulants and antiplatelet agents with early intravenous antibiotic administration is crucial in the management of this condition. MRI of the brain is an important tool for early diagnosis and guiding the treatment decision. The purpose of this article is to review the imaging appearances and the possible mechanisms of the intracranial findings in the patients with neurological complications of infective endocarditis.

Keywords: Cerebral infection, Infective endocarditis, Intracranial hemorrhage, Mycotic aneurysm, Stroke.

Introduction

Infective endocarditis is an infectious disease that causes vegetations along the cardiac valves or endocardium, involving both native and prosthetic valves, and implanted cardiac devices. The incidence of infective endocarditis has increased in the past few decades due to the frequent use of long-term intravenous lines and cardiac devices [1, 2]. Patients who present with a valvular or structural cardiac abnormality are at significantly increased risk of this disease. The most common pathogen is *Staphylococcus aureus*, the microbiota of the skin and upper respiratory tract, found in about 40% of the patients. The second common pathogen, *Streptococcus viridans*, has been reported in about 17% of the patients, followed by enterococci in about 11% [3].

Neurological sequelae are the most severe extracardiac complications related to high rates of death and disability. Approximately 80% of the patients with infective endocarditis have abnormalities detected on magnetic resonance imaging (MRI) of the brain, and most of them are asymptomatic embolic events [4]. Stroke is the most common neurological complication, either ischemic infarction or hemorrhage. The mycotic aneurysm and cerebral infection have been described as the second and third manifestations, respectively [5].

The risks of neurological complications in infective endocarditis depend on the characteristic of vegetation and the duration of the antibiotic treatment [6]. Neurological presentations can be non-specific and diverse ranging from silent events to lethality. Moreover, physical examination can be clouded over when it comes to dealing with impairment of the consciousness resulting from severe cardiac failure or sepsis-related encephalopathy. Therefore, MRI of the brain is crucial for detection of the CNS complications. Various MRI abnormalities have been found related to different manifestations.

Ischemic stroke

Ischemic stroke is the most common neurological complication of infective endocarditis, which has been reported in up to 50% [6]. Almost all ischemic events are presented as cardioembolic patterns (Figure 1 and 2), and these embolic materials are composed of mixed fibrin-platelet clots and microorganisms [1].

The previous studies reveal high rates of post-thrombolytic intracranial hemorrhage with low rates of favorable outcomes in ischemic stroke associated with infective endocarditis [5, 7]. Hence, anticoagulation and antiplatelet agents should be avoided in this form of stroke, conversely to the non-infectious embolic events.

Doubtless, left-sided infective endocarditis has been more relevant to ischemic stroke than right-sided infective endocarditis. In addition, some studies found increased risk of cerebral ischemia in the cases with mitral valve vegetations compared to the aortic valve [3, 8]. MCA territory is the most affected part of the brain due to the high demand of cerebral blood supply; likewise, more than one territorial combination will probably be seen [8].

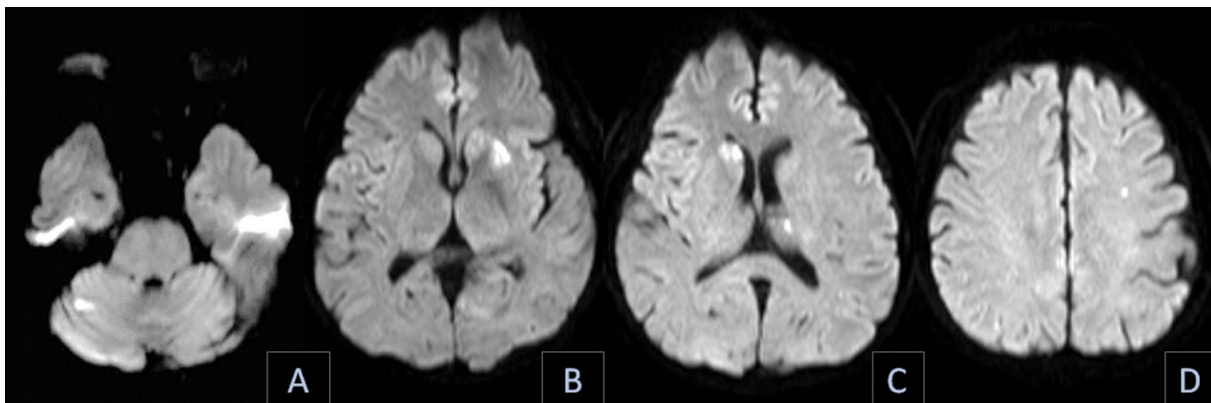


Figure 1. A 73-year-old female underlying type A aortic intramural hematoma and calcified bicuspid aortic valve underwent Bentall procedure and developed *S. epidermidis* septicemia. Diffusion-weighted imaging (A-D) shows multiple small acute infarctions in the right cerebellum, bilateral basal ganglia, left thalamus and left centrum semiovale, which are in different arterial territories suggesting embolic insults.

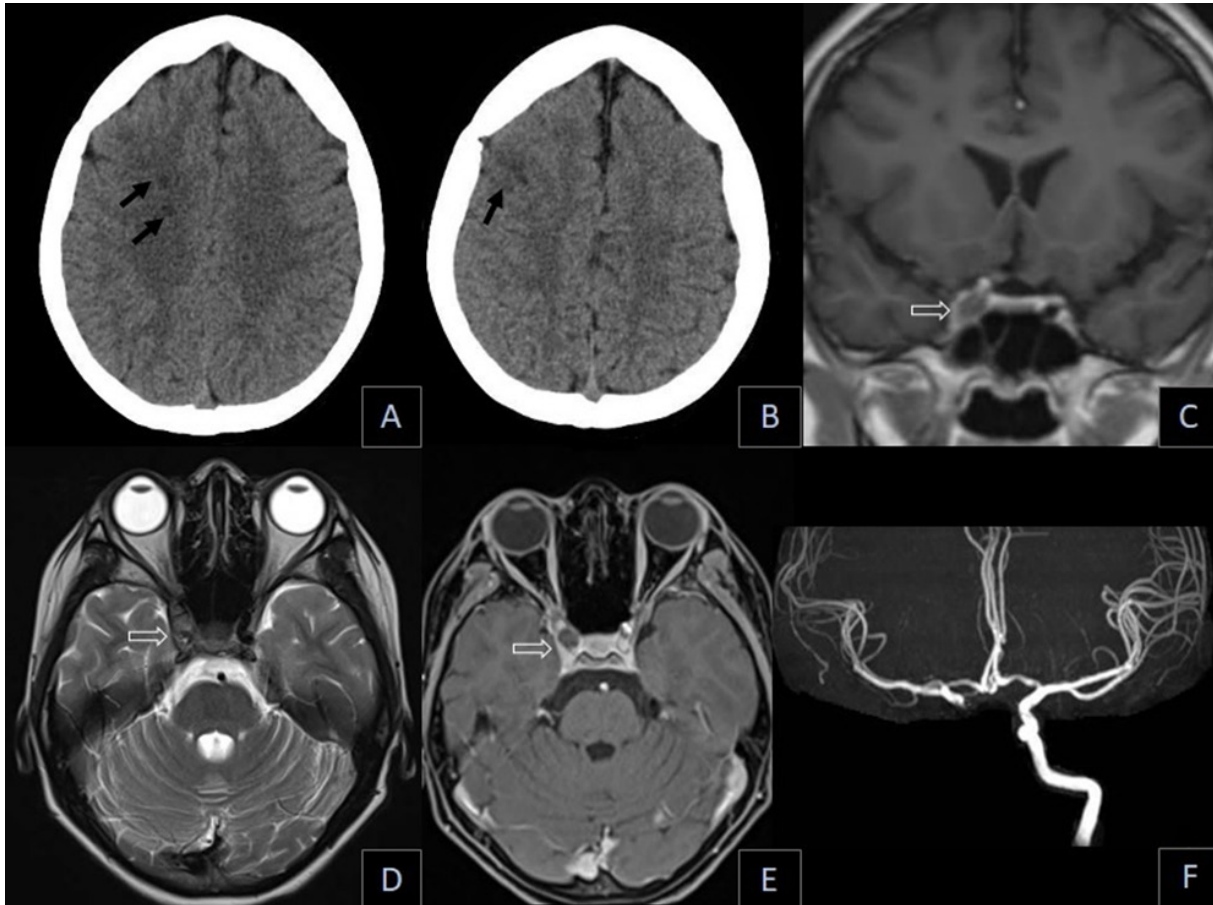


Figure 2. A 15-year-old female underlying severe AR and moderate to severe MR presenting with acute limb ischemia and acute left hemiparesis. The immediate CT scan of the brain (A and B) shows a few small acute infarctions in the right centrum semiovale and a small wedge-shaped acute infarction in the right frontal lobe (black arrows). The follow-up MRI performed 18 days later; axial T2-weighted image (D), axial post contrast T1-weighted image with fat suppression (E) and coronal post contrast T1-weighted image (C) reveal heterogeneous signal intensity and an abnormal bulging contour of the right cavernous sinus with an absent flow void in the cavernous segment of the right ICA (open white arrows). 3D time of flight MR angiography on the same date (F) confirms the absent flow in the right ICA from the distal extracranial segment up to the cavernous segment. Findings are suggestive of right cavernous ICA occlusion concomitant with ipsilateral cavernous sinus thrombosis.

Intracranial hemorrhage

Intracranial hemorrhage is the second most common CNS complication, found in 30% of the patients with infective endocarditis [5]. The hemorrhagic lesion can manifest as subarachnoid hemorrhage or lobar parenchymal hemorrhage, which may be caused by hemorrhagic transformation of prior ischemic infarction, progression, or growth of the microbleeds and ruptured aneurysm (Figures 3 and 4) [5].

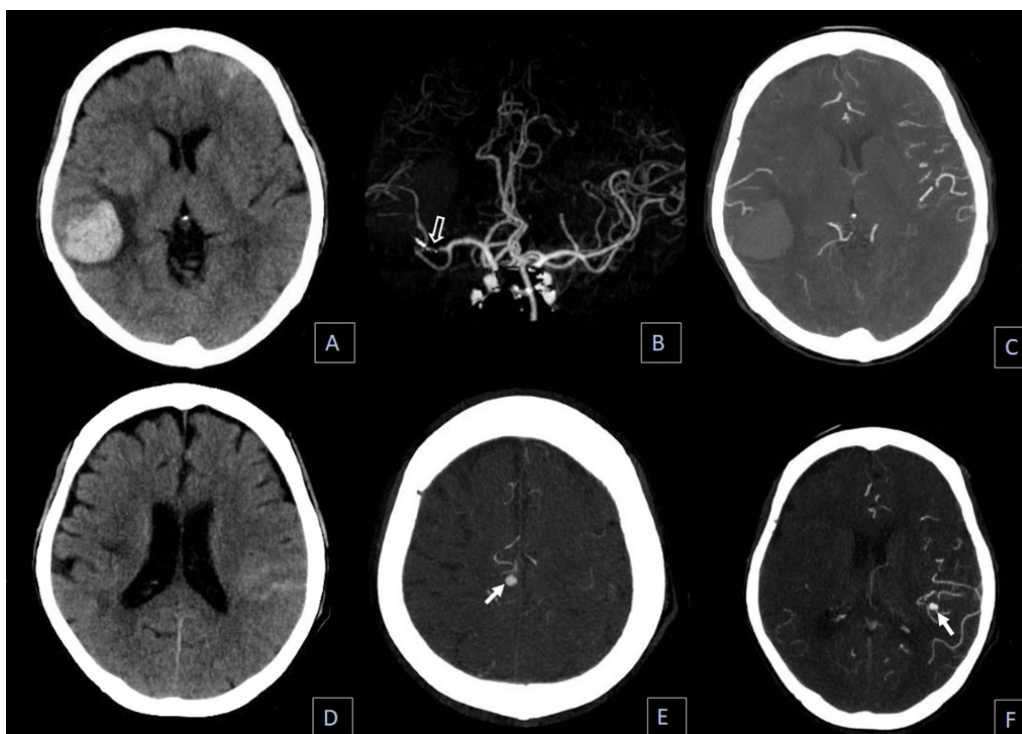


Figure 3. A 51-year-old female underlying SLE and AIHA, post aortic valve replacement, and LV-RA fistula repair, developed candida septicemia and infective endocarditis of the prosthetic heart valve. Axial CT brain (A) reveals acute intraparenchymal hematoma in the right temporal lobe and acute subarachnoid hemorrhage in the left frontal sulci. 3D MIP (B) and axial MIP CT angiography (C) show severe stenosis of the proximal M2 segment of right MCA (open arrow) and no evidence of aneurysm. The follow-up CT 4 days later (D) reveals new acute subarachnoid hemorrhage in the left fronto-parietal sulci and axial MIP CTA (E and F) shows two new aneurysms arising from the cortical branch of the right ACA and the opercular segment of the left MCA (solid arrows).

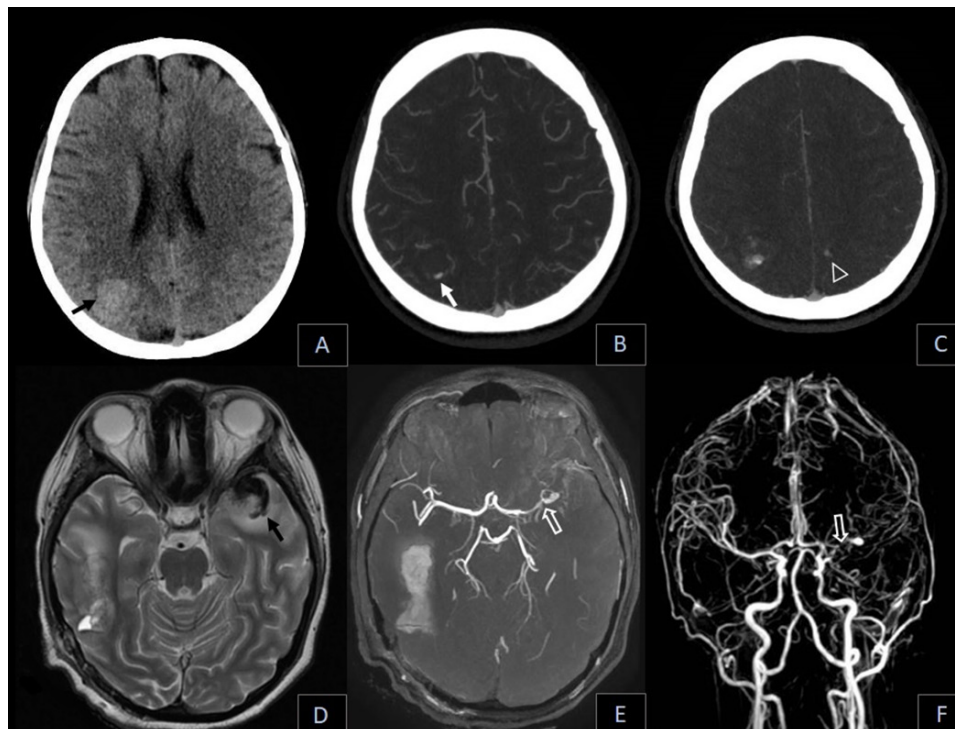


Figure 4. A 20-year-old-female with moderate to severe mitral regurgitation and a 0.8x0.3-cm oscillating mass at the posterior mitral valve leaflet. Axial CT brain (A) demonstrates subacute intraparenchymal hematoma in the right parietal lobe (black arrow). Further CT angiography (B) shows a small aneurysm in the right parietal area (solid white arrow). Axial delayed phase CT angiography (C) shows increased contrast accumulation surrounding the right parietal aneurysm and a new small nodular contrast pooling in left parietal lobe (open white arrowhead), suspicious of mycotic aneurysms with hemorrhage and contrast extravasation. The patient underwent follow-up MRI after craniotomy and hematoma removal ten days afterward. The axial T2-weighted image (D) shows new intraparenchymal hematoma in the left anterior temporal lobe (black arrow). Axial MIP time-of-flight MRA (E) and contrast enhanced MRA (F) demonstrate new severe stenosis of the proximal M1 segment of the left MCA and a saccular aneurysm distal to the luminal stenosis (open white arrows).

Generally, cerebral microbleeds can be found in those with old age, Alzheimer's disease, and small vessel diseases, such as hypertension, cerebral amyloid angiopathy, and atherosclerosis. Increased incidence of cerebral microbleeds has been documented in the patients with infective endocarditis [9]. Microbleeds are the insults of subacute microvascular inflammation from immunologic vasculitis and/or embolism in the vasa vasorum [6]. These microhemorrhages tend to present in cortical distribution, found in about 85% of the patients [9]. The rest have been seen in the subcortical area, basal ganglia, and posterior fossa.

The previous study described the characteristics of microbleeds from infective endocarditis as a small Bull's eye-liked lesion on T2WI/GRE T2*WI, which appears to be round/oval-shaped lesion measured less than 10 mm with central T2 hypointensity surrounded by the faint T2 hyperintense area [10]. Enhancement on the T1W post-gadolinium image is often seen. The central T2 hypointensity area represents microhemorrhage, tiny, infected aneurysms, or bacterial clots, while the peripheral hypersignal intensity reflects a parenchymal reaction or edema due to rapid regression of the lesion on serial follow-up imaging after an antibiotic treatment [10].

Intracranial mycotic aneurysm

Intracranial mycotic aneurysm has been found in less than 10% of neurological complications associated with infective endocarditis. 'Infectious intracranial aneurysm' has been proposed as the preferred term by some authors because the term 'mycotic' may represent the fungal etiology [5].

The explanation of infectious intracranial aneurysm is septic emboli in the vasa vasorum or due to intraluminal embolism to the distal vasculature. These septic emboli cause inflammation from the interaction between microorganisms and the host's immune response resulting in destruction of the vascular wall [5].

Unlike the fungal intracranial aneurysms, those mostly found in the proximal intracranial vessels, the bacterial mycotic aneurysms tend to affect the distal vessels [5]. Furthermore, they can be multiple, bilateral, and cortical locations, as well as saccular or fusiform shapes (Figures 3, 4 and 5).

MR angiography and CT angiography provides high sensitivity in diagnosis of mycotic aneurysm in up to 95% of the cases, despite increased challenge in the aneurysms smaller than 5 mm [6, 11]. Vascular occlusion or stenosis can co-exist with mycotic aneurysm (Figures 4 and 5).

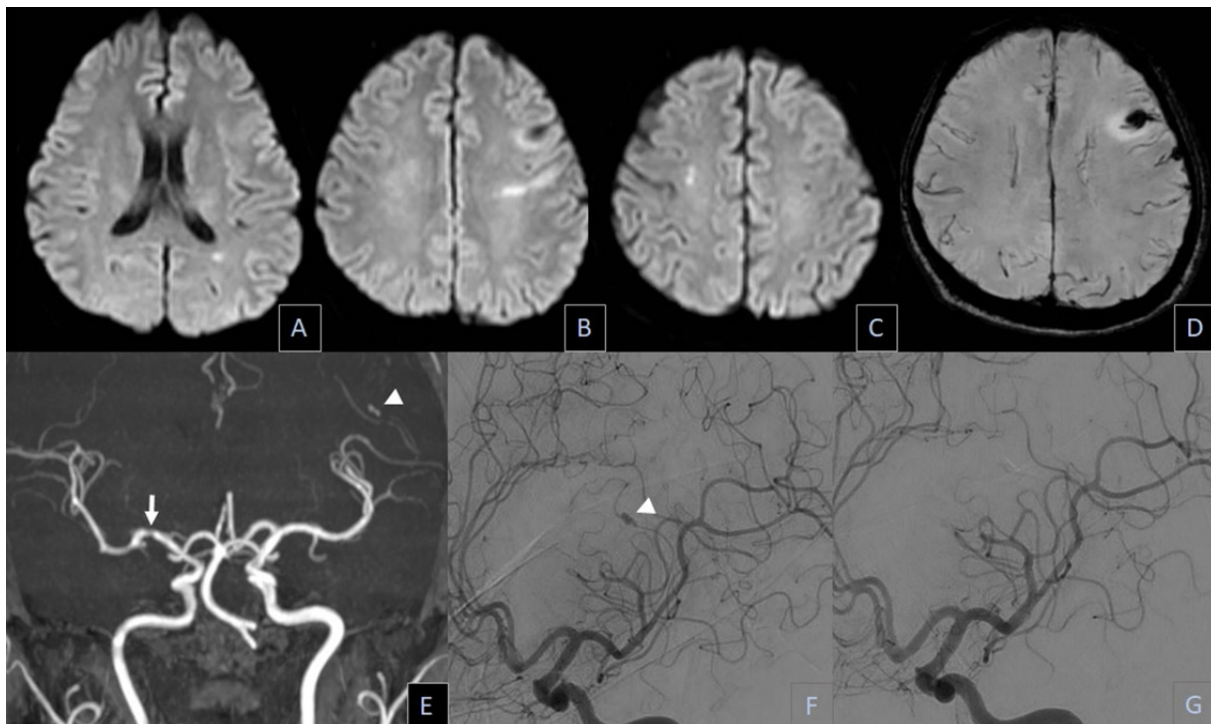


Figure 5. A 54-year-old male with severe prolapsed posterior mitral leaflet and *Streptococcus gordonii* septicemia, was discovered with two oscillating masses at the aortomitral continuity fibrosa. Axial diffusion-weighted images (A-C) reveal a few small acute infarctions in deep white matter of the left parietal lobe and the bilateral centrum semiovale. Axial susceptibility-weighted image (D) shows small intraparenchymal hematoma in the left frontal lobe with adjacent sulcal subarachnoid hemorrhage. Coronal MIP time of flight MRA (E) demonstrates a small aneurysm arising from the cortical branch of the left MCA (arrowhead) and focal moderate stenosis of the M1 segment of the right MCA (arrow). Digital subtraction angiography (F) confirms a 4x4-mm fusiform aneurysm arising from the frontal branch of the left M4 MCA (arrowhead), representing ruptured mycotic aneurysm. There is complete obliteration of the aneurysm after NBCA glue embolization (G).

CNS infection

Intracranial infection can be manifested as cerebritis, cerebral abscess, and meningitis. The proposed mechanism of cerebral infection refers to bacterial hematogenous spread similar to an infectious intracranial aneurysm, in which the septic emboli invade the vascular walls and then spread into the brain parenchyma and meninges, resulting in cerebritis, intraparenchymal abscess, and meningitis [2].

When the abscesses are large enough, they can present as high T2W lesions with central restricted diffusion and rim enhancement (Figures 6 and 7). Nevertheless, the microabscesses, defined as the enhancing lesion measured less than 10 mm, are more common in infective endocarditis (Figure 8) [11].

Occasionally, the dirty CSF sign seen as sulcal FLAIR/DWI hyperintensity in the cerebral sulci adjacent to the Bull's eye-liked lesion may be seen, which represents the presence of pus or blood from meningitis and vasculitis [10].

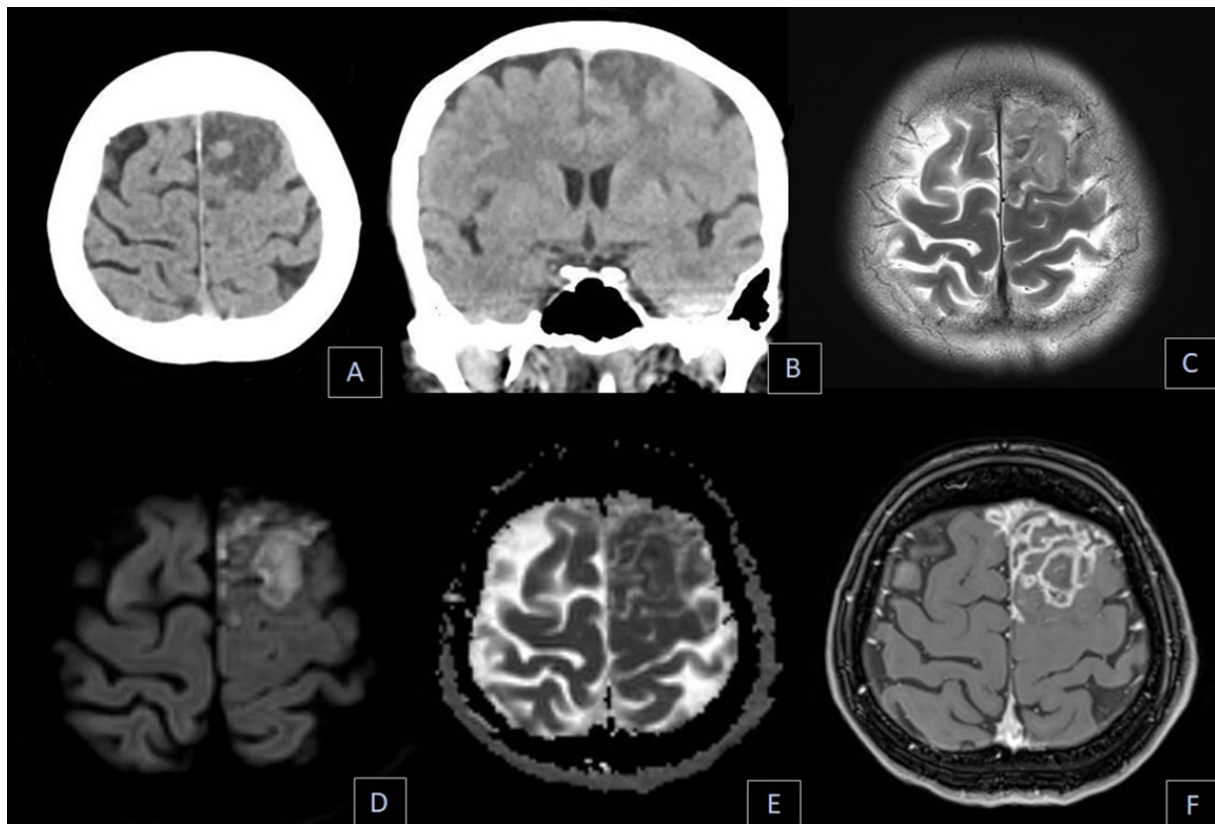


Figure 6. A 60-year-old female was shown with severe MR and infective mitral endocarditis. Axial and Coronal CT brain (A and B) demonstrates a well-demarcated hypodense lesion involving the parasagittal left frontal lobe. The patient underwent MRI two weeks afterward. Axial T2 weighted image (C), DWI (D), ADC (E) and post-contrast T1 weighted image (F) show persistent heterogeneous T2 hyperintensity of the left frontal lobe lesion with restricted diffusion and layering rim enhancement, likely representing cerebritis and abscess.

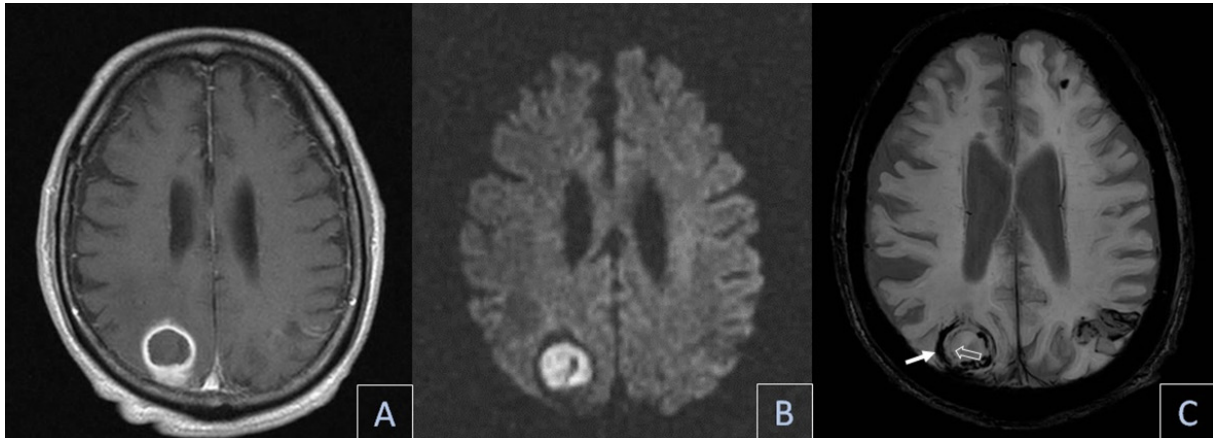


Figure 7. An 80-year-old male was presented with severe AR post bioprosthetic valve replacement with infective endocarditis caused by *Streptococcus gallolyticus* and *Enterococcus faecalis*. Axial MRI post-contrast T1 weighted image (A) reveals smooth rim enhancing abscess in the right parietal lobe with internal restricted diffusion on DWI (B). SWI of the same patient (C) shows a smooth complete outer dark rim (solid arrow) and an immediate internal bright line (open arrow), representing a dual rim sign. Subarachnoid hemorrhage in the left parietal region and a microbleed in the left frontal lobe are also noted.

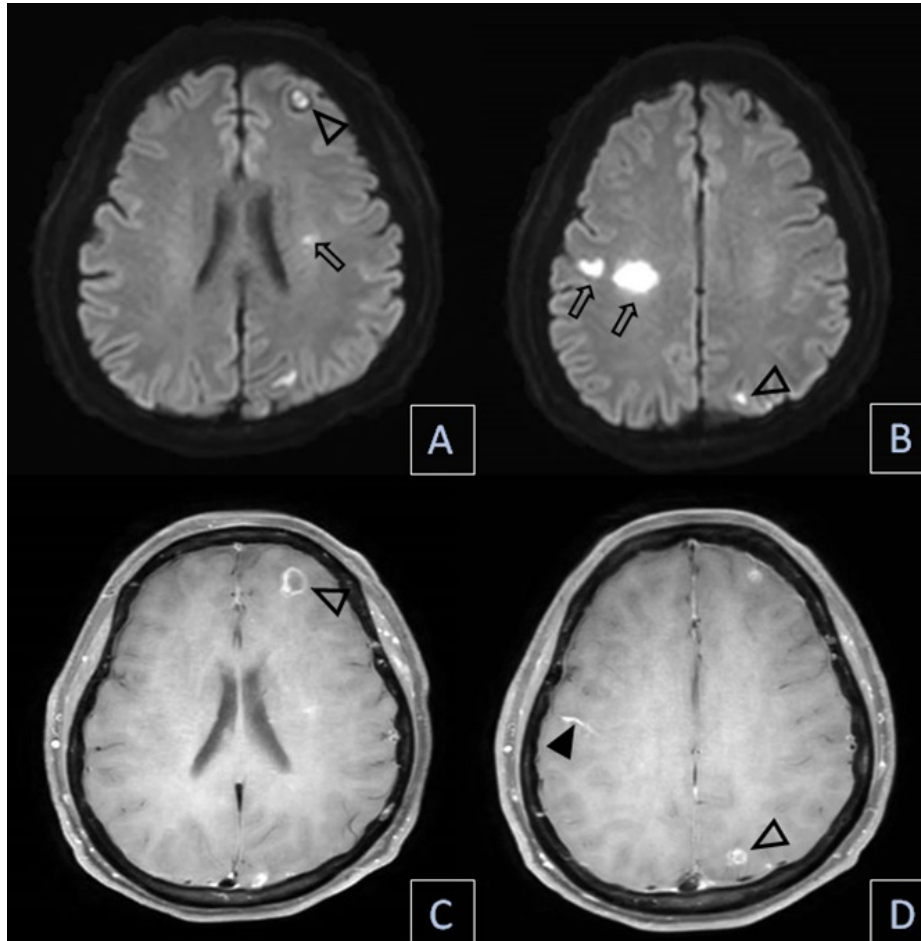


Figure 8. A 54-year-old-female underlied moderate to severe MR with infective mitral endocarditis. Axial MRI diffusion-weighted images (A and B) and post-contrast T1 weighted images (C and D) show two small rim enhancing microabscesses in the left frontal lobe and the left parietal lobe (open black arrowheads), a few small acute infarctions in the left corona radiata and the right centrum semiovale (open black arrow), and meningeal enhancement in the right frontal sulci (solid black arrowhead).

Conclusion

Intracranial complications of the patients with infective endocarditis have been described in the pieces of literature, including embolic infarction, intracranial hemorrhage, mycotic aneurysm and CNS infection. More than one combination is frequently encountered in an individual patient. A wide range of CNS symptoms can be accompanied by an alteration of the mental status, which raises a challenge in clinical diagnosis alone. Imaging evaluation with MRI and radiologists' awareness of the wide range of possible abnormal MRI findings would help in the early diagnosis and timely initiation of the proper management.

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