Studies four cases about fibromuscular dysplasia in Kingston General Hospital, Kingston, Ontario, Canada

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ABSTRACT
Fibromuscular dysplasia (FMD) is a non-atherosclerotic disorder of medium-sized vessels. FMD has a different presentation as well as clinical complications related to different known mechanisms. The etiology of FMD is unknown however genetic, hormonal, environmental factors may have a relation or overlap with vascular connective tissue diseases is observed. FMD most frequently involved arteries are the renal and internal carotid arteries however it may affect any arterial beds along the body for that all patient with FMD should complete screening of other vascular involvements, especially for central nervous and cardiovascular systems.

Keywords: Fibromuscular dysplasia, stenosis, dissection, aneurysm
1. INTRODUCTION

Fibromuscular dysplasia (FMD) is a non-atherosclerotic disorder of medium-sized vessels. FMD has a different presentation as well as clinical complications related to different known mechanisms (Geavlete et al., 2012). FMD can present with arterial stenosis, occlusion, aneurysm, and dissection involving any medium-sized arteries throughout the body. The most frequently involved arteries are the renal and internal carotid arteries (75-80%), followed by the vertebral, visceral, and external iliac arteries (Olin and Sealove, 2011). The location of diseased segments determines symptoms, which commonly include renovascular hypertension, headache, and pulsatile tinnitus (Olin et al., 2012). However rare presentation of FMD can happen like myocardial infarction or mesenteric ischemia. The etiology of FMD is unknown however genetic, hormonal, environmental factors may have a relation or overlapping with vascular connective tissue diseases is observed. The overwhelming majority of people affected (> 90%) are women (Olin and Sealove, 2011). Men with FMD seem to have a more aggressive course with a rate of aneurysm or dissection two times higher than that in women with FMD (Kadian-Dodov et al., 2016).

The diagnosis of FMD should be suspected in the case of young or middle-aged women presenting with migraine headaches, pulsatile tinnitus, or hypertension and for women with cervical bruises without typical risk factors for atherosclerotic disease or it should be suspected in patients who have suffered an arterial dissection or aneurysm (Dworkin and Cooper, 2009). FMD should be differentiated from atherosclerosis especially in patients who suffered from hypertension as FMD differ in terms of presentation, clinical consequences as well as treatment: the balloon angioplasty proved to be efficient and to provide positive results in FMD patients, whereas the best management for atherosclerosis lesions is still controversial (Geavlete et al., 2012). In this case series I reported four cases of FMD with four different presentations that have been observed during my residency training in Adult Nephrology Program at Kingston General Hospital in Kingston, Ontario, Canada, from 2014-2017. The first case is a patient who presented with acute coronary syndrome then finally diagnosed with FMD. The second case is a patient who presented with acute renal infarction as a consequence of FMD. The third case is a patient who has been diagnosed with FMD based on imaging study that used for screening of secondary hypertension. The last case is a patient who has been diagnosed with FMD and presented with generalized weakness due to severe hypokalemia likely in setting of diuretic usage however FMD may play a role. Dependent of various consequences and possibility of efficient management of FMD, should FMD diagnosed patient require complete screening of other vascular involvements, especially for central nervous and cardiovascular systems then provide an adequate management if possible these to be studied.

2. MATERIAL AND METHODS

Case (1), a 47-year-old female patient was admitted to hospital on February 9th, 2017 who has been presented to the hospital with typical features of acute coronary syndrome and on examination there was audible bruit along the femoral arteries bilaterally. Routine investigations were normal apart from a mild increase in the troponin. Coronary angiography carried out on the same day on admission and showed distal left anterior descending (LAD) coronary dissection that treated medically without any intervention.

Computed tomography (CT) of abdomen and pelvis showed the feature of beaded appearance involving renal and external iliac arteries bilaterally (figures 1 and 2).

Case (2) a 34-year-old man patient, who is a known case osteochondritis presented to the emergency department on October 14th, 2017, with a history of sudden onset severe right flank pain radiated to his back associated with nausea and vomiting. On examination, the patient was vitally stable and systemic examinations were unremarkable aside from diffuse tender abdomen without any peritoneal signs. Routine investigations were unremarkable except evidence of red blood cells in his urine analysis. A CT scan of the abdomen was performed to rule acute abdomen causes and surprising revealed wedge-shaped hypointensating region of the medial aspect of the inferior pole of the right kidney fig 2, for that renal angiogram done and showed a 1cm pseudo aneurysm along the right renal hilum, with mild wall irregularity in the mid segment of the renal artery, without presence of a pressure gradient see fig 3. MRI neck showed mild stenosis along the right carotid artery with an associated hypoplastic right A1 segment with irregularity on both internal carotid arteries, more prominent on the right see figure (4) and MRI head was unremarkable.

Case (3) a 44-year-old female who is following within nephrology general clinic as she diagnosed in February 2017 with Fibromuscular dysplasia based on incidental findings on imaging studies as a routine screening for secondary hypertension by Doppler US, since then the patient followed frequently for the progression of renal artery with Doppler ultrasound every six to twelve months and unfortunately angioplasty required for complete occlusion of the left renal artery.

Case (4) a 49-year-old female patient with a known case of migraine headache, depression, hypertension, and bilateral reduction mammoplasty and remote history melanoma treated with local excision. She was admitted to the hospital frequently because of generalized fatigue and muscle cramping that attributed to severe hypokalemia. Complete workup for hypokalemia was done and...
came back negative except renal angiogram which revealed of the beaded appearance of the right main renal artery that angioplastied successfully in August, 2017 figure (5). However, her potassium not improved after this procedure and urine test coming back positive for hydrochlorothiazide a few weeks later.

These cases illustrate diverse presentations of FMD. The most frequently involved arteries are the renal and internal carotid arteries however it may affects any arterial beds along the body for that all patient with FMD should complete screening of other vascular involvements especially for central nervous and cardiovascular systems then further prophylactic intervention may be warranted (table 1).

<table>
<thead>
<tr>
<th>Presenting symptoms</th>
<th>N  (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>285 (63.8)</td>
</tr>
<tr>
<td>Headache</td>
<td>234 (52.4)</td>
</tr>
<tr>
<td>Pulsatile tinnitus</td>
<td>123 (27.5)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>116 (26.0)</td>
</tr>
<tr>
<td>Cervical bruit</td>
<td>99 (22.2)</td>
</tr>
<tr>
<td>Neck pain</td>
<td>99 (22.2)</td>
</tr>
<tr>
<td>Tinnitus</td>
<td>84 (18.8)</td>
</tr>
<tr>
<td>Chest pain or shortness of breath</td>
<td>72 (16.1)</td>
</tr>
<tr>
<td>Flank/abdominal pain</td>
<td>70 (15.7)</td>
</tr>
<tr>
<td>Aneurysms</td>
<td>63 (14.1)</td>
</tr>
<tr>
<td>Cervical artery dissection</td>
<td>54 (12.1)</td>
</tr>
<tr>
<td>Epigastric bruit</td>
<td>42 (9.4)</td>
</tr>
<tr>
<td>Hemispheric TIA</td>
<td>39 (8.7)</td>
</tr>
<tr>
<td>Postprandial abdominal pain</td>
<td>35 (7.8)</td>
</tr>
<tr>
<td>Stroke</td>
<td>31 (6.9)</td>
</tr>
<tr>
<td>Claudication</td>
<td>23 (5.2)</td>
</tr>
<tr>
<td>Amaurosisfugax</td>
<td>23 (5.2)</td>
</tr>
<tr>
<td>Weight loss</td>
<td>23 (5.2)</td>
</tr>
<tr>
<td>Horner syndrome</td>
<td>21 (4.7)</td>
</tr>
<tr>
<td>Renal artery dissection</td>
<td>14 (3.1)</td>
</tr>
<tr>
<td>Azotemia</td>
<td>9 (2)</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>8 (1.8)</td>
</tr>
<tr>
<td>Mesenteric ischemia</td>
<td>6 (1.3)</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>25 (5.6)</td>
</tr>
</tbody>
</table>

3. RESULTS

Case 1

A 47-year-old female patient was admitted to hospital on February 9th, 2017, complaining of right arm pain radiating to her neck with chest heaviness lasting 1.5 hours. Her past medical history includes attention deficit disorder and obstructive sleep apnea not requiring continuous pressure airway pressure or any oxygen support at home. She was using oral contraceptive pills and dextroamphetamine on a regular basis. Her father died suddenly by the age of 45 year due to unexplained reasons. She is a second-hand smoke exposure. Her blood pressure was 111/71mmHg, pulse rate 90 beats/minute, heart sounds were normal and chest examination revealed clear breath sounds. Abdomen examination was soft, non-tenderness or organomegaly; auscultation did not reveal any bruit along the descending aorta or renal arteries. However there was audible bruit along the femoral arteries bilaterally.

ECG showed normal sinus rhythm with poor R wave progression with some infrequent episodes of accelerated idioventricular rhythmoma cardiac monitor. Chest X-ray was unremarkable and initial blood workup includes electrolytes, renal function and complete blood count and cardiac enzymes all within normal limits aside from mild increase of troponin 0.067 followed by a rise to 2 on the same day. Coronary angiography carried out on the same day on admission and showed distal left anterior descending (LAD) coronary dissection that treated medically without any intervention. Computed Tomography (CT) of abdomen and pelvis showed the feature of beaded appearance involving renal and external iliac arteries bilaterally (figures 1 and 2). CT of neck vessels was normal. Patient discharged on anti-ischemic treatment and after 3 months when she referred to nephrologist vasculitis
screening and acute phase reactants markers (ESR and CRP) ordered all were negative and MRA of the head done, it did not show any abnormalities.

Figure 1 The patient (Case 1, CT scan abdomen showing “string of beads” deformity of left renal artery.

Figure 2 The patient (Case 1), iliac CT angiogram showing the “string of beads” deformity bilaterally of the vessel lumen with alternate stenosis and beading.

Case 2
A 34-year-old man patient, who is a known case osteochondritis presented to the emergency department on October 14th, 2017, with a history of sudden onset severe right flank pain radiated to his back associated with nausea and vomiting. He had been seen
on Emergency department four days before these new complaints and was presented with progressive nausea and vomiting and discharged from there with a diagnosis of gastritis. His blood pressure was 140/90mmHg, heart rate 88 beats/minutes, his heart sounds were normal without extra heat sounds, the chest was clear on auscultation and abdominal examination was soft and diffusely tender without any peritoneal signs, no organomegaly or renal bruits on auscultation. Initial laboratory investigations were unremarkable (WBC 9.5x10, Hgb 141g/l, Plt 369), (Na 131umol/l, K 3.5umol/l, and Cl 96umol/l), (Creatinine 77umol/l, urea 2.6mmol/l), (ESR18, CRP6.7). Urin analysis showed (++blood, no nitrites or leukocyte esterase). A CT scan of the abdomen was performed to rule out appendicitis, and nephrolithiasis as a provisional diagnosis which revealed wedge-shaped hypoattenuating region of the medial aspect of the inferior pole of the right kidney (figure 2), then he was admitted to the hospital for further investigation and renal angiogram showed a 1cm pseudo aneurysm along the right renal hilum, mild wall irregularity in the mid segment of the renal artery, without presence of a pressure gradient (figure 3). MRI neck showed mild stenosis along the right carotid artery with an associated hypoplastic right A1 segment with irregularity on both internal carotid arteries, more prominent on the right (figure 4) and MRI head was unremarkable. The patient was started on anticoagulation with heparin followed by warfarin in to complete three months a total course then followed with aspirin lifelong. Also during hospitalization, his BP readings were high and controlled by using Ramipril 5 mg with amlodipine 7.5mg.

**Figure 3** CT scan (Case 2), showed the wedge-shaped hypo attenuating region of the medial aspect of the inferior pole of the right kidney.

**Figure 4** MRA neck (case 2), showed mild stenosis along the right carotid artery with an associated hypoplastic right A1 segment.
Case 3
A 44-year-old female who is following within nephrology general clinic as she diagnosed in February, 2017 with fibromuscular dysplasia based on incidental findings on imaging studies as a routine screening for secondary hypertension, FMD which is well established with complete stenosis of the right renal artery with right kidney atrophy but fully patent left renal artery and normal left kidney function, after she did have a percutaneous angioplasty of the left renal artery which showed mild stenosis, also there is a moderate stenosis of abdominal aortic bifurcation and severe stenosis of the origin of the celiac axis, she is monitoring the progression of renal artery with Doppler ultrasound every six to twelve months. She also knew case of hypertension, hypothyroidism, and vitiligo. Her current medication is cilazapril-hydrochlorothiazide 5-12.5mg daily, amlodipine 10 mg daily, Synthroid (adjusted according to her thyroid testing) and Loestrin. She is asymptomatic since February, 2017, her BP controlled on her current regimens and her kidney function was preserved and stable, creatinine 86umol/l. She has been considering screening for cerebrovascular FMD in the coming months.

Case 4
A 49-year-old female patient with a known case of migraine headache, depression, hypertension, and bilateral reduction mammoplasty and remote history melanoma treated with local excision. she was admitted in the hospital frequently because of generalized fatigue and muscle cramping that attributed to severe hypokalemia with ECG changes, all endocrine-related etiologies hypokalemia as well as all other causes of hypokalemia are ruled out including genetic tests for Gentleman’s, Barter’s and Liddle’s syndromes. And renal angiogram was ordered in August, 2017 to rule out renal artery stenosis which revealed of the beaded appearance of the right main renal artery that angioplastied successfully figure (5). However, her potassium not improved after this procedure and urine test coming back positive for hydrochlorothiazide few weeks later.

Figure 5 The patient (Case 4) renal angiogram before angioplasty showing “string of beads” deformity of the renal artery.

Indications for Renal Artery Revascularization
1. Resistant hypertension (defined as failure to reach goal blood pressure on appropriate 3-drugs regimen including diuretics).
2. Recent onset hypertension with the goal of hypertension cures especially in young patients.
3. Those who are unable to tolerate antihypertensive medications or who are noncompliant with their medication regimen.
4. Renal artery dissection: rarely intervention needed, but if so, stenting is generally the procedure of choice.
5. Renal artery aneurysm(s): surgical resection, endovascular coiling, or placement of covered stent is usually used.
6. Branch renal artery disease and hypertension: some lesions can be treated with PTA, but if not possible, surgical
revascularization may be required.

7. Preservation of renal function in patient with severe stenosis, especially in pediatric population with perimedial fibroplasia or intimal fibroplasia

4. DISCUSSION

Fibromuscular dysplasia (FMD) is a non-inflammatory, non-atherosclerotic disorder of medium-sized vessels that can present with arterial stenosis, occlusion, aneurysm, and dissection. The most frequently involved arteries are the renal and internal carotid arteries (75-80%), followed by the vertebral, visceral, and external iliac arteries (Olin and Sealove, 2011), however, it has been observed in nearly every arterial beds. 1.65% of patients with renal artery FMD had evidence cerebrovascular involvement, and 64% of patients with cerebrovascular FMD demonstrated evidence of renal FMD on imaging studies (Olin et al., 2012). Three or more vascular sites involvements observed in about 20% of patients. Among adults, FMD is more common among females. In most large series, approximately 90 percent of cases are in women (Geavlete et al., 2012; Kadian-Dodov et al., 2016). The mean age at diagnosis was 52 years, with a range of 5 to 86 years, in the past; it was believed that FMD was a disease of young women (Olin et al., 2012).

The etiology of FMD is unknown, it appears to have a genetic basis as 7-11% of the first degree relative of patients with FMD is similarly affected and all are siblings, and no vertical transmission was reported (Perdu et al., 2007). It is hypothesized that FMD may have overlapping features with vascular connective tissue disease, such as Loey’s-Dietz syndrome or the vascular type of Ehlers-Danlos syndrome. However, the prevalence of genetic mutation associated with connective tissue disease was negligible in a cohort of clinically confirmed FMD patients who underwent genetic testing (Poloskey et al., 2012). Hormonal influences (based on female predilection) or use estrogen supplements, trauma, developmental ischemia arising from vasa vasorum, or smoking also have been considered as a possible cause (Savard et al., 2013; Rutherford, 2015).

FMD classified in two ways, Pathological and Angiographic classifications. Pathological classification, is classified into 3 main types according to the arterial layer affected as follows Intimal fibroplasia (<10% of all cases of renal FMD), Medial fibroplasia: Further classified into 3 subtypes: medial dysplasia (80% of renal cases and most carotid cases), perimedial fibroplasia (10-15% of all renal cases), and medial hyperplasia (1-2% of all renal cases), and Adventitial fibroplasia (<1% of all renal cases) (Harrison and McCormack, 1971; Stanley, 1975; Begelman and Olin, 2000). However, pathological specimens are rarely obtained in the most of cases as these cases treated if required either medically or by percutaneous endovascular therapy if intervention warranted. Pathological classification has been replaced by an Angiographic classification which classifies FMD into; Multifocal FMD (more common) has the angiographic appearance of a "string of beads."

FMD presentation may result from different mechanisms; ischemia related to stenosis, dissection and occlusion of major arteries, rupture of aneurysms, or embolization of intravascular thrombi from dissection or aneurysm depending upon the arterial segment involved, the length and degree of stenosis, and the angiographic class of fibromuscular dysplasia (FMD) and some cases are asymptomatic in up to 5.6%, and FMD diagnosed accidentally while doing imaging for other reasons. Table 1 illustrates the frequency of symptoms reported among patients in the US Registry for FMD. However, some of these symptoms are poorly understood by clinician often results in a delay of diagnosis, frequently by several years. Until recently renal FMD, generally presenting as early-onset or difficult to control hypertension which is the most common presenting complaint among patient with FMD however renal impairment is rare which was in the range of 2% of patients in US Registry. Patient with cerebrovascular FMD can present with diverse symptoms ranging from headache, neck pain and pulsatile tinnitus to arterial dissection, or stroke or, occasionally subarachnoid hemorrhage (1.1%) (Olin et al., 2012). There is a strong association between FMD and spontaneous coronary artery dissection (SCAD). In patients with SCAD, up to 85 percent will have angiographic evidence of FMD (Saw et al., 2012, 2013; Tweet et al., 2012). SCAD is present in 10% of women under the age of 55 years who present with an acute coronary syndrome ACS, the most common coronary artery involved in the left anterior descending coronary artery in its mid to distal segment (Tweet et al., 2012; Saw et al., 2013).

The gold standard for diagnosis is conventional arteriography. Duplex ultrasound may be useful for renal artery disease, particularly for follow up. Computed tomographic arteriography (CTA) or Magnetic resonance arteriography (MRA) have reasonable sensitivity and specificity for larger renal vessels but do not give the hemodynamic information available from direct arteriography. Both CTA and MRA have been recommended for diagnostic evaluation for FMD in cerebrovascular circulation or other visceral or large arteries of extremities, but still conventional subtraction arteriography the gold standard in this vascular bed. The conditions that most commonly mimic the presentation of fibromuscular dysplasia (FMD) are atherosclerotic vascular disease and vasculitis.
Both atherosclerosis and FMD may cause renal artery stenosis and carotid artery disease. Patients with atherosclerosis are usually older and have typical cardiovascular risk factors (Tullis et al., 1999) such as dyslipidemia, diabetes mellitus, and a history of tobacco use, whereas individuals with FMD are usually younger and have fewer cardiovascular risk factors. However, given that FMD can occur in older patients, age alone does not exclude the diagnosis. In addition to that renal atherosclerosis usually affect the proximal part of the renal artery (RA), unlike renal FMD which affect mid to distal part or even branches of RA. Another possibility is vasculitis like polyarteritisnodoso or Takayasu arteritis but patients with these conditions are exhibit constitutional symptoms with fever, malaise, and weight loss and have evidence of anemia, thrombocytopenia, and abnormalities of acute phase reactants. An exception might be in the setting of an acute infarction which may exhibit these symptoms.

FMD patients should be advised to quit smoking and avoid using estrogen therapy or any illicit drugs that might be increased risks of dissection or aneurysm rupture. Given the association of FMD with vascular aneurysms raises the question of vascular screening of other vascular beds and referral for endovascular or surgical procedures when indicated until present no clear evidence for that. Obtain complete family history including any vascular insults or sudden death in family members seems to be important to do further imaging screening for the patient or family members. Then according to symptoms, location and severity of arterial lesions, comorbidities and previous vascular events due to FMD determine the therapy. As mentioned before the most common manifestation of FMD is hypertension that’s due to renal artery stenosis. Options for treatment of hypertension include medical therapy alone or revascularization by either percutaneous transluminal angioplasty (PTA) or surgery (Slott and Olin, 2004). However, independent of angioplasty, hypertension should be treated. The underlying pathogenesis of hypertension includes activation of the renin-angiotensin-aldosterone system and, in patients with bilateral disease or retention of sodium and water in a patient with a single functioning kidney. The initial drug class of choice is an angiotensin-converting enzyme (ACE) inhibitor or angiotensin receptor blocker (ARB) (Tullis et al., 1999; Dworkin and Cooper, 2009; Olin et al., 2012). The goal for FMD related hypertension is the same as similarly aged hypertensive patients due to other etiologies. If goal blood pressure is not reached with angiotensin inhibition alone, other antihypertensive drugs should be added as necessary like diuretics or calcium channel blockers. All patients who started on ACE inhibitors or ARB should have frequent laboratory testing approximately one to two weeks after initiating an ACE inhibitor or ARB to assess for these potential side effects. The drug should be discontinued if acute kidney injury (i.e. Creatinine increased by 30%) occurs or if hyperkalemia develops that is severe and cannot be controlled with other means, such as dietary potassium restriction or diuretic therapy.

There are no randomized trials comparing revascularization with medical therapy alone in patients with renal FMD. Revascularization can be beneficial in selected patients with renal FMD and hypertension. An appropriate indication for revascularization in the setting of renal FMD was according to the 2014 Scientific Statement Writing Group. In a meta-analysis of 70 studies of revascularization in patients with FMD involving >2600 patients, Trinquart and colleagues demonstrated that younger age and shorter duration of hypertension are associated with an increased likelihood of cure with angioplasty or surgery (Trinquart et al., 2010). In addition, factors associated with a decreased likelihood of clinical benefit of (PTA) include abnormal renal function, smaller ipsilateral kidney, or metabolic abnormalities like abnormal fasting glucose or hyperlipidemia (Davies et al., 2008). The two options for revascularization include PTA, typically without placing a stent or Surgery. There are no comparative trials, but PTA achieves similar technical success and is associated with a lower risk of adverse events in observational studies. However, surgery is recommended if the arterial anatomy is not amenable to PTA as in patients with small renal arteries (<4 mm), with branch renal artery disease, or with extensive intimal fibroplasia. In addition, patients who fail PTA should have surgical repair.

FMD of the internal carotid and vertebral arteries occur with a similar frequency as a renal artery. FMD and may be associated with dissection, stenosis, intracranial aneurysm, transient ischemic attack (TIA) and stroke, or may be entirely asymptomatic. The treatment of cerebrovascular FMD also depends in part upon the absence or presence of symptoms. Antiplatelet therapy is reasonable in all patients as long as no contraindication to antiplatelet, most experts prescribe 81-325mg of aspirin or 75mg of clopidogrel as alternative (Brott et al., 2011). Percutaneous balloon angioplasty is recommended for patients with TIA or stroke if sites amenable for intervention or stenting in case of failed balloon angioplasty. For patients with carotid or vertebral artery dissection, treatment consists of heparin followed by warfarin in for 3 to 6 months, and then ultimately life long antiplatelet therapy has been recommended. Stenting is reserved for patients with a dissection who fail anticoagulation therapy. If there is an intracranial aneurysm present, then serial imaging (every 6 to 12 months) with magnetic resonance angiography (MRA) or computerized tomographic angiography (CTA) should be performed so that the aneurysm can be treated once it reaches a pre-specified size with covered stents or coil embolization.

In patients with as mesenteric, iliac, coronary and renal arteries, FMD is generally prescribed lifelong aspirin for thromboprophylaxis, although there are little data support this practice. In addition, FMD in these locations is treated with revascularization (usually percutaneous transluminal angioplasty [PTA]) only in symptomatic patients (e.g., those patients with...
claudication, intestinal ischemia, coronary ischemia). Aneurysms can be treated with covered stents, coil embolization or surgical resection when the size warrants such treatment.

5. CONCLUSION
Fibromuscular dysplasia is a disorder that can affect any medium-sized arteries in the body, commonly renal and internal carotid arteries. It can cause a number of complications like hypertension or tears of the artery (dissection) like in Case 1 or infarction of affected organ as in Case 2 if left untreated. FMD diagnosed by pathognomonic angiographic appearance. All patient with FMD should complete screening of other vascular involvements including for intracranial aneurysm at least once with MRA or CTA, Then subsequent imaging surveillance is customized to the location and severity of arterial lesion identified. Treatment of FMD is according to symptoms, location, and severity of arterial lesions, comorbidities, and previous vascular events.

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REFERENCE