Retrospective analysis of clinical outcomes in the management of patients with floating aortic thrombus

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Introduction
Floating aortic thrombus is a rare vascular presentation. Little is known about the underlying responsible pathology and natural history of this underreported condition.
Patients and methods
A retrospective analysis was done to review all cases diagnosed with idiopathic floating aortic thrombus, presented to our hospitals during the period from March 2016 to March 2021. All collected material were processed to analyze demographic data, presenting symptoms, risk factors, diagnostic modalities, management strategies, and outcome over mid-term and long-term follow-up visits.
Results
This study included nine patients, four (44.4%) males and five (55.6%) females. Mean age: 63 ± 12.2 year; one patient was under active cancer treatment and another patient was recently recovering from coronavirus disease 2019 infection. All patients had average follow-up for 3–36 months. Most of the patients had the thrombus at the infrarenal aortic segment (three patients), while two had the thrombus at the distal aortic arch; two at the thoracic segment and two at the visceral aortic segment. All patients were presented with manifestations of distal arterial embolization. Extremity embolization was seen in seven (77.8%) patients and visceral embolization in two (22.2%) patients. All patients were started on unfractionated heparin, five (55.6%) patients needed surgical and or endovascular interventions during hospitalization, while four (44.4%) patients were managed conservatively. Two (22.2%) patients needed initial surgical thrombectomy for acute mesenteric/limb ischemia, while three other patients needed percutaneous aspiration thrombectomy with balloon angioplasty and stent insertion. Inhospital distal embolization occurred in two (22.2%) patients for whom stent grafts of the proximal aorta were inserted to exclude floating thrombus. All patients showed thrombus regression over a period of 1–3 months with no recurrent embolic events on successive follow-up.
Conclusion
Floating aortic thrombus (free-floating thrombus) is a serious condition. Initial anticoagulation is followed by revascularization of the ischemic organ if applicable followed by definite treatment of the thrombus with endovascular catheter-based approaches if possible has an overall good outcome.

Keywords:
anticoagulation, covered stent, embolization, endovascular, floating aortic thrombus, peripheral embolization

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Introduction

Idiopathic free-floating thrombus (FFT) of the aorta is a rare vascular disease, but it can lead to catastrophic consequences. The initial presenting manifestations are usually cerebral symptoms or organ ischemia due to peripheral thromboembolism. Optimal management protocol is not yet established in the available literature [1]. While formation of intra-aortic thrombus is a common finding in the diseased aorta (due to aneurysm formation or dissection), this is rather a rare finding in apparently normal aorta [1]. Although the exact pathogenesis of this condition remains unclear hypercoagulable status is a suspected underlying cause in some cases, while others have no identifiable risk factors [2]. These patients might present with systemic, peripheral embolization or both, some silent cases are diagnosed during workup for nonrelated condition [2]. Initial assessment of thromboembolism in some cases revealed floating aortic thrombus as the source of embolism [3]. Surgical thrombectomy, thrombolysis, and endovascular procedures are the main common primary treatments for FFT [3]. The most common aortic segments affected by FFT reported in clinical studies are the descending thoracic aorta and the aortic arch. Detailed etiopathological mechanisms are not yet

fully understood [2]. About 100 cases were reported in published literatures, most of those publications were anecdotal reports [1–3]. Here, we report our experience with a group of patients with idiopathic FFT, who were managed successfully at our departments with no recurrence of aortic thrombosis or relapse of symptoms.

Aim

Review of our institutional experience in the management of idiopathic aortic floating thrombus against the available mid-term and long-term outcomes to assess the best ways of management of such serious presentation.

Patients and methods

We run a retrospective review of our hospitals medical files archive in our Vascular Surgery Unit in Cairo University Hospital (Kasr Al-Ainy Hospital) in addition to another two major tertiary care centers in Saudi Arabia (Saudi German Hospital, Dammam Branch and Soliman Fakeeh Hospital, Jeddah) searching for all patients diagnosed with idiopathic floating aortic thrombus, who have been referred to the Vascular Surgery Departments during the period from March 2016 till March 2021. Patients were diagnosed with floating aortic thrombus based on results of multidetector contrast-enhanced computed tomography angiography (CTA) either incidentally or during workup for the diagnosis of peripheral and/or systemic (visceral or cerebral) thromboembolism disease when a mass plugging inside the descending thoracic or abdominal aorta with the nonattached part was found in a parallel-wall nonaneurysmal aorta with no dissections or history of related trauma. Patients with mural thrombus in an otherwise aneurysmal aorta, cases of aortic localized thrombosis related to trauma or aortic dissection, and cases of total intraluminal aortic thrombosis were excluded from the analysis as well as patients presented by peripheral and/or cerebral ischemic manifestations secondary to arterial embolic events without radiological evidence of primary floating aortic thrombus at the time of presentation. The data was collected and analyzed for epidemiological data, risk factors, presenting manifestations, diagnostic workup tools, commenced lines of treatment, and final management outcomes. All patients' data were retrieved from the electronic medical files and being a retrospective review, patients' informed consents were waived. The research was approved by the hospital quality office and medical board committee in both hospitals.

Results

Nine patients, four males and five females (mean age±SD 63 ± 12.2 years) were found; five patients were known with diabetes mellitus, four patients were suffering from primary (essential) hypertension, one patient reported chronic heavy smoking, thrombophilia screening was positive in three patients, one patient had active cancer disease, one patient gave a history of previous coronary artery bypass grafting, and one another patient has recently recovered from coronavirus infection (coronavirus disease 2019). All patient's demographic data are summarized in Table 1.

The diseased aortic segments as depicted from the axial cuts of cross-sectional images was as follows: distal aortic arch in zones 2 and 3 in two patients, descending thoracic aorta distal to the origin of left subclavian artery (LSA) in two patients (one of them had floating thrombus in two different sites of the thoracic aortic segment), abdominal visceral aortic segment in two patients, and infrarenal segment of the abdominal aorta in three patients. Distribution of the affected aortic segments is summarized in Table 2.

As regards the presenting clinical pictures of the affected patients, all the nine patients presented with end-organ ischemia as shown in Table 3.

Regarding the distal showering complication of the floating aortic thrombus, the superior mesenteric artery (SMA) was found occluded in one patient

Table 1 Patient's demographic data

	n (%)
Age	61 ± 6 years
Male	4 (44.4)
Female	5 (55.6)
Diabetes mellitus	5 (55.6)
Hypertension	4 (44.4)
Smoking	1 (11.1)
Thrombophilia	3 (33.3)
Active cancer	1 (11.1)
Post-COVID-19	1 (11.1)

COVID-119, coronavirus disease 2019.

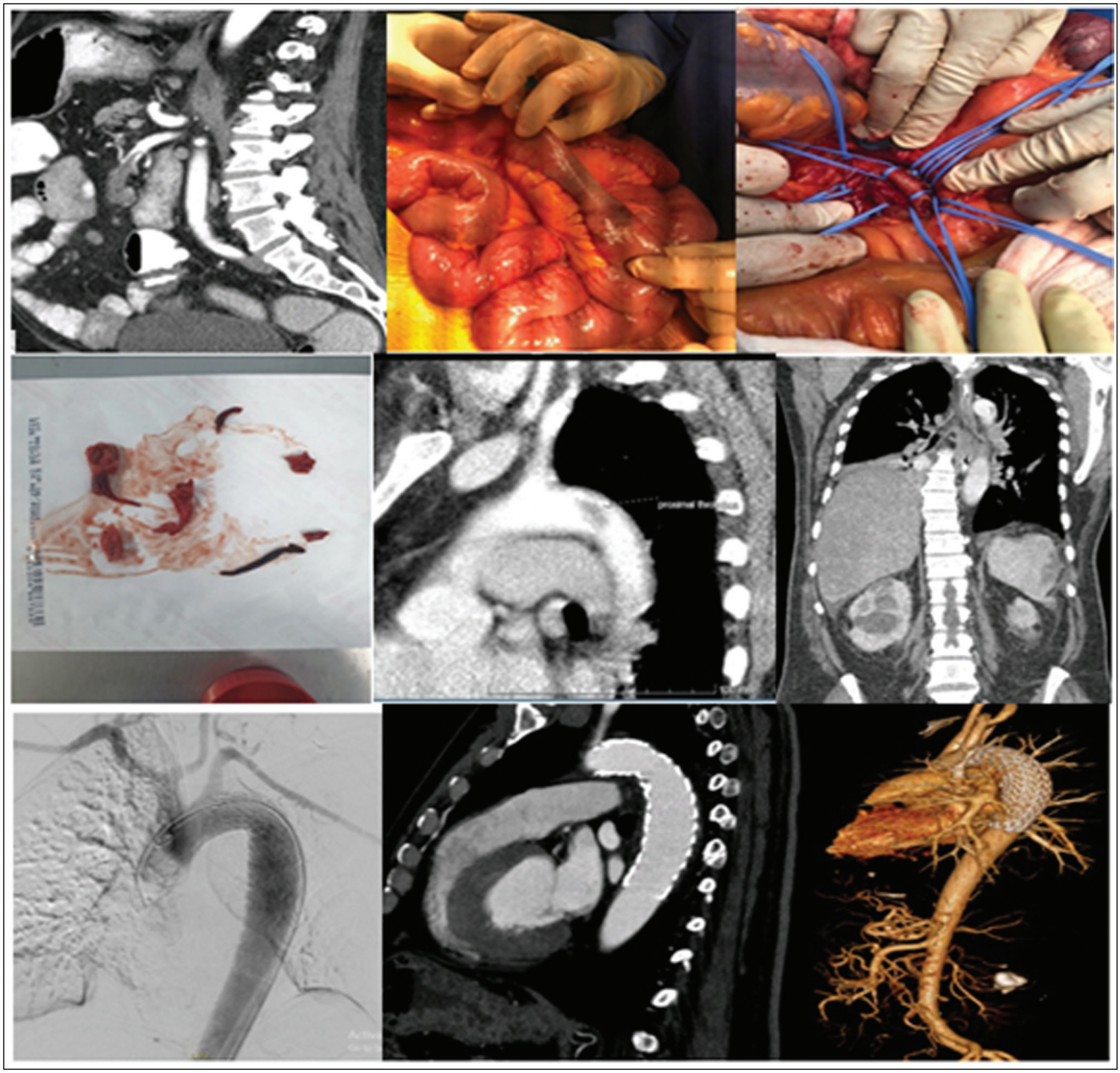
Table 2 Sites of the affected aortic segments

Anatomical segment	*n* (%)
Distal aortic arch (zones 2/3)	2 (22.2)
Descending thoracic aorta	2 (22.2)
Visceral segment of abdominal aorta	2 (22.2)
Infrarenal segment of abdominal aorta	3 (33.3)

Table 3 Patient classification and presentation

Presentation	*n* (%)
Mesenteric ischemia	1 (11.1)
Renal infarction	2 (22.2)
Upper limb ischemia	2 (22.2)
Lower limb ischemia	5 (55.6)

Figure 1

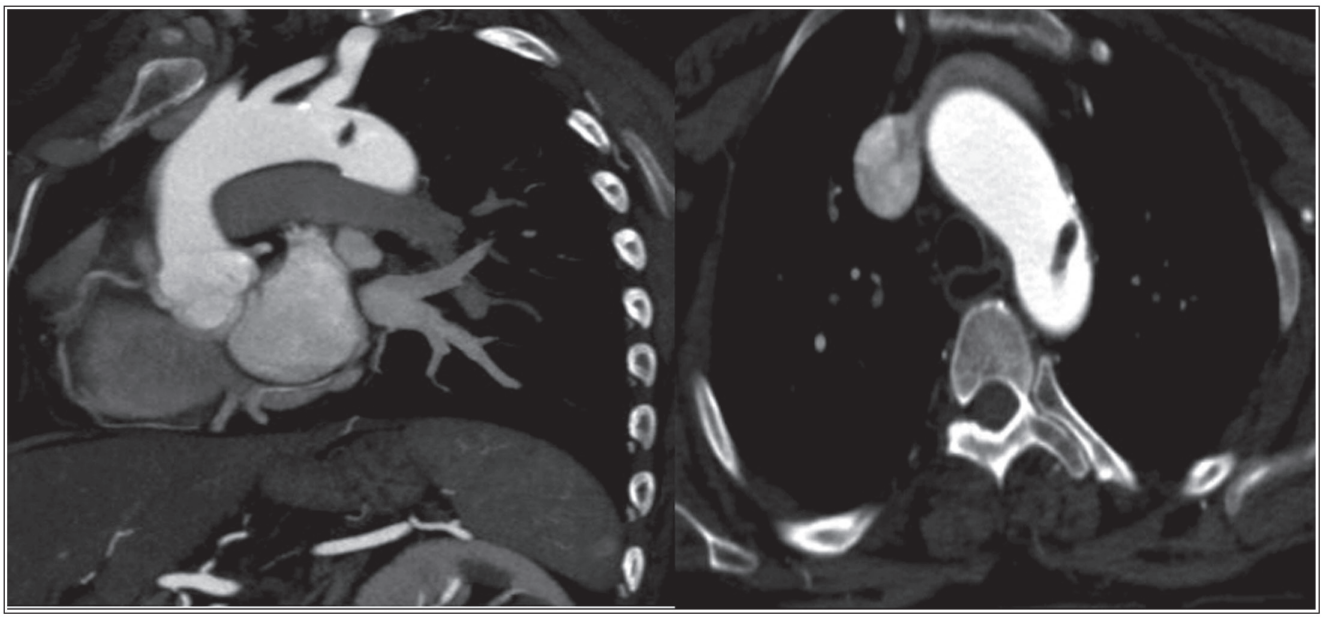


A 59-year-old male patient presented with acute mesenteric ischemia with CTA showing superior mesenteric artery (SMA) occlusion. Exploration of the SMA was done; we found embolic occlusion of the SMA just distal to the middle colic branch. Embolectomy was performed with improvement of intestinal perfusion without the need for bowel resection. The free-floating thrombus distal to the left subclavian artery was thought to be the source. Despite therapeutic anticoagulation, the patient developed inhospital lower limb embolic ischemia; so, exclusion of the thrombus was done with the use of thoracic aortic stent graft. Postoperative follow-up CTA showed complete resolution of the problem. CTA, computed tomography angiography.

(Fig. 1), left renal artery in two patients, right common iliac artery in one patient (Fig. 2), popliteal artery in four patients, tibial artery in two patients, LSA in one patient, and left ulnar artery in one patient. Despite embolic occlusion of the above-mentioned arterial territories, only few patients were suffering from severe acute ischemic complications of the affected regions as one patient had mesenteric ischemia, one patient had radiological documented renal infarctions with lumbar dull aching pains but without laboratory evidence of renal function deteriorations, two patients had acute left upper limb ischemia of Rutherford stage I, and five patients had acute lower limb ischemia of Rutherford stage I/IIa. The affected distal arterial locations are summarized in Table 4.

The management plan differed according to the individual patient's clinical conditions with some patients needing urgent initial surgical procedures or minimally invasive interventions as follows (Table 5):

Figure 2



Two different cases of infrarenal floating aortic thrombus, one patient presented with right iliac artery embolic occlusion (left photo), the other one presented with recurrent popliteal embolism (right photo).

Table 4 Site of distal embolization

Distal embolization site	*n* (%)	Presenting symptoms
Isolated left renal artery	1 (11.1)	Renal infarctions
Isolated right common iliac artery	1 (11.1)	Lower limb ischemia (compensated)
Isolated popliteal artery	1 (11.1)	Lower limb ischemia
Isolated left subclavian artery	1 (11.1)	Upper limb ischemia
Isolated left ulnar artery	1 (11.1)	Upper limb ischemia
Combined SMA, splenic, and renal arteries	1 (11.1)	Acute mesenteric ischemia and renal infraction
Bilateral popliteal arteries	1 (11.1)	Bilateral acute lower limb ischemia
Combined tibial and popliteal arteries	2 (22.2)	Acute lower limb ischemia

SMA, superior mesenteric artery.

Table 5 Urgent management procedures

Management	*n* (%)
Initial surgical intervention	2 (22.2)
Initial endovascular intervention	3 (33.3)
Initial conservative management with anticoagulation with later endovascular intervention	3 (33.3)
Conservative management with anticoagulation only	1 (11.1)

(1) The patient who presented by acute abdominal pain with evidence of acute mesenteric ischemia with bowel infraction due to embolic occlusion of SMA had undergone an urgent laparotomy with thromboembolectomy of SMA using Fogarty's balloon thrombectomy catheter (4/3 French) (Fig. 1) with no bowel resection performed for ischemic bowels due to absence of bowel gangrene.

Figure 3

Floating aortic thrombus seen distal to the origin of the left subclavian artery (LSA) with evidence of distal showering causing acute left upper limb ischemia (right side). Follow-up CTA after 1 month of catheter-based aspiration thrombectomy followed by therapeutic anticoagulation showing marked resolution of the thrombus (left side). CTA, CTA, computed tomography angiography.

(2) Patients with acute limb ischemia (Fig. 3) have undergone percutaneous catheter-based aspiration thrombectomy using the Indigo pump aspiration machine (Penumbra Inc., Alameda, California, USA) with or without balloon angioplasty and

stenting for the affected artery to regain an acceptable blood flow to the affected limb as shown by the final completion angiography done at the end of the procedures.

(3) Other than initial urgent interventional procedures, all patients started on therapeutic doses of parenteral anticoagulation with unfractionated heparin at a maintenance dose of 18–20 IU/kg/h and were kept under close observation in an intermediate care unit. Despite being on therapeutic anticoagulation, two patients had inhospital embolic events that were managed conservatively denoting unstable aortic thrombus with embolic potentials. For these two patients, exclusion of the index aortic thrombus was done by insertion of a covered stent in the affected aortic segment (thoracic aorta in both patients) using the standard percutaneous thoracic endovascular aortic repair technique (Fig. 1).

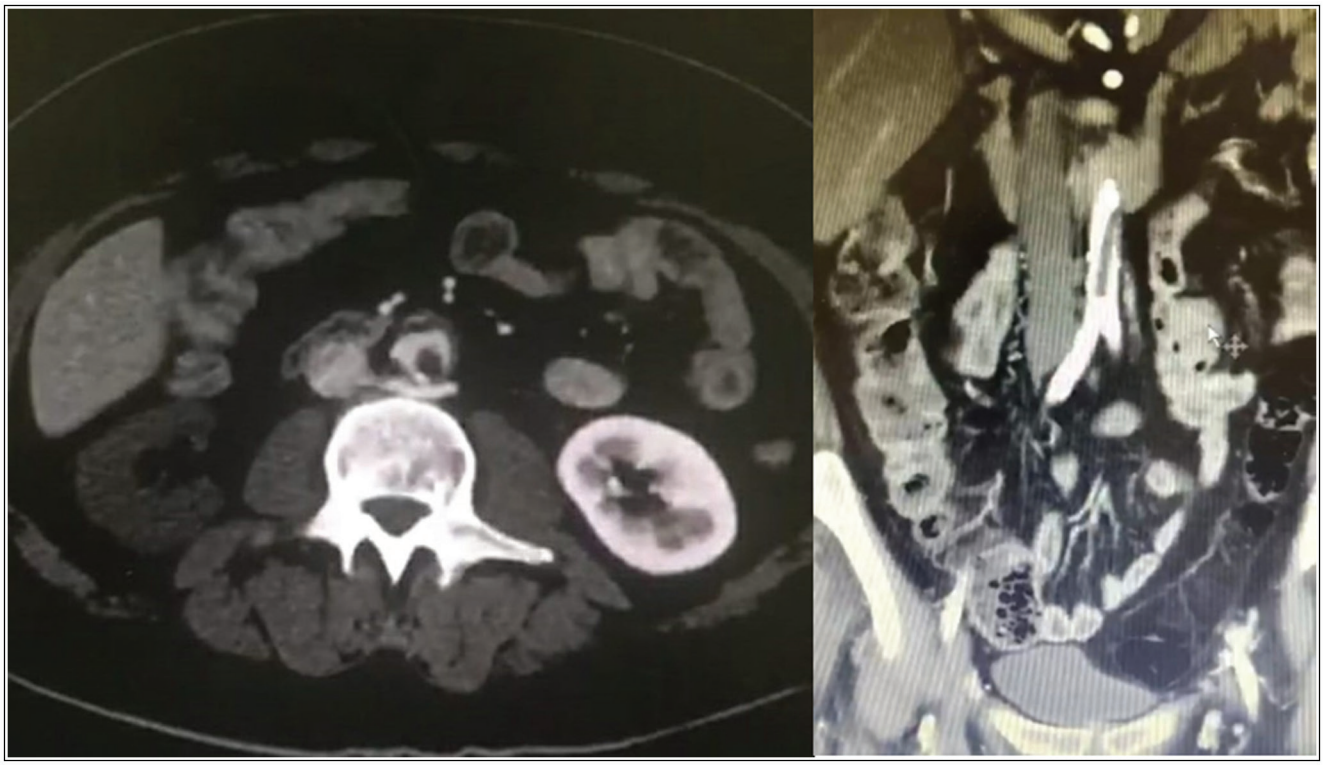
(4) For patients who had undergone interventional procedures followed by angioplasty, they all were shifted to oral anticoagulation with either new oral anticoagulants (NOACs) or vitamin-K antagonists drugs in one patient only after 1 week as home medication with addition of single antiplatelet drug (e.g. clopidogrel 75 mg once daily) and discharged home after confirming no further complications from the aortic thrombus with evidence of gradual regression of the thrombus on the serial follow-up CTA. Other patients who had not undergone any interventional catheter-based angioplasty procedures and those who were managed conservatively (Fig. 4) were discharged on the same regimen without antiplatelet drugs. For types of adjunctive therapy see Tables 6 and 7.

(5) The duration of anticoagulation therapy was dependent in many cases on the underlying individual patient's diagnosis and the type of management each patient had received together with the associated risk factors. Broadly speaking, it ranged between 3 months in some patients to long-term in other patients. The anticoagulants that were given was NOAC in eight patients (Apixaban, Rivaroxaban, or Dabigatran), while only one patient was kept on warfarin according to hematologist recommendation. Antiplatelet therapy for 6 months was given to all patients who received endovascular treatments in combination with NOACs (four patients).

(6) All patients had undergone follow-up CTA in a period of 3 months after discharge with radiological evidence of various grades of complete or partial thrombus regression except in one patient with stationary thrombus load while on noncomplicated clinical course.

(7) Follow-up visits were registered at 6 months in two patients, 12 months in one patient, 13–24 months in three patients, and more than 24 months in

Figure 4



Large floating aortic thrombus arising near the renal artery origin (juxta renal). The patient presented with the left renal infarction and was managed conservatively with anticoagulation therapy alone.

Table 6 Type of adjunctive anticoagulation therapy

Patient group according to the adjunctive therapy	Type	*n* (%)
Conservative group	NOAC	1 (11.1)
Surgical or endovascular aspiration with no angioplasty.	NOAC or VKA	3 (33.3)
Endovascular intervention with angioplasty±stent insertion.	NOAC+clopidogril	5 (55.5)

NOACs, new oral anticoagulants; VKA, vitamin-K antagonists.

Table 7 Duration of anticoagulation therapy

Duration of anticoagulation	Number	Indication
3–6 months	4	Active cancer (1 patient)
		Symptomatic presentations without risk factors (2 patients)
		Post-COVID-19 (1 patient)
Long term (>12 months)	5	Positive thrombophilia screening
		Conservative group

COVID-119, coronavirus disease 2019.

Table 8 Follow-up CT angiography at 3 months

Follow-up CTA (at 3 months)	*n* (%)
Complete thrombus regression	4 (44.4)
Partial thrombus regression	2 (22.2)
Stationary thrombus	1 (11.1)
Exclusion of the thrombus with covered stent	2 (22.2)

CTA, computed tomography angiography.

three patients with all patients having no clinical or radiological evidence of recurrent thromboembolic events. Table 8 summarizes the results of follow-up CTA done at 3-monthperiods.

Discussion

Mural thrombi within the thoracic or the abdominal aorta and ulcerated atherosclerotic aortic plaques are the most frequent noncardiac causes of arterial embolization, but a FFT within the aortic lumen is a relatively rare clinical entity [4,5]. Imaging modality of choice for the diagnosis of FFT includes CT aortography (CTA) followed by transesophageal echocardiography. CTA preferentially permits visualization of thoracic and abdominal aorta, supra-aortic branch vessels, presence of aortic wall calcifications, and distal arterial embolization sites. Thrombi inside the cardiac chambers, ascending aorta, and aortic arch regions are well visualized by transesophageal echocardiography. It permits differentiation between floating and adherent thrombus as well as assessment of atherosclerotic processes in the proximal part of the aorta [6]. The treatment of FFT in the aorta is still debatable and there is no robust data or consensus between authors regarding therapy recommendations [2,7]. Because of rarity of available data and experience, no specific treatment guidelines exist for the optimal management of mobile aortic thrombus. In several reports, therapeutic anticoagulation alone successfully resolved the thrombus without the need for any morbid interventions [8,9]. The success of anticoagulation alone has been largely attributed to the high prevalence of coagulation abnormalities in patients with floating aortic thrombi. Despite success of anticoagulation, there are no widely established evidence-based recommendations on the use of either anticoagulants or antiplatelet agents in the management of such rarely encountered lesions [10]. Catheter-based aortic interventions has recently become the treatment of choice in many aortic pathologies including aneurysm, dissection, penetrating atherosclerotic ulcer, traumatic dissection, and intramural hematoma. However, few reports have been published regarding endovascular stent-graft treatment of mobile aortic thrombi [11,12]. Even though the outcome was favorable in all cases, the risk of distal artery embolization during guide wire navigation, and further during passage of the large stent graft delivery sheaths could be a major drawback for safe endovascular treatment [13]. On the contrary, a more aggressive approach with open-aortic surgical repair under left ventricular bypass with hypothermic circulatory arrest has been attempted as a definite treatment of floating aortic thrombus in some publications. A meta-analysis of 200 patients with aortic mural thrombus in a nonaneurysmal aorta with minimal atherosclerotic changes were reviewed by Fayad *et al*. [14]. It showed that 112 patients were managed conservatively while 88 patients were treated through open surgical thrombectomy. Open surgical thrombectomy was found to have better outcome in terms of recurrence and/or persistence of aortic thrombus with lower complication rates (like limb loss) than anticoagulation therapy alone. Moreover, 25% of patients of the conservative treatment arm were found to have undergone secondary aortic surgery due to recurrence of peripheral arterial embolization. Weiss *et al*. [15] reported the outcome of 10 patients with free-floating aortic thrombi for whom open-aortic thrombectomy was carried out in six patients utilizing the left cardiac bypass with hypothermic circulatory arrest with uneventful postoperative course with no recurrence or embolic complication for 5 years postprocedure.

In this retrospective review, we represented nine cases of this rare vascular diagnosis that had come with different clinical presentations over a period of 5 years in our Vascular Surgery Unit at Cairo University hospitals in addition to two major tertiary care hospitals in Saudi

Arabia. A considerable number of those patients were initially presented with serious limb-threatening or life-threatening manifestations related to extremity and/or mesenteric artery embolization. The serious problems of threatening limb or mesenteric ischemia draws the attention for the need of a standardized evidence-based protocol of management, which we tried to outline in this review based on our local institutional experience with this relatively small number of cases. Our patients presented with visceral and distal embolization without aneurysmal changes in the involved segment of aorta. Management ranged from anticoagulation for sessile, small thrombi to endovascular stent grafting for large aortic thrombus outside the visceral aortic segment, but no open surgical aortic thrombectomy was attempted, given the high risks involved with such morbid procedures.

In our review, patients with FFT presented initially with either severe limb ischemia (seven patients), mesenteric ischemia (one patient), or renal infraction (Tables 3, 4). Only two patients were considered for stent grafting due to inhospital distal arterial embolization events despite being on therapeutic anticoagulation, which explained the instability of the floating thrombus and gave us alarms for the possibility of further embolization events. Procedures for stent-graft therapy were carried out after management of acute events (e.g. peripheral thromboembolectomy). The thrombus was poorly visible on initial aortic angiography being partially occlusive and because of that, the landing zones of stent grafts were marked by the use of fixed anatomical points like vertebral bodies, origins of LSA, and celiac artery origin, which was decided preoperatively during procedural planning utilizing the CT aortography. However, in one case the thrombus shadow was seen on initial aortography using a catheter inserted from the LSA. The maximum stent graft oversizing was not more than 5% and no balloon dilation was attempted to avoid thrombus fragmentation. We insured at least 2 cm graft coverage on both ends of the thrombus as a safety zone to avoid thrombus from being squeezed out, resulting in recurrent distal embolization.

Although the exact etiology of FFT of the aorta is till idiopathic, some previous studies have found early atherosclerotic plaques at attachment sites of the thrombus with the aortic walls. Therefore, arteriosclerosis should be suspected as a causative pathology in every patient presented with aortic FFT, especially those who have risk factors for atherosclerosis [16,17]. Because of that, measures for secondary prevention of cardiovascular risks is probably indicated in all patients, like lifelong aspirin and statin therapy, but there is no good quality evidence for that recommendation. Also, thrombophilia problems seem to be prevalent in patients with floating aortic thrombi, which emphasizes the importance of hematologic workup. Despite this fact, there are no robust recommendations on anticoagulation and antiplatelet therapy in patients with floating aortic thrombus as regards the duration and dosing.

For early diagnosis of this fatal vascular disorder, we have searched the literature but unfortunately, early diagnosis depends largely on routine screening of high-risk individuals. However, the disease being idiopathic and extremely rare, no high-risk group could be identified to help starting a regular screening program except in patients with thrombophilia disorders, who are already kept on life-long anticoagulation therapy with no available cost–benefit studies to assess the value of early diagnosis. The only available recommendation found is to start a life-long therapeutic anticoagulation therapy for any case with suspected thrombophilia problem [2].

The original number of cases that were retrieved from medical files was 21 cases that included both symptomatic and asymptomatic cases, but we have excluded asymptomatic cases that were accidently discovered as most of that cases were primarily managed by watchful observation and full therapeutic anticoagulation with complete resolution of the aortic thrombus later on during follow-up periods, a management that is traditionally used by all vascular surgeons.

Adding the asymptotic cases to our analysis will add nothing to what is usually practiced by all vascular society but will falsely disturb our results. We have instead spot the light on symptomatic cases only that were presented and/or referred to us by objective manifestations. We have tried to explore the results of our various management plans for those cases to pave the way to our colleagues to know how to approach such a rare vascular problem in the absence of clear recommendations or guidelines in the literature. The number of symptomatic cases was relatively small (nine cases) because this problem in its entirety (symptomatic and asymptomatic) is extremely rare and symptomatic cases specifically are furthermore rare. Our results are not aiming to give solid recommendations as it is hard with this small number of cases to do that, but we are aiming to present our experience with those cases to the surgical society to help other vascular surgeons to build up on and decide their own management plans accordingly should any one was faced with this problem in the future.

The main limitations of this study were its retrospective pattern and the relatively small sample size which were largely attributed to the rarity of such vascular problems. Furthermore, because there was no standard protocol in the literature for such patients, our management was largely guided by the individual patient's presentation.

Conclusion

Floating aortic thrombus is a potentially serious condition. Based on our review data and the available previous publications there is no robust recommendations for a standard therapy. Each case should be evaluated separately on individual basis and the management plan can be initiated then. Therapeutic anticoagulation seems to be a wise decision to start with, followed by revascularization of the affected organs or limbs using surgical or percutaneous catheter-based techniques if applicable. Other specific interventional therapies can be planed based on each case scenario. Endovascular thrombus exclusion by stent grafts (if indicated) is a safe and good option with excellent results in selected cases.

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Conflicts of interest

There are no conflicts of interest.

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