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Case Report

Fat embolism in the popliteal vein detected on CT: Case report and review of the literature ☆

*Tucker Burr, MD, Hamza Chaudhry, MD, Cheryl Zhang, BA, Vasilios Vasilopoulos, RT(R), CIIP, Emad Allam, MD**

Loyola University Medical Center, Department of Radiology, 2160 S 1st Ave, Maywood, IL 60153

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ABSTRACT

Fat emboli are a common phenomenon, but are rarely detected or reported on extremity CT imaging. We present a case of fat embolus in the popliteal vein in the setting of a femoral fracture. This is the most distal fat embolus described in the literature. There are no guidelines regarding intervention if a fat embolus is detected in a peripheral vein on CT. A review of all the previous cases of peripheral fat emboli is presented for reference.

Background

The phenomenon of fat embolism is well-established, having been described separately in humans in the 1800s by von Bergmann and Zenker [1,2]. Fat embolism is the presence of macroscopic fat within vasculature. The incidence is high following trauma, reported at 90% on histologic examination by Eriksson et al [3]. Important clinical sequelae including pulmonary and neurologic complications are also well documented. It is rare, however, to encounter venous fat at the site of trauma on imaging. In our literature search we encountered only ten case reports of fat emboli in the venous system detected on computed tomography (CT) imaging to date, including one in the inferior vena cava (IVC) (Table 1) [4–13]. Note that symptoms and signs and even imaging findings of fat emboli are often difficult to distinguish from those of concurrent trauma. Here we share a rare case of macroscopic fat embolism clearly identified adjacent to the site of trauma within the venous circulation on CT after trauma.

Case presentation

A 52-year-old male with no significant medical history presented as a level 2 trauma transfer after a 15 foot fall from

☆ Formal consents are not required for the use of entirely anonymised images from which the individual cannot be identified- for example, xrays, ultrasound images, pathology slides or laparoscopic images, provided that these do not contain any identifying marks and are not accompanied by text that might identify the individual concerned.

* Corresponding author. (E. Allam)
E-mail address: emad.allam@lumc.edu (E. Allam).

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Table 1 – Tabulation of reported cases of fat emboli in-transit, including our current case.

Case Report	Age	Sex	Fracture location	Fat embolus location	Maximum size	% luminal diameter of fat embolus*	Fat-fluid level	Intervention for fat embolus	FES Symptoms†
Liu P, et al. 1990	15	M	Bilateral femora	IVC just above bifurcation	3 cm	30%	Yes	None reported	Pulmonary
Harris AC, et al. 2000	18	M	Left femur, pelvis	Left common femoral vein	0.9 cm on ultrasound	50%	Yes	Surgical venotomy with no fat embolism found, prophylactic anticoagulation	None
Roson N, et al. 2008	64	F	Right femur, pelvis	Right common and superficial femoral vein	1 cm on first CT, 6 cm on second CT	90%	No	IVC filter, surgical thrombectomy	None
Vasconcelos V, et al. 2015	22	M	Left femur	Left femoral vein and IVC	Not measured	20%	Yes	IVC filter, surgical thrombectomies, therapeutic anticoagulation	Pulmonary
Healy N, et al. 2015	20	M	Right femur, left tibia and fibula, pelvis	Right common femoral vein	Not measured	30%	Yes	None reported	Pulmonary
Sousa I, et al. 2017	22	M	Right femur, tibia, and foot	Right common femoral vein	Not measured	<50%, two separate fat globules	No	None reported	None
Chowdhary V, et al. 2017	51	M	Right tibia and fibula	Right superficial femoral vein	6.8 cm	50%	Yes	None reported	None
Moliere S, et al. 2018	18	M	Left femur	Left common femoral vein, with migration to left external iliac vein	<1 cm	50%	Yes	Steroids	Pulmonary and neurologic
Lee H, et al. 2018	48	M	Right femur and tibia, pelvis	Right common iliac vein	Not measured	60%	Yes	IVC filter	None
Ayoobi-yazdi N, et al. 2020	21	F	Bilateral femora	Right external iliac vein	Not measured	70%	No	Prophylactic anticoagulation	Pulmonary
Burr T, et al. 2020 (current article)	52	M	Right femur	Right popliteal vein	2 cm	70%	No	Prophylactic anticoagulation	None

* Based on images provided.

† It may be difficult to differentiate post-traumatic symptoms from fat embolism syndrome (FES) symptoms, particularly pulmonary.

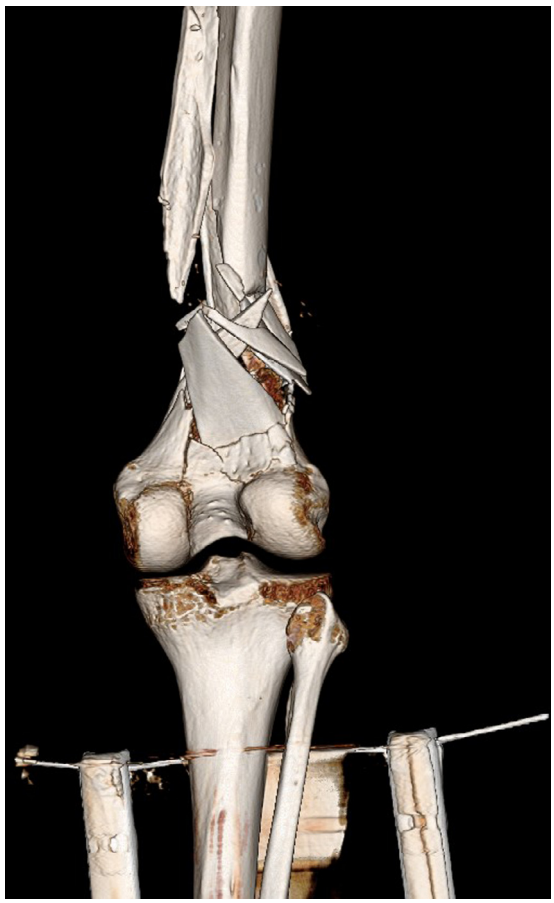

Fig. 1 – Three-dimensional volume-rendered reconstruction of CT showing comminuted and displaced intra-articular distal femoral fracture from a posterior view. Traction pin is present in the tibia.

a roof at work, sustaining an open right distal femoral intra-articular fracture and a left proximal humeral fracture. The patient did have a greater than 40 pack-year history of smoking.

Imaging findings

A non-contrast CT scan of the right femur including the knee joint was performed for further characterization of the fracture with slice thickness of 1.25 mm utilizing bone and soft tissue kernels. The CT was obtained in traction, with a pin through the proximal tibia. The three-dimensional reconstruction images show the extent and severe comminution of the distal femoral fracture (Fig. 1). Soft tissue windows delineate vascular structures including the popliteal vein which contained focal intraluminal hypoattenuation matching that of subcutaneous fat (approximately -77 Hounsfield units), compatible with popliteal vein fat embolism, presumably arising from the distal femur marrow (Figs. 2 and 3). The fat embolism measured 0.5 by 0.5 cm in axial dimensions and approximately 2 cm in craniocaudal dimension, occupying up to

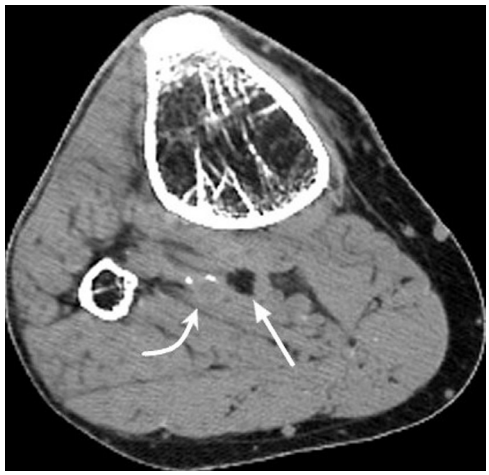

Fig. 2 – Axial CT image at the level of the proximal tibia and fibula. Macroscopic fat within the popliteal vein compatible with fat embolus (straight arrow). Other than small foci of peripheral atherosclerotic calcification, the adjacent popliteal artery (lateral to the vein at this level) appears normal on this non-contrast CT (curved arrow).

Fig. 3 – Sagittal CT image. Fat embolus within the popliteal vein (straight arrow), posterior to the level of the proximal tibia. Compression of the popliteal vein by a posteriorly displaced femoral fracture fragment, above the level of the embolus (curved arrow). Gas within the femoral fracture and knee joint (*).

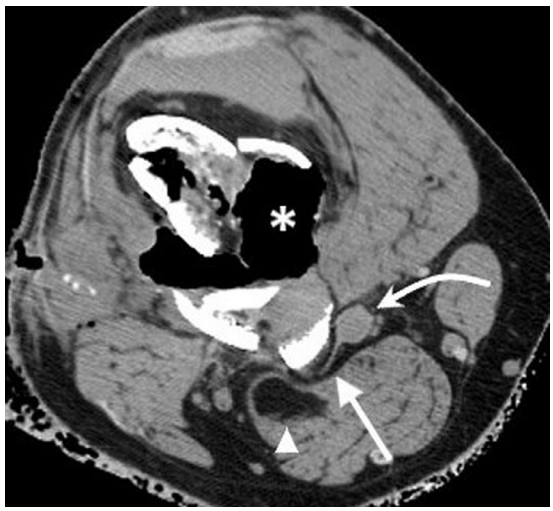

Fig. 4 – Axial CT image at the level of the distal femur. Severe compression of the popliteal vein by a posteriorly displaced femoral fracture fragment, with the popliteal vein assuming a linear slit-like appearance (straight arrow). Adjacent popliteal artery (medial to the vein at this level) is patent and round (curved arrow). Gas within the femoral fracture compatible with open fracture (*). Small lipoma in the semimembranosus muscle (arrowhead). Hemorrhage within the suprapatellar knee joint is partially imaged.

70% of the diameter of the vein, with a tapered appearance superiorly. Additional smaller foci of fat were seen in the vein proximally. No linear fat-fluid level was seen within the vein. Unrelated to the fat embolism, the popliteal vein was severely compressed by a femoral fracture fragment proximal to the fat embolism (Figs. 3 and 4), raising concern for migration of the popliteal vein fat embolism following reduction of the femoral fracture and decompression of the adjacent popliteal vein. Note that the fat embolism was distal to the fracture site, at the level of the tibia rather than the femur. Lack of intravenous contrast limited evaluation for vascular injury. Lipohemarthrosis and gas were present in the knee joint. No imaging of the right distal tibia/fibula or right ankle/foot was obtained. Chest CT with contrast at the time of admission obtained as part of trauma survey (3 hours prior to the femur CT) showed no pulmonary embolism or pulmonary opacities.

Treatment and follow-up

Upon discovery of the fat embolism, vascular surgery was consulted with recommendations to obtain duplex ultrasound and administer anticoagulation post-surgery. IVC filter placement was not considered necessary given lack of strong evidence to support such an intervention in the setting of fat embolus. ORIF of the femoral fracture was performed without complication approximately 24 hours after admission. Anticoagulation with enoxaparin at prophylactic dose (30 mg subcutaneous injection every 12 hours) was started on postoperative day 4 following femoral ORIF (postoperative day 1 following humeral ORIF). Sequential compression devices were applied throughout hospitalization.

A duplex ultrasound of the right lower extremity on postoperative day 3 following femoral ORIF demonstrated a patent popliteal vein without embolus (Fig. 5). No shortness of breath or altered mental status was noted during his hospital stay. The patient did not require mechanical ventilation or supplemental oxygen postoperatively. No follow-up chest imaging was obtained. The patient was discharged home on postoperative day 13 following femoral ORIF on a prophylactic dose of enoxaparin (40 mg subcutaneous injection daily for 7 days). On follow-up orthopedic visit three months later, the femoral fracture was healing, and no systemic symptoms were noted.

Discussion

Fat embolism is a widely recognized and encountered complication after trauma and orthopedic surgery, most commonly involving a large long bone such as the femur. Although rare and often clinically silent, the patient may develop significant clinical sequelae of Fat Embolism Syndrome (FES). This typically presents after 24-72 hours with a classic triad of respiratory distress, neurologic symptoms, and petechial rash.

Two theories attempt to describe the pathogenesis. A mechanical theory postulates that traumatically displaced bone marrow enters torn venules that remain tethered to the bone [14]. A biochemical theory postulates that intravenous fat degrades into toxic intermediaries with inflammatory effects, possibly explaining the classic 24-72 hour delay in symptoms [15,16]. Once within systemic circulation, fat cells may trigger prothrombotic aggregation within the lungs, or within cerebral circulation through paradoxical embolism or microembolism. Different grading systems have been proposed for FES, with worsening respiratory status being the most common criterion [17–19]. Nearly all described findings may be confounded in the setting of trauma. Nevertheless, FES is a serious diagnosis including respiratory symptoms and neurologic sequelae with potential for significant morbidity and mortality.

Fat embolism is likely a common phenomenon, but it is unclear why fat emboli in-transit have been rarely reported. Nearly all reported cases of peripheral fat emboli detected on CT have been published after 2014, suggesting that this phenomenon may have been infrequently imaged or underrecognized previously. Our case is the only reported case of a fat embolus seen distal to the fracture site. This is also the only case of fat embolism detected below the level of the knee, making it the most distal fat embolus reported in the literature. In our case, the fat embolus may have persisted in the lower extremity due to occlusion/near occlusion of the vein superiorly causing stagnation of blood flow and fortuitous detection of the fat embolus. Diagnosis of FES may be difficult due to delayed presentation and confounding symptomatology. Communicating the rare diagnosis of embolic fat in-transit within venous drainage to the clinician may increase suspicion and expedite diagnosis and treatment for FES. Major veins should be inspected on CT examination in the setting of trauma to exclude regional fat embolism.

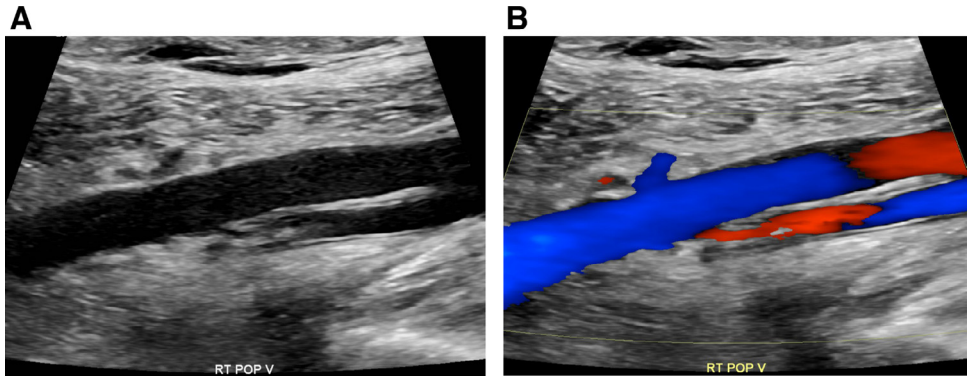

Fig. 5 – (A) Ultrasound image of the right popliteal vein demonstrates a patent vein without evidence of thrombosis or intraluminal fat. (B) Corresponding Doppler image of the right popliteal vein demonstrates normal blood flow.

There are no guidelines for prophylaxis of FES if an asymptomatic fat embolism in-transit is detected on CT. Retrievable IVC filter placement may be considered, although there is minimal evidence to support this intervention given the rare occurrence of this finding. There is a single case report showing an IVC filter clearly capturing a fat embolism on CT [20]. In regard to fat emboli, Lee et al [12] described placement of a retrievable IVC filter in a patient with right common iliac vein fat embolus seen on CT. The patient developed no signs or symptoms of fat emboli, and the IVC filter was removed 17 days after placement. Harris et al [5] reported surgical venotomy following detection of a fat embolus in the left common femoral vein, although no thrombus or fat was found on surgical exploration of the vein, with presumed fragmentation/migration of the fat in between the time of CT and surgical venotomy. Roson et al [6] reported a fat embolus in the right femoral vein increasing in size on serial imaging, prompting IVC filter placement and surgical thrombectomy. Vasconcelos et al [7] reported a large fat embolus in the left femoral vein and IVC, necessitating IVC filter placement and surgical thrombectomy.

Treatment of FES is supportive. The role of systemic anticoagulation and corticosteroids is controversial, as these have not proven to improve morbidity or mortality. In particular, heparin stimulates lipase activity and therefore increases the clearance of lipids from circulation, but the associated increase in free fatty acids could exacerbate the underlying proinflammatory physiology [21]. Since fat emboli often occur in the setting of trauma requiring surgery, anticoagulation may not be feasible until after surgery. Corticosteroids are also relatively contraindicated following surgery due to the risk of infection. Our patient was successfully given anticoagulation at a prophylactic dose without development of symptoms to suggest FES.

Of the ten previously reported cases of fat embolism detected on CT, five exhibited pulmonary and/or neurologic symptoms, although some pulmonary symptoms or requirement for mechanical ventilation may have been related to trauma rather than fat emboli [4,7,8,11,13]. Three patients were treated with IVC filters, two of whom also underwent surgical thrombectomy [6,7,12]. It is unclear if the size, shape, or location of the fat embolism seen on CT has any correlation with subsequent development of symptoms. The only documented case of fat embolism detected on imaging with subsequent development of both neurologic and pulmonary sequelae had a subcentimeter fat embolism in the extremity at the time of initial CT, showing that small fat emboli can be clinically significant [11]. Previous reports have not consistently mentioned the size of the embolus. Patient age and comorbidities may potentially play a role in whether the embolism becomes symptomatic or clinically significant. Fat embolus should be visible on ultrasound as a hyperechoic intraluminal lesion or small hyperechoic foci, and may be mobile [5,6,22]. Grayscale images should be analyzed carefully, as many of the sonographic criteria used to diagnose a DVT may be not be met by a fat embolus, including lack of compressibility, spontaneity, phasicity, and augmentation [23]. Negative duplex ultrasound 3 days after surgery in our case may be due to migration or fragmentation of the fat embolism previously seen on CT, and a negative test is therefore of limited value. Since fat is clearly discerned on non-contrast CT, further evaluation with a contrast-enhanced CT is unlikely to aid in diagnosis of fat embolus, although it may help detect concomitant vascular injury if this is a clinical concern.

Conclusion

Vigilance for fat emboli on extremity CT examinations obtained for fracture is advised, and these may even be present distal to the fracture site. The clinical significance of such fat emboli in-transit without associated symptoms is unknown, although our case suggests that such fat emboli could be incidental without clinical consequence. The rarity of this finding precludes evidence-based recommendations. IVC filter placement and possibly surgical thrombectomy may be considered, especially if the fat embolus is large or progressively increasing in size. The role of anticoagulation in fat embolism and fat embolism syndrome is controversial.

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