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CASE REPORT

Successful carbon dioxide angiography guided endovascular thrombectomy of the superficial femoral artery in a young patient with critical limb ischemia

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Abstract Currently, the treatment of thromboembolic ischemia of the lower extremities includes percutaneous rotational thrombectomy and aspiration devices. However, the standard approach for endovascular treatment requires the administration of iodine contrast agents, which is problematic in patients with pre-existing renal disease and diabetes. Herein, we describe a case of a CO_2 angiography guided endovascular thrombectomy of the superficial femoral artery (SFA) in a young patient with critical limb ischemia. Mechanical thrombectomy using the Rotarex system, catheter aided aspiration and subsequent stent placement in the SFA was entirely guided using CO_2 angiography.

Keywords Carbon dioxide angiography · Renal failure · Rotarex catheter · Thrombectomy thrombus aspiration · Self-expanding nitinol stent

Introduction

Peripheral artery disease (PAD) shows rapidly increasing morbidity and mortality during the last years and is estimated to affect up to 30 % of elderly primary care individuals within the next years [1–4]. Particularly, patients with critical limb ischemia (CLI) show poor outcome with extremely high (>20 %) amputation and death within the first year after diagnosis [5]. These patients very frequently exhibit comorbidities, such as renal failure and diabetes mellitus [6] and are at high risk of metabolic acidosis and septic shock if perfusion is not re-established.

Current guidelines provided by the task force for the treatment of PAD recommend a 'first endovascular' approach when vascular revascularization is required, particularly in patients with CLI [7]. However, the standard approach for endovascular treatment requires the administration of potentially nephrotoxic iodine contrast agents. In this regard, contrast induced nephropathy is a common complication in patients with CLI and pre-existing renal disease and diabetes, which can be associated with irreversible loss of renal function, resulting in increased in-hospital and long-term mortality [8–10]. Apart from conventional iodine contrast agents, however, carbon dioxide (CO_2) can be used as an alternative contrast medium, as it is almost instantaneously absorbed and has, therefore, been acknowledged as a safe alternative for guiding peripheral interventions [11].

Herein, we report on a successful CO_2 angiography guided endovascular thrombectomy of the superficial femoral artery (SFA) in a young patient with critical limb ischemia. In this patient, treatment of the SFA required the initial administration of a very low amount of iodine contrast agent and was then entirely guided using CO_2.

Case presentation

A 49 year-old male patient was referred to our department with severe foot pain, which was present since about 2 weeks and increased within the last 2 days. Clinical

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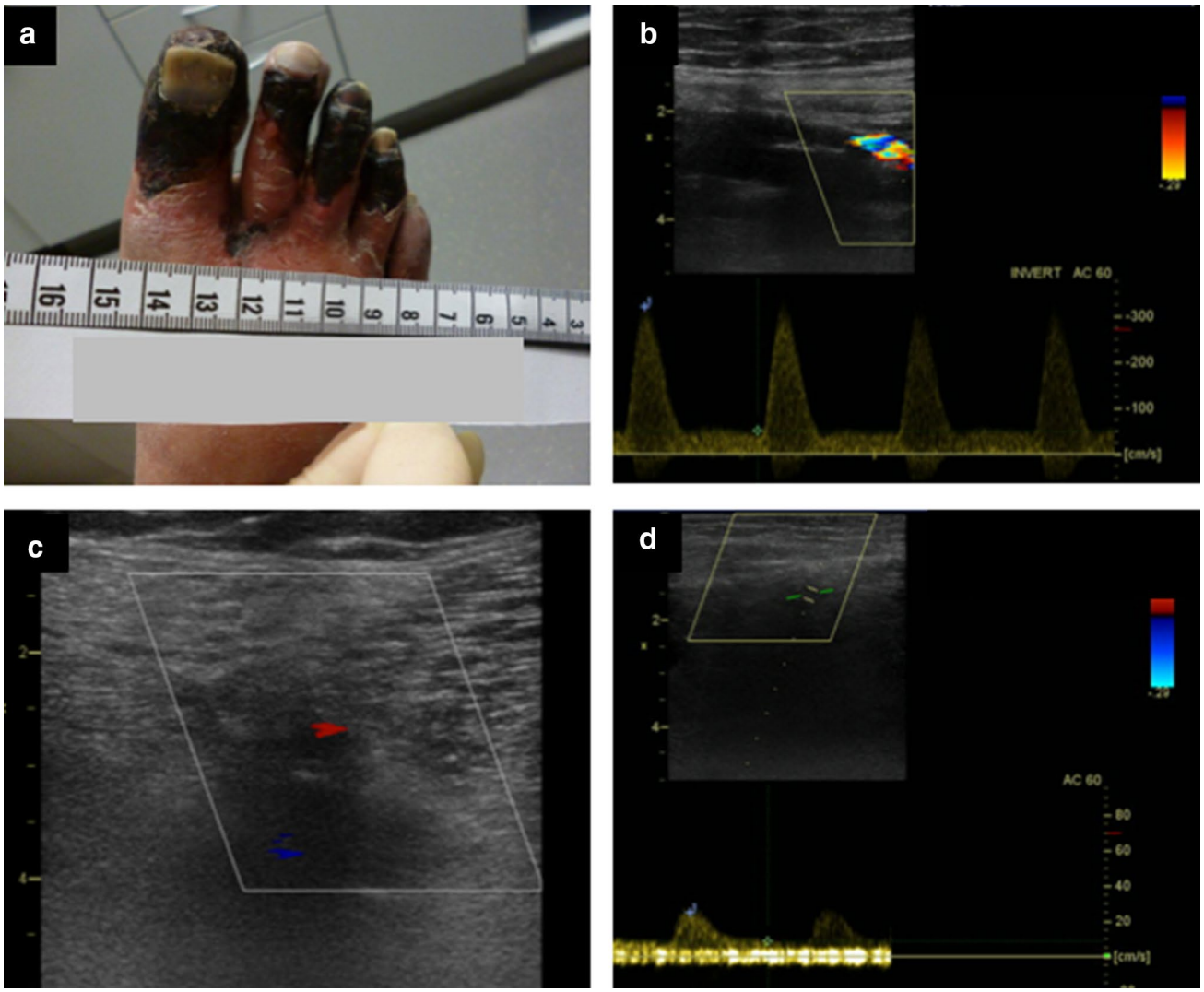

Fig. 1 Clinical and Doppler sonography acquisitions. **a** Clinical image at admission. Note the wet gangrene of toes I–V. 1B. Doppler sonography in the distal superficial femoral artery. Note the significantly increased peak systolic velocity, indicative of significant stenosis. 1C transverse acquisition at the same level. Note the significantly reduced arterial lumen suggesting subtotal occlusion. 1D Doppler sonography in the distal segment of the posterior tibial artery. Note the presence of a blunted monophasic flow profile

inspection revealed the presence of wet gangrenous necrosis of his right foot (Fig. 1a) and duplex sonography revealed the presence of biphasic flow in the right common femoral artery (CFA) and in the SFA, with significantly increased velocity in the distal SFA (Fig. 1b) due to significant lumen narrowing, as it could be appreciated in transverse acquisitions (Fig. 1c). A sharp monophasic blood flow was observed in the popliteal artery and blunted monophasic flow were noted in the anterior and posterior tibial arteries (Fig. 1d).

The patient had a history of chronic kidney disease secondary to membranoproliferative glomerulonephritis, first diagnosed 5 years before the admission in our hospital, with previous episodes of acute on chronic kidney insufficiency.

Laboratory parameters at admission exhibited a severely reduced renal function (creatinine = 4.97 mg/dl, GFR = 13 ml/min/1.73 m^2) in addition to leukocytosis (14.7 × $10^3/\mu l$) and eleveted C-reactive protein levels (103.4 mg/l). Furthermore, an increased proportion of HbA1c was noted (HbA1c = 6.6 %), compatible with type 2 diabetes mellitus. Echocardiography showed a moderately reduced left ventricular ejection fraction (ejection fraction of ~40 %).

Thus, the diagnosis of CLI (Rutherford class 6) of the right foot was made and coronary artery disease was suspected due to impaired left ventricular function. Due to the clinical status of the patient, suspected ischemic heart disease and comorbidities, a percutaneous approach for treating the vascular lesions was deemed appropriate and the

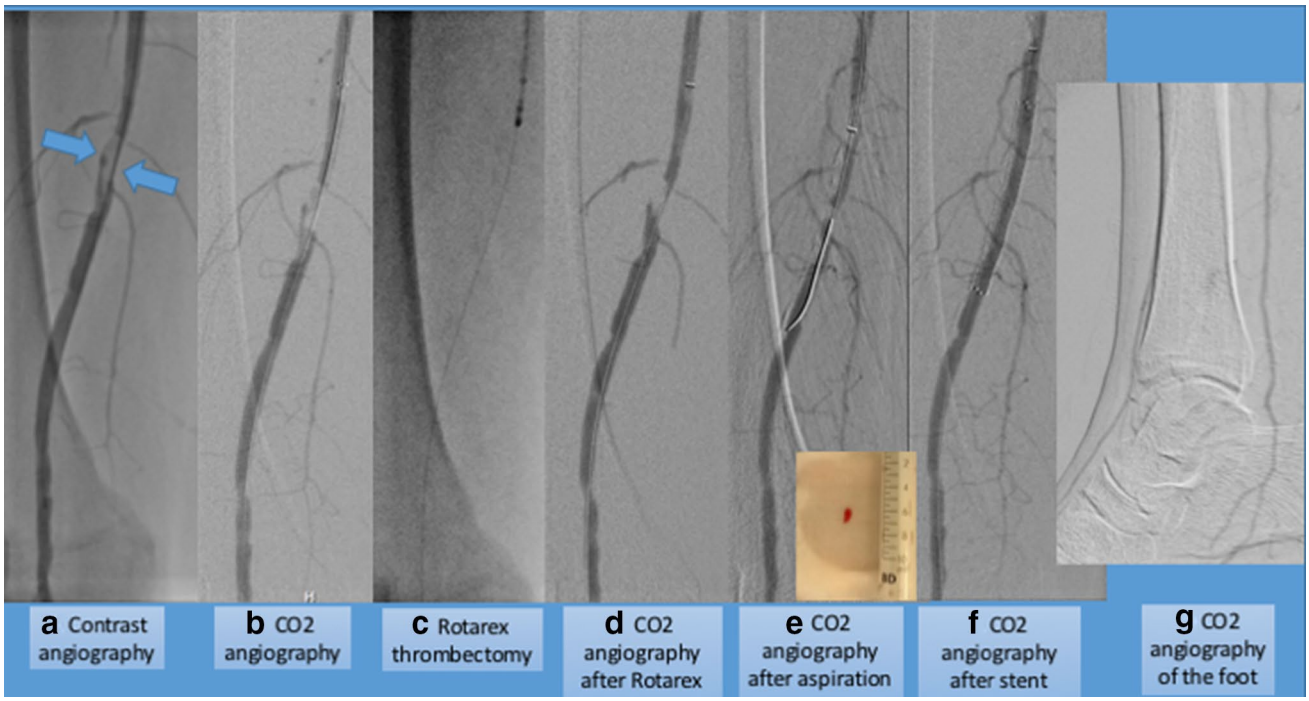

Fig. 2 Non-DSA acquisition reveals the presence of a subtotal thrombotic occlusion of the distal SFA (*blue arrows* in **a**). The corresponding CO_2 angiography image can be appreciated in **b**. CO_2 aided DSA after Rotarex® catheter thrombectomy (**c**, **d**). Subsequent repeated aspiration leads to partial thrombus removal (**e**) and placement of a self-expanding nitinol stent results in a good primary CO_2 angiographic result (**f**) and good angiographic flow in the anterior and posterior tibial arteries (**g**) (color figure online)

patient was scheduled for invasive digital subtraction angiography (DSA). After inserting a 6F guiding introducer sheath (Terumo Destination®, Terumo interventional systems, Eschborn, Germany) by antegrade puncture of the right CFA we initially performed moving table non-DSA acquisition with a single injection of ~5 ml iodine contrast agent. This acquisition revealed the presence of a subtotal thrombotic occlusion of the distal SFA (blue arrows in Fig. 2a) causing flow-limiting stenosis, with resultant slow flow in the distal vasculature. Thus, the diagnosis of subacute thrombotic occlusion of the SFA was made. Due to the presence of renal failure we decided to proceed with CO_2 guided thrombectomy (CO_2-Angioset, Optimed, Ettlingen, Germany). In Fig. 2b, the corresponding CO_2 angiography image of the distal SFA can be appreciated. Subsequently, 500 mg Aspirin and 5000 I.U. of heparin were injected intra-arterial and Rotarex® catheter (AB medica GmbH, Düsseldorf, Germany) thrombectomy was performed (Fig. 2c). This resulted in reduction of the thrombotic burden, as shown by CO_2 guided DSA (Fig. 2d). Subsequently repeated aspiration using the Terumo Destination® sheath was attempted, with successful aspiration of part of the thrombus. However, as the thrombus could not be completely removed (Fig. 2e), we proceeded with the placement of a self-expanding nitinol Innova™ stent (7.0 × 60 mm; Boston Scientific, Ratingen, Germany) with a good primary CO_2 angiographic result (Fig. 2f) and good angiographic flow in the anterior and posterior tibial arteries (Fig. 2g). CO_2 volumes of 60 and 40 ml were used, respectively, for above and below the knee DSA acquisitions.

After the procedure, ishemic pain symptoms were resolved and the patient was put on treatment with aspirin and clopidogrel for 2 months. Clopidogrel was paused after 2 months and aspirin will be continued life-long, as long as no clear contraindications arise.

Follow-up Duplex-sonography at the next day exhibited an excellent perfusion of the stent with biphasic flow continuing into the poplitean artery. A history of atrial fibrillation was not present and the Holter-ECG examination did not identify arrhythmias as a potential source of thromboembolism. Cultures prelevated from the gangrene were positive for *Corynebacterium*, *Staphyloccoccus* and *Bacteroides*. A significant reduction in the levels of inflammation parameters was achieved after reperfusion in combination with antibiogram guided intravenous antibiosis. Subsequently, an amputation of left toes I–V was performed 5 days after the angiography. The laboratory findings before discharge showed an improvement of the creatinine values (creatinine = 3.61 mg/dl, GFR = 19 ml/min/1.73 m^2). Wound healing could be successfully achieved after 3 months, as it can be appreciated in Fig. 3 and the further clinical course of the patient was

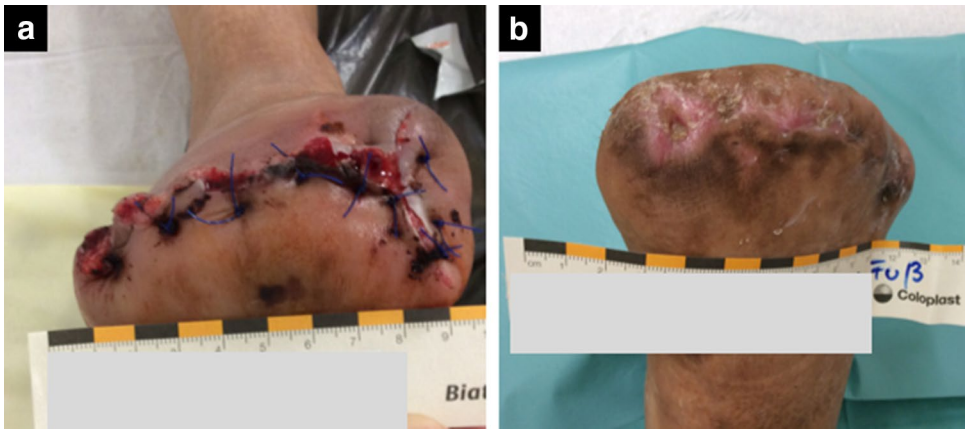

Fig. 3 Clinical image after toe amputation **a** at 1 day, **b** at 3 months follow-up. Note the complete closure of the wound at follow-up

uneventful. He was discharged in a clinically stable status and is currently followed regularly in our multidisciplinary team (cardiology, angiology, diabetology and nephrology).

Discussion

This is one of the first cases reporting the usefulness of CO_2 angiography aided endovascular thrombectomy of the superficial femoral artery (SFA) using the Rotarex system in a young patient with critical limb ischemia. Rotarex thrombectomy and subsequent aspiration, as well as PTA and stent placement required the initial administration of only ~5 ml iodine contrast agent and was then entirely guided using CO_2.

Critical limb ischemia is associated with high amputation and mortality rates, depending on concomitant risk factors and treatment options [12, 13]. Ischaemia of the limb is initially reversible, but causes irreversible tissue death, if left untreated. Particularly in the case of acute and subacute thrombotic limb ischemia, percutaneous mechanical thrombectomy using the Rotarex catheter represents a useful approach for the effective treatment of peripheral arteries and bypass occlusions [14, 15]. Using this thrombectomy system, recanalization of thrombotic arteries is achieved faster and more effective compared to intra-arterial thrombolysis. In addition, this endovascular approach offers several advantages over open surgical embolectomy techniques [16, 17].

However, the standard approach for endovascular mechanical thrombectomy requires the administration of iodine contrast agents, which may result in contrast induced nephropathy, especially in patients with pre-existing renal disease and diabetes. In this case we report on the successful use of CO_2 as a safe alternative for guiding mechanical thrombectomy in a young patient with subacute thrombotic occlusion of the SFA and with renal disease and diabetes mellitus, as comorbidities.

CO_2 angiography was performed using a pressure reduction valve, which is pre-set to 1.3 bar. This enables safe withdrawal of pure medical CO_2 from gas bottles or online wall connections (99.7 vol% or higher). With the CO_2 Angio-set, a 100 ml syringe with an adjustable dose chamber in 20 ml steps, connected to a special stop-cock with a 90° rotary valve is used for gas loading and injections into the vessel. According to the instruction of the manufacturer, CO_2 volumes of 60 and 40 ml were used, respectively, for above and below the knee DSA acquisitions. In our patient CO_2 injections were well tolerated, without the need of analgesia or sedation.

Although the use of CO_2 for visualising the arterial vessels is generally considered safe [18, 19], care must be taken when injecting this gas above the diaphragm, as this can result to coronary or cerebral embolization. In addition, cases of transient mesenteric ischemia due to vapor trap in the mesenteric arteries have been reported [20]. Furthermore, right to left shunts and chronic obstructive pulmonary disease (COPD) limit the applicability of CO_2 as a contrast agent. Finally, CO_2 angiography may lead to increased radiation exposure for both patient and operator, because a higher frame rate is required during imaging [21].

In our patient, Rotarex thrombectomy, thrombus aspiration and PTA with stent placement could be guided using CO_2 angiography, which helped re-establishing blood flow in the limb with only minimal administration of iodine contrast agent at the beginning of the procedure. Alternatively, intravascular ultrasound (IVUS) in combination with duplex sonography and pressure gradient measurements may have been a valuable alternative for guiding our endovascular procedure, the former providing information on lesion morphology and the latter on vessel blood flow. However, the removal and reinsertion of the IVUS catheter would be necessary after every single step of aspiration, thrombectomy, PTA and stent placement ECT, which would probably result in a more costlier and time-consuming procedure. In addition, bypass surgery needs to

be considered as an option for treatment of patients with CLI. In our case, an endovascular approach was chosen due to comorbidities and suspected coronary artery disease, which may have led to peri-operative myocardial infarction. Furthermore, duplex-sonography suggested a rather short high grade lesion of the distal SFA, translating to a TASC A lesion, so that an 'endovascular first' strategy was considered.

Conclusion

Herein, we describe a case of a CO_2 angiography guided endovascular thrombectomy in a young patient with subacute thrombotic subtotal occlusion of the superficial femoral artery and critical limb ischemia. Rotarex catheter thrombectomy, thrombus aspiration and stent placement was guided by CO_2 angiography, requiring a minimal amount of iodine contrast agent.

Compliance with ethical standards

Conflict of interest The authors have no conflict of interest to declare.

Ethical standards This study complies with the Declaration of Helsinki. Informed consent from patient was obtained before performing the procedure as well as regarding the publishing of his clinical data in an anonymized form.

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