Pharmacomechanical Thrombectomy for Acute Limb Threatening Lower Extremity Arterial Thrombosis Secondary to COVID-19

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Abstract

Purpose The aim of this study was to report the clinical effectiveness and safety of pharmacomechanical thrombectomy (PMT) for acute limb threatening lower extremity arterial thrombosis secondary to coronavirus disease 2019 (COVID-19).

Methods In this retrospective study, the clinical and imaging records of six patients (6 men, mean age 56 years) with COVID-19-related lower extremity arterial thrombosis and treated with PMT using the Angio-Jet device were reviewed. Patients presented with symptoms of acute pain in the affected limb, pallor, pulselessness, paresthesia, or paralysis. Thrombosis involved below knee arteries in all patients, and above knee arteries in three patients. Reteplase 18 mg was infused into the thrombus using the power pulse mode on the Angio-Jet device. This was followed by rheolytic thrombectomy and then, intra-arterial infusion of urokinase 100,000 IU/hour for 5 hours. All patients received systemic intravenous heparin. Technical success, clinical success, and complications of PMT were analyzed.

Results The mean thrombectomy duration was 190.83 ± 99.18 seconds. Adjuvant balloon angioplasty was performed in two patients. The mean hospital stay was 7.67 ± 4.50 days. PMT was technically successful in all (100%) patients. Five patients had excellent clinical outcome with at least one palpable pulse and no tissue loss. One patient required minor amputation. One patient developed self-limiting retroperitoneal hematoma.

Conclusion In our series, PMT with supplemental intra-arterial urokinase infusion was highly successful in treating acute peripheral arterial thrombosis secondary to COVID-19.
Introduction

The first case of SARS-Cov-2—severe acute respiratory syndrome coronavirus 2—was reported in December 2019, from Wuhan, China. Later in March 2020, the World Health Organization declared the disease as pandemic and named it as coronavirus disease 2019 (COVID-19).1 The disease presentation ranged from asymptomatic disease to life-threatening SARS.2 A few patients were reported to have developed arterial and venous thrombosis. COVID-19 virus directly invades the endothelium through the angiotensin converting enzyme 2 receptors present on the endothelium and causes endotheliitis. This leads to localized activation of proinflammatory factors (cytokine storm) and vascular thrombosis.3

Acute limb ischemia (ALI) is a vascular emergency marked by sudden disruption of arterial perfusion threatening the viability of the limb. Symptoms occur within 14 days of onset of the thrombotic or embolic event.4,5 Sudden stoppage of blood supply affects all metabolically active tissues such as muscles, bones, nerves, and skin, resulting in symptoms of pain, pallor, paresthesia, paralysis, poikilothermia, and skin loss.6 If the supply is not restored promptly, there is a higher risk of limb loss. The incidence of ALI ranges from 9 to 16 cases per 100,000 population per year for lower limb4,7,8 and 1 to 3 cases per 100,000 people per year for upper limb.9 Despite early revascularization, 30-day mortality rate and amputation rate are between 10 and 15%. Incidence of arterial thrombosis in COVID-19 disease is unknown. Only a few case reports and one small series have reported outcomes of interventions in patients with COVID-19-related lower extremity arterial thrombosis.10–13

In this study, we report the outcomes of pharmacomechanical thrombectomy (PMT) in six patients who presented with ALI secondary to COVID-19-related lower extremity arterial thrombosis.

Methods

Study Subjects

This is a retrospective, institutional review board approved study. Six consecutive patients (6 men, mean age 56.17 ± 11.68 years) with COVID-19 (detected on real-time reverse transcription–polymerase chain reaction test) and presenting with acute lower extremity ischemia to our hospital during the COVID-19 pandemic from October 1, 2020, to February 28, 2021, were included in this study. Cases with ALI with no history of COVID-19 and nonsalvageable limb were excluded from the study.

Of the six patients, three had mild COVID-19 disease (high-resolution computed tomography [HRCT] severity scores of 4, 5, and 5, respectively) and were treated as outpatients, while three had moderate lung involvement (HRCT severity scores were 9, 9, and 11 respectively) and required hospitalization for oxygen support. These three hospitalized patients were on prophylactic anticoagulation using enoxaparin 40 mg subcutaneous (SC), once a day.

All patients had clinically salvageable limb at the time of presentation. The presenting symptoms were acute pain in the affected limb, pallor, pulselessness, paresthesia, or paralysis. Three patients had diabetes mellitus and systemic hypertension while three others had no comorbidities. The ankle brachial index (ABI) and toe brachial index (TBI) were not recordable at the time of presentation. The preprocedural diagnosis of ALI was achieved clinically with assistance of color Doppler or by computed tomography angiography. The location and extent of arterial occlusion on angiography is depicted in —Fig. 1. Thrombosis involved below knee arteries in all patients, and above knee arteries in three patients. All six patients had thrombosed anterior and posterior tibial arteries, peroneal artery, and occlusion of the dorsalis pedis artery and plantar arteries. The popliteal artery was involved in four patients while the superficial femoral artery was thrombosed in two patients. Common iliac, external iliac, and common femoral arteries were thrombosed in one patient each.

Pharmacomechanical Thrombectomy

Preprocedurally, patients were hydrated using intravenous (IV) normal saline at 70 to 100 mL/hour (depending upon cardiac status) for at least 3 hours, and the same IV hydration was continued during and after the procedure. The Angio-Jet thrombectomy system with the Solent Omni 6F catheter (Boston Scientific, Natick, Massachusetts, United States) was used in all patients. Depending on the location of the thrombus, an antegrade or a retrograde or bilateral femoral arterial access was obtained under local anesthesia and ultrasound guidance. All patients received 5,000 IU bolus of unfractionated heparin and additional 1,000 IU at every hour of the procedure. Following diagnostic angiography, a 4F Head Hunter catheter and a 360 cm hydrophilic angled tip 0.035 wire (Terumo, Japan) were used to cross the thrombotic occlusion and the wire was kept in the plantar arch. Over the wire, the Solent Omni catheter was advanced and thrombolitics (Reteplase 18 mg) was sprayed in the “power pulse mode” along the entire length of the thrombus. The dwell time of the thrombolytic drug was a minimum of 60 minutes. A repeat angiogram was performed to evaluate the effect of thrombolytic drugs. Then the Omni catheter was reintroduced and the residual thrombus was removed using the “thrombectomy mode” by withdrawing or advancing the catheter at the rate of 5 to 10 mm/sec. Thrombectomy was repeated if thrombus persisted. Thrombectomy time never exceeded 480 seconds. Adjuvant procedures such as balloon angioplasty were performed in two patients. All patients received additional thrombolysis to treat microvascular thrombi, with intra-arterial infusion of urokinase at the rate of 100,000 IU per hour along with heparin at 1,000 IU/hour for 5 hours. A check angiogram was performed to evaluate the end result.

Postoperative Management

All patients were treated with oral aspirin 75 mg once a day, rivaroxaban 2.5 mg twice a day, cilostazol 100 mg twice a day, and rosuvastatin 20 mg/day along with other supportive
treatment for COVID-19 and other comorbidities. Patients were monitored for bleeding, renal failure, and other complications.

**Outcomes**
The effectiveness of PMT was assessed on its technical and clinical success. The technical success was defined as angiographic visualization of previously thrombosed vessels as a direct continuity or by distal reformation in the foot. The clinical success was determined by relief of pain, restoration of pulse in the foot, improvement of motor and sensory functions, and requirement of major or minor amputation. The outcome was rated as excellent, good, fair, and poor, depending upon the clinical outcome as described in Table 1.

**Results**
The mean procedural time (excluding extended thrombolysis) was 157.33 ± 69.73 minutes. Average dose of heparin

![Bar graph showing pre- and post-Angio-Jet thrombectomy results showing technical success in six patients of coronavirus disease 2019-related lower limb arterial thrombosis causing acute limb ischemia.](image)

**Table 1** Categorization of clinical outcome following pharmacomechanical thrombectomy in COVID-19-related arterial thrombosis

<table>
<thead>
<tr>
<th>Clinical success criteria</th>
<th>Excellent</th>
<th>Good</th>
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<tr>
<td></td>
<td>• No rest pains</td>
<td>• No rest pains</td>
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<td></td>
<td>• Clinical palpation of at least one pulse in the foot (dorsalis pedis artery ± posterior tibial artery) irrespective of patchy mottling of the skin in the foot</td>
<td>• Clinical palpation of at least one pulse in the foot (dorsalis pedis artery ± posterior tibial artery) irrespective of patchy mottling of the skin in the foot</td>
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<td>• Motor movements of foot well preserved</td>
<td>• Motor movements of foot partly lost (partial foot drop) recovering within 7 days</td>
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<td>• Patient walking without support within 7 days after treatment</td>
<td>• Patient walking with support within 7 days after treatment</td>
</tr>
<tr>
<td></td>
<td>• Patient not requiring minor amputation within 30 days after treatment</td>
<td>• Patient requiring minor amputation within 30 days after treatment</td>
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(Continued)
required was 12,333.33 ± 471.40 units. The mean hospital stay was 7.67 ± 4.50 days.

The technical success of PMT was 100%. On postprocedural angiography, all six (100%) patients had adequate patency of the plantar arch (►Fig. 1, ►Fig. 2, ►Fig. 3). Two patients who had an underlying atherosclerotic stenosis required angioplasty. The clinical success after PMT was evaluated according to our institutional guidelines (►Table 1). Five (83.33%) patients had excellent outcome and one (16.67%) patient had good outcome.

One patient developed spontaneous, self-limiting, right iliopsoas hematoma on the next day, which was managed conservatively. There was no gastrointestinal, genitourinary, or intracranial bleed in any of our patients. Hemoglobinuria was seen in two (33.33%) patients, which resolved within 24 hours after the procedure. Procedure-related anemia (mean Hb drop of 0.38 ± 0.22 g/dL) was seen in all patients, with no patients requiring blood transfusions after the procedure. None of the patients developed renal failure. Reperfusion edema was minimal and none of the patient required fasciotomy.

**Patient Follow-Up**

The average follow-up was 167.67 ± 53.33 days. During the follow-up, there were no deaths as of May 31, 2021. Color Doppler did not show any reocclusion of the recanalized arteries. Postprocedural ABI/TBI was normal in all six patients at 3 months of follow-up. No patient had rethrombosis or reocclusion requiring repeat intervention during the follow-up period. Only one patient required amputation of the little toe. No further tissue necrosis, amputation, or death was noted.

**Discussion**

COVID-19 differs from other viral infectious diseases in many ways. Arterial thrombosis is an extremely rare complication
of other infectious diseases. Intact endothelium maintains the delicate balance between procoagulants and anticoagu-
lants in the blood. COVID-19 virus invades the endothelium leading to inflammatory damage of the endothelium causing platelet activation, aggregation, and “in situ” thrombus formation. Arterial thrombosis in COVID-19 frequently involves young men, large arteries (aorta, mesenteric vessels, and large peripheral vessels) without preexisting arterial atherosclerotic disease. There is a lack of abnormality in coagulation parameters in COVID-19 infection. The classical parameters of disseminated intravascular coagulation, such as low platelet count, prolonged prothrombin time, and fibrinogen consumptions, are either mild or lacking in COVID-19.3

Incidence of COVID-19-related arterial thrombosis was reported to be 4.4% in critically ill patients.14 In our study,
extensive arterial thrombosis was noted in three patients with mild COVID-19 infection who were being home quar-
tained and in three patients having moderate disease re-
quiring hospitalization for oxygen support. None of our 
patients required intensive care unit admission for their 
COVID-19 disease, suggesting arterial thrombosis can hap-
pen even in mild and moderate diseases. Three patients who 
were treated as outpatients received no anticoagulation 
therapy, while the remaining three hospitalized patients 
received prophylactic anticoagulation. Few studies reported 
arterial thrombosis in COVID-19 patients despite adequate 
prophylactic anticoagulation (enoxaparin 40 mg SC, once a 
day) and advocated for therapeutic anticoagulation to pre-
vent arterial thrombosis. Some reports have emphasized the 
role of intermediate intensity anticoagulation (enoxaparin 
0.5 mg/kg, SC, once a day) for prevention of arterial 
thrombosis.3

In non-COVID-19 patients, arterial thrombosis commonly 
affects men more than women.15,16 This may be due to the 
differences in the genetic and hormonal profiles of two sexes 
and favorable immune modulation by female sex hor-
mones.15–17 In our study, all affected patients were men. It 
is not clear whether female sex offers immunity to arterial 
thrombosis in COVID-19.

Despite the extensive distal arterial thrombosis, treat-
ment by PMT was very successful in these patients. Despite 
skin mottling and early motor loss, PMT provided excellent 
outcomes. Adjunctive procedures such as balloon angioplasty 
with or without stenting and extended intra-arteral 
thrombolysis to treat the residual microvascular thrombi 
should be considered. There was no incidence of immediate 
thrombosis, which may be due to a decrease in the viral 
load during the treatment or due to the combined use of 
aspirin and rivaroxaban.

Hemoglobinuria was seen in two (33.33%) patients. Low 
incidence of hemoglobinuria in our series was probably 
because of thrombotic occlusion of distal and small caliber 
arteries, having less clot burden requiring less thrombec-
tomy duration and, so, less hemolysis. Hemoglobinuria did 
not result in impairment of renal function, probably secondarily to adequate pre-, during-, and postpro-
cedure IV hydration.

Delay in treatment of ALI results in high mortality and 
morbidity. Despite starting treatment within 12 hours of 
onset of ischemia, mortality and limb salvage rates are 19 
and 93%, respectively.18 With further delay in treatment of 
more than 12 hours of onset of ischemia, mortality and limb 
salvage rates further worsen to 31 and 78%, respectively.19,20 
In our series, the mortality and limb salvage rates were 0 and 100%, respectively, even after delayed presentation of 24 to 
96 hours. Arterial thrombosis in COVID-19 infection can 
involve one or more arteries simultaneously and is due to 
endothelitis, causing patchy thrombosis that propagates 
slowly to become extensive and gives more time for treat-
ment after the onset of ischemia.

There are many limitations to our study. Our study is 
retrospective and has a very small sample size. Despite the 
small size, our study proved the effectiveness of PMT 
in COVID-19-related peripheral arterial ischemia. The fol-
low-up was short, but adequate to demonstrate lack of 
rethrombosis in the short term. A larger prospective study 
with longer follow-up would be desirable to affirm our 
findings.

Conclusion

PMT is safe and effective in acute limb threatening arterial 
thrombosis secondary to COVID-19 infection. Rheolytic 
thrombectomy along with extended intra-arteral pharma-

cological thrombolysis could restore perfusion quickly lead-
ing to limb and life salvage.

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