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Thrombotic complications after radial arterial line placement in systemic sclerosis: a case series

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Abstract

Objective—To demonstrate potential thrombotic complications after radial arterial line placement in patients with scleroderma.

Methods—This is a retrospective case series of 4 patients with scleroderma who were hospitalized in the intensive care unit (ICU) requiring invasive hemodynamic monitoring and developed severe complications after radial arterial line placement. We reviewed their medical records to assess their laboratory findings and clinical presentations.

Results—All four patients met the 2013 ACR/EULAR criteria for systemic sclerosis and had a radial arterial line placement in the setting of invasive hemodynamic monitoring. 2 of 4 patients had arterial line placement during surgery; while 1 patient had it placed for invasive blood pressure monitoring during an ICU admission for renal crisis; and 1 patient had arterial line placement during cardiac resuscitation, but before administration of vasopressor support. 3 of 4 patients had major ischemic events including digital gangrene, hand auto-amputation, and below-elbow amputation. One patient had temporary hand ischemia with recovery of perfusion with immediate arterial line removal within 24 hours.

Conclusions—Radial arterial line placement may trigger critical ischemic events in scleroderma patients. This experience suggests that placement of radial lines needs to be thoughtfully weighed

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prior to insertion in patients with scleroderma, and alternative options should be carefully considered.

Keywords

arterial line placement; Raynaud's phenomenon; systemic sclerosis; vasculopathy

INTRODUCTION

Systemic sclerosis (SSc) or scleroderma is an autoimmune disease characterized by immune dysregulation, widespread tissue fibrosis, and a prominent vasculopathy. Raynaud's phenomenon is almost universal, resulting in cold or stress induced vasospasm [1]. Both capillary and total digital blood flow is compromised during a Raynaud's event. However, the vascular disease of scleroderma is not limited to the skin in that the pathology of vessels is seen in other involved organs. Macrovascular disease is evident in the peripheral arteries and known to cause occlusion in the digital, palmar arch, and more proximal vessels like the ulnar artery [2,3]. Digital arteries have significant luminal narrowing with the characteristic intimal fibrosis of scleroderma vascular disease. Thus, both small arteries and larger vessels are susceptible to sudden occlusion.

Due to this pre-existing vasculopathy affecting digital circulation, patients with scleroderma may be at increased risk from complications due to radial arterial line placement. We highlight this risk by presenting this case series of 4 patients with scleroderma who developed major complications, including digital and hand gangrene and below-elbow amputation after radial arterial line placement.

MATERIALS AND METHODS

This is a retrospective case series of 4 patients with systemic sclerosis, defined by the 2013 ACR/EULAR criteria [4]. All patients had consented to be a part of an Institutional Review Board (IRB) approved database of the Johns Hopkins Scleroderma Center except for one patient who died in the hospital, for whom an IRB exemption was obtained.

RESULTS

Patient 1

Patient 1 was a 34 year old African-American woman with a history of limited scleroderma overlap with lupus who developed distal digital infarctions of her right hand after right radial arterial line placement. Her limited scleroderma was manifested by Raynaud's phenomenon with recurrent digital ulcers, severe interstitial lung disease s/p lung transplant, telangiectasia, sclerodactyly, calcinosis cutis, esophageal dysmotility, and gastroesophageal reflux disease (GERD). Her lupus overlap was manifested by discoid lesions, leukopenia, thrombocytopenia, and positive anti-Smith antibody. Her anti-phospholipid antibodies were negative. She was also positive for anti-nuclear antibody (nucleolar and speckled pattern >1:640 titer) but negative for anti-centromere and topoisomerase 1 antibodies. She had scleroderma for 18 years when she developed abdominal pain, emesis, and hematochezia with concern for ischemic bowel. She required an exploratory laparotomy and total

abdominal colectomy with eventual end ileostomy. During this complicated course, she underwent placement of a right radial arterial line. This was complicated by radial artery dissection, likely from direct radial injury from the line placement, and possible thrombosis. She was treated with tissue Plasminogen Activator (tPA), intravenous heparin, and ultimately warfarin as she developed edema, necrosis and blistering of her fingers (see Figure 1). This photo was taken 1.5 months after radial artery cannulation. This patient ultimately developed digital dry gangrene and auto-amputation. She died 1 year later from complications of multisystem disease.

Patient 2

Patient 2 was a 26 year old African-American woman noted to have diffuse skin tightening of the proximal arms and legs meeting criteria for diffuse scleroderma. She was ANA positive (> 1:640 titer, speckled pattern), anti-U1 RNP and RNA Polymerase III antibody positive. The patient developed headaches 2 weeks prior to admission and was noted to be hypertensive in an outside emergency room. She was subsequently found to be cognitively disoriented, and her blood pressure was 214/130. She developed generalized tonic-clonic seizures, and was noted to be in acute renal failure with a creatinine of 3.4 mg/dL and thrombocytopenic with a platelet count of 99,000/microliter. Her clinical presentation was consistent with scleroderma renal crisis based on her hypertensive emergency with seizures, posterior reversible encephalopathy syndrome, microangiopathic hemolytic anemia, and acute kidney injury. She had a right radial arterial line placed for invasive blood pressure monitoring. Soon afterwards, the patient developed pain in the right hand and the radial pulse was no longer palpable. She developed numbness and coolness of the hand. She had a right upper extremity Doppler ultrasound that demonstrated an acute occlusion of the right distal radial artery (Figure 2), multiphasic right ulnar artery waveforms which indicated normal flow through the ulnar artery, and a patent right superficial palmar arch. The arterial line was removed within 24 hours, and therapy with heparin was recommended to the patient. However, the patient declined anticoagulation given an antecedent gastrointestinal bleed. She ultimately recovered and had no compromise in hand function over time.

Patient 3

Patient 3 was a 57 year-old female with history of coronary artery disease s/p myocardial infarction (MI) without percutaneous coronary intervention, peripheral artery disease s/p femoral to popliteal artery bypass, and limited scleroderma. Her limited scleroderma was manifested by Raynaud's phenomenon, sclerodactyly, facial telangiectasia, severe pulmonary hypertension, and positive anti-centromere antibody. She was admitted to an outside hospital for worsening dyspnea and was found to have a large pericardial effusion with tamponade physiology. She underwent emergent pericardial window with removal of 700cc of serous fluid. Immediately after this procedure, she had cardiac arrest and was intubated. In the setting of her cardiac arrest, she also had left radial arterial line placement for hemodynamic monitoring. She was also given vasopressors at the time of her cardiac arrest. She developed mottling and pain of the left hand shortly after the radial line placement with digital ischemia. The radial arterial line was removed prior to transfer to our institution. On transfer, she had completed digital infarcts of her left thumb and 3rd digit. She had no palpable radial pulse. We could not completely exclude that diffuse

atherosclerotic vasculopathy and/or vasopressors at the time of her cardiac arrest and resuscitation contributed to the digital ischemia. Orthopedics was consulted and nitropaste was recommended but she had no reperfusion thereafter, and developed dry gangrene of the digits. Despite treatment with intravenous epoprostenol for her pulmonary hypertension and pressor support, she ultimately had no improvement in her cardiopulmonary status and died.

Patient 4

Patient 4 was a 32 year old African-American female with history of diffuse scleroderma manifested by proximal skin tightening, Raynaud's phenomenon with recurrent digital ulcers on amlodipine, and GERD with positive ANA (nucleolar pattern 1:320). Anti-centromere and anti-topoisomerase antibody were negative, and RNA Polymerase III antibody was not previously checked. She was transferred to Johns Hopkins Bayview Medical Center from an outside hospital for management of a subarachnoid hemorrhage. One day prior to presentation to the outside hospital, she complained of the "worst headache of her life," and head CT done at that time revealed a subarachnoid hemorrhage in the right suprasellar cistern over the right frontal convexity. Upon transfer, a 4-vessel angiogram showed a 1.5-cm posterior communicating artery aneurysm on the right side. She underwent a right frontotemporal craniotomy for clipping of posterior communicating artery aneurysm. A left radial arterial line was placed for hemodynamic monitoring and soon thereafter, she developed left hand and wrist gangrene. The line was removed and nitropaste was attempted to reverse the digital ischemia. Unfortunately, she ultimately required a left below-elbow amputation approximately 3 weeks following the line placement. She also had further complicating factors to her hospitalization including MRSA pneumonia and parenchymal bilateral cerebellar hemorrhage and pontine edema. She also became hypotensive, requiring vasoactive pressors and developed an additional right 5th toe digital ulcer which developed into dry gangrene and a large left heel ulcer that developed into left heel gangrene. It is important to note that the vasopressor was given after the initial hand ischemia. Five months after discharge from the hospital for her subarachnoid hemorrhage, she underwent left below-the-knee amputation and right 5th toe amputation.

DISCUSSION

The radial artery is one of the most common sites of cannulation for invasive monitoring in the intensive care unit or operating room. Transradial catheterization is also increasingly being used for percutaneous coronary intervention and diagnostic coronary angiography as it reduces the incidence of complications such as bleeding and hematoma [6,7]. Transradial access is thought to be safe. In fact, the reported incidence of permanent hand ischemic damage is 0.09% in case reviews of the literature in the normal population. However, with every procedure, there are potential adverse effects. In fact, temporary occlusion of the artery has ranged from 1.5% to 35% (mean 19.7%) [8,9], and recently, it has been described that transradial coronary angiogram or intervention is highly associated with artery dissection and hematoma even at 30 days post procedure [5]. Furthermore, digital embolization following cannulation can potentially lead to irreversible digital ischemia. In one prospective study of 32 non-scleroderma patients, it was reported that the incidence of

thrombotic embolization was 23%, but only 2 patients had clinical signs of vascular insufficiency of the digits [10].

Despite the radial artery being a common point of access for procedures, the potentially damaging consequences of digital embolization or hand ischemia in high risk patient populations, such as scleroderma, may be under-appreciated. We have demonstrated that patients with scleroderma may have significant risk of irreversible ischemic complications after radial arterial line placement. The reason for this significant risk is likely multifactorial and may include temporary occlusion of the radial artery from cannulation, in the setting of underlying vasculopathy and fibrosis in scleroderma, macrovascular disease proximally, and impaired fibrinolysis.

The vasculopathy of scleroderma is not limited to the microcirculation, but has also been reported in larger blood vessels manifested by macrovascular disease, as defined as involvement of blood vessels with an internal diameter of >100 microns [11]. Vacuolization and destruction of capillary endothelial cells, severe intimal hyperplasia and fibrosis of digital arteries have also been reported in scleroderma[3,12]. The prevalence of symptomatic macrovascular disease in systemic sclerosis using a validated World Health Organization questionnaire for intermittent claudication has been reported to be 21.7% vs. 4.6% in a normal Scottish population [13]. It has been reported in multiple cohorts that 16–20% of scleroderma patients had at least one digital amputation due to digital ischemia [14–17]. The presence of proximal vessel disease in the radial or ulnar arterial circulation may increase the risk of major ischemic complications after radial artery cannulation in scleroderma patients with underlying microvascular disease, resulting in worsening digital ischemia, ulceration, gangrene or even amputation. Digital stenosis or occlusions are most frequently found in the ulnar artery, 2nd to 5th proper palmar digital artery, and the superficial palmar arch [18]. While it is less frequently reported in the radial artery [19], one study demonstrated an increased wall to lumen ratio in scleroderma patients compared to controls using a high resolution echo-tracking device, and this suggested increased circumferential wall stress of the radial artery [20]. In this context, mechanical changes of the radial artery may favor downstream occlusive phenomena in patients with Raynaud's phenomenon and scleroderma. We speculate that since the temporary occlusion of the radial artery has been reported in up to 35% (mean of 19.7%) of patients having a radial artery cannulation [8,9], the combination of the temporary occlusion with the underlying vasculopathy of systemic sclerosis may have contributed to permanent ischemia in 3 of our 4 patients.

Another upstream vessel, the ulnar artery, has been reported to be associated with occlusive disease. Recently, a duplex sonographic study of 79 patients with scleroderma vs. 40 healthy controls demonstrated that at baseline 17 of 79 (22%) patients with scleroderma had ulnar artery occlusion [21]. These patients were followed for a mean of 53 months, and new or recurrent digital ulcers occurred more often in upper extremities with ulnar artery occlusion than in those without. Given the high prevalence of underlying macrovascular disease of the upper extremity and hand in scleroderma, it has been recommended that the Allen's test be performed routinely on all patients with severe Raynaud's phenomenon and refractory digital ulceration to investigate the possibility of ulnar artery occlusive disease [2].

Impaired fibrinolytic activity may also be a contributing factor for thrombotic complications in scleroderma. The balance of intravascular coagulation/fibrinolysis is thought to be altered in favor of coagulation and fibrinolytic activity is impaired in scleroderma [22]. Ames et. al found defective tissue plasminogen release (tPA) and higher levels of tPA inhibitor in scleroderma compared to controls consistent with a low fibrinolytic state. Thus, patients with scleroderma may also have alterations in the fibrinolytic pathway which may predispose them towards fibrin deposition and vascular obstruction, and dampened response for fibrinolysis [22–24].

This case series highlights the fact that patients with scleroderma may be at high risk of radial artery occlusive disease after cannulation, which can potentially lead to amputation. To our knowledge, there has been only one reported case of a scleroderma patient with digital ischemia following radial artery cannulation that ultimately resulted in partial digital amputation in the United States [25]. There is also a case report of a Dutch patient with scleroderma who developed a cold, ulcerated right hand following coronary angiography via the radial artery; improvement followed treatment with bosentan [26]. Based on our experience treating scleroderma patients, we now advise the following: First, the necessity of invasive monitoring should be closely examined prior to placement of radial arterial lines in scleroderma patients. Second, noninvasive evaluation of the ulnar artery should be conducted using bedside exams such as the Allen's test or arterial doppler to assess for flow, as the presence of an underlying ulnar artery vasculopathy may increase the risk of major ischemic complications. Third, an alternative location such as the femoral artery should be considered for invasive monitoring if feasible. Due to the large caliber of the femoral artery, there is less chance of thrombosis and thus may be a preferred site of access for invasive monitoring. We recognize that the risk of local site and bloodstream infections are higher with femoral arterial line placement; however, given this population's unique characteristics, the benefits of choosing this site for line placement may outweigh the risks. Lastly, if a radial arterial line is absolutely required, frequent physical examination monitoring of distal flow should be performed to assess for any signs of ischemia.

CONCLUSIONS

While our case series does not provide an estimate of the prevalence of vascular complications after arterial line placement, it emphasizes the importance of taking measures to prevent catastrophic arterial events among patients with scleroderma who may be at significant risk due to underlying peripheral vascular disease.

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Figure 1.
Infarction of distal fingertips and desquamation after radial arterial line placement.

Figure 2.
Ultrasound of distal right radial artery showing partial occlusion after right arterial line placement