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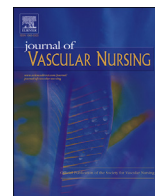
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Vascular medicine in the COVID-19 era: The Vanderbilt experience

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Coronavirus disease of 2019 poses significant risks for patients with vascular disease. Telemedicine can help clinicians provide care for patients with vascular disease while adhering to social-distancing guidelines. In this article, we review the components of telemedicine used in the vascular medicine practice at the Vanderbilt University Medical Center. In addition, we describe inpatient and outpatient diagnosis-based algorithms to help select patients for telemedicine versus in-person evaluation.

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Introduction

In December 2019, a series of pneumonia cases of unknown cause emerged in Wuhan, Hubei, China.¹ Analyses of lower respiratory tract samples identified the culprit as a novel coronavirus subsequently named severe acute respiratory syndrome coronavirus 2 (SARS-CoV2).¹ SARS-CoV2 and its associated respiratory illness, coronavirus disease of 2019 (COVID-19), then spread internationally leading to the declaration of a pandemic by the World Health Organization on March 11, 2020.² It quickly became clear that vascular disease is a major source of morbidity and mortality for patients with COVID-19. Postmortem analysis of the lung tissue from patients with COVID-19 revealed extensive small vessel endothelial injury, thrombosis, and microangiopathy.³ Early data also suggest COVID-19 increases risk for both venous and arterial thromboembolism.^{4,5} In Italy, one of the countries hardest hit by the pandemic, reduced physical activity and fear of seeking medical care may have contributed to later presentations and worse outcomes for patients with peripheral artery disease (PAD).⁶ Therefore, it is critical that vascular clinicians remain engaged in both inpatient and outpatient care during the pandemic.

Challenges for vascular clinicians

Although social distancing is necessary to mitigate spread of the virus among both patients and providers, this presents significant challenges to the provision of high-quality care. As vascular medicine providers, we rely on the nuances of the physical examination to evaluate, diagnose, and manage our patient population. Palpating peripheral pulses, auscultating bruits, and inspecting lower extremities for pigmentation changes and ulcers are essential components of our clinical practice. Much of our clinical decision-making depends on diagnostic imaging, and a single patient may require multiple imaging studies over a short time frame. Finally, many of our medical therapies, particularly anticoagulant and antithrombotic agents, require close follow-up and/or laboratory monitoring. As a result, a means to provide many forms of vascular care from a physical distance became paramount.

History of telemedicine in vascular practices

Telemedicine (TM), which is the use of telecommunications technology to provide health care from a distance, has found increasing use in recent years, especially for patients with chronic diseases. Components of TM include educational websites, tele-coaching, telemonitoring, telerehabilitation, and/or tele-consultation (Table 1).⁸ TM was adopted early for patients with heart failure. Numerous TM management strategies have been developed to reduce rehospitalizations, morbidity, mortality, and costs.⁸ Despite the variety of tested strategies in this patient population, supportive data remain mixed, and applications of these efforts remain encumbered by regulatory, payer, and other policy

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Table 1
Components of telemedicine

Components	Examples
Educational websites	<ul style="list-style-type: none"> • Preoperative information for patients to improve their preparedness for surgery • Postoperative programs to assist patients in their recovery process
Telecoaching	<ul style="list-style-type: none"> • Real-time individualized phone, video, or web-based text interactions with patients to identify symptoms in an accurate and timely manner and to effectively change their behavior with supportive guidance
Telemonitoring	<ul style="list-style-type: none"> • Inpatient or ambulatory tracking of patients through wireless measurement of vital parameters or activity or through electronic questionnaires regarding health.
Telerehabilitation	<ul style="list-style-type: none"> • Coaching, feedback, and or pharmacologic interventions might be provided based on these data • Patients are supported by electronic health devices in their recovery process instead of within a rehabilitation center or via in-person physiotherapy sessions
Teleconsultation	<ul style="list-style-type: none"> • Video-based consultation with a provider to facilitate shared decision-making regarding a potential surgical procedure

Adopted from M.E. Haveman, S.F. Kleiss, K.F. Ma, C.G. Vos, C. Unlu, R.C.L. Schuurmann, R.P.H. Bokkers, H.J. Hermens, J.P.M. De Vries, Telemedicine in patients with peripheral arterial disease: is it worth the effort?, Expert Rev Med Devices 16(9) (2019) 777–786.⁷

issues.⁸ Nonetheless, great interest in TM services remain, spurred by the shift from a fee-for-service to a value-based health care model.

Limited data support the use of TM for patients with vascular disease. In an exploratory study of patients with critical limb ischemia, eleven individuals underwent interviews regarding their

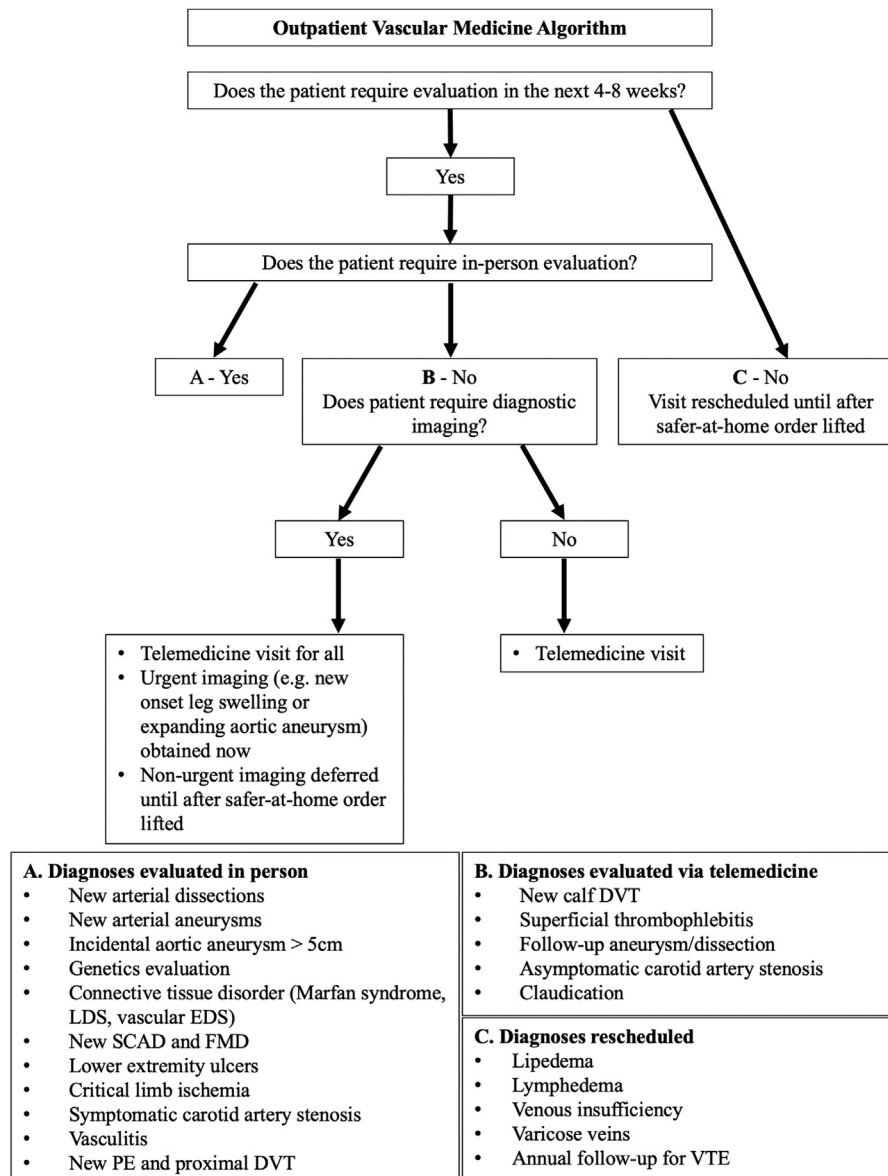


Figure 1. Outpatient vascular medicine algorithm. Vascular medicine providers used this algorithm to help determine whether patients could be evaluated via telemedicine, rescheduled, or evaluated in-person. LDS refers to Loey-Dietz syndrome; EDS = Ehlers-Danlos syndrome; SCAD = spontaneous coronary artery dissection; FMD = fibromuscular dysplasia; PE = pulmonary embolism; DVT = deep vein thrombosis; VTE = venous thromboembolism.

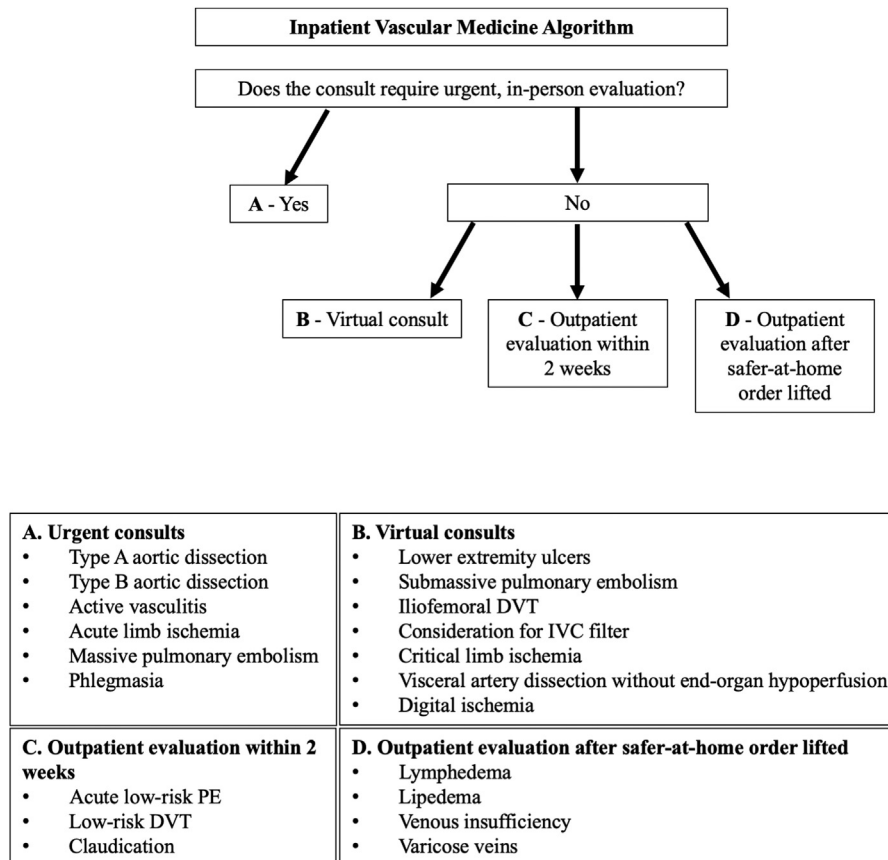


Figure 2. Inpatient vascular medicine algorithm. Algorithm to triage inpatient consultations and facilitate evaluations that reduced potential exposures for both patients and providers. DVT = deep vein thrombosis; IVC = inferior vena cava; PE = pulmonary embolism.

perceptions of TM. Eight in ten participants had home internet service, and 50% felt comfortable using technology on their own.⁹ After lower extremity revascularization for PAD, telemonitoring and telecoaching have been used ranging from a wound imaging application to remote vital sign monitoring, and telehealth-based questionnaires regarding intermittent claudication.⁷ One such example is implementation of the WoundCheck application as part of a 14-day postoperative follow-up protocol.¹⁰ This application allows patients to transmit photographs and have questions answered about their recovery process through a smartphone application. TM has even been used to diagnose and treat venous thromboembolism during spaceflight.¹¹ Nonetheless, data concerning TM for patients with vascular disease remain limited, and previous examples typically focus on individual disease processes rather than the full spectrum of vascular conditions. As a result, clinicians were left to devise their own processes as the COVID-19 outbreak expanded.

The Vanderbilt experience

Before the COVID-19 outbreak, TM in the Vanderbilt Heart and Vascular Institute at Vanderbilt University Medical Center (VUMC) was limited to anticoagulation management and remote device monitoring by the electrophysiology and heart failure services. On March 30, 2020, the Governor of Tennessee issued an executive “Safer at Home” order requiring all residents, with some exceptions, to remain in their homes as a way to reduce the impact of COVID-19.¹² In anticipation of this order, VUMC rapidly authorized video TM and embedded it into our Epic-based electronic health record (EHR) (Epic Systems, Verona, WI). For providers, this was

launched by clicking an icon next to each outpatient encounter, which then launched the Zoom video platform (Zoom Video Communications, San Jose, CA). Patients similarly launched Zoom from a HIPAA-compliant, web-based portal referred to as “My Health at Vanderbilt,” which predated the pandemic and also houses information regarding appointments, laboratory data, and imaging results. Patients and providers were able to interact via Zoom on webcam-equipped computers, smartphone, and tablets. Backup imaging platforms to account for unforeseen technology issues included Apple Facetime, Facebook Messenger, Google Hangouts video, WhatsApp video chat, and Skype. In rare cases, either owing to technology issues or unreliable internet access, these video encounters were converted to telephone encounters.

Similar to an in-person encounter, a TM visit includes a full history of present illness as well as review of each patient’s medical and surgical history, current medications, allergies, social history, family history, and review of systems. For the physical examination, patients obtained their own blood pressure if a sphygmomanometer was available. Our team instructed patients on measuring their own radial pulse, and patients were questioned regarding any irregularity of their pulse. If a scale was available, patients provided their weight and self-reported height. We asked patients to move their faces close to the camera to assess for craniofacial abnormalities, as in cases of possible connective tissue disorders, as well as scleral icterus or oropharyngeal abnormalities. A crude assessment for jugular venous distension was similarly performed by having patients move the camera to the neck area. We observed patients’ chest wall expansion with breathing, and we asked them to palpate their abdomens for tenderness. Patients then flipped their phone screens or placed their camera on the floor to show

their lower extremities. To determine if the lower extremities were swollen, we asked the patient to press their finger into the skin to assess for pitting edema. We were also able to assess for the presence of varicose, reticular, and spider veins, lymphedematous changes in the foot, ulcers, hair loss, and skin color changes. In many cases, patients sent additional photos via our EHR's secure messaging platform if better resolution was required or if skin changes fluctuated over time. After the physical examination, the provider would share their EHR computer screen with the patient to review laboratory testing and imaging. After a joint discussion of management recommendations, follow-up testing and appointments were arranged by clinical support staff.

Because our vascular medicine practice routinely cares for patients in other states, licensing became a challenge. Initially, patients were required to cross the state line into Tennessee to complete TM visits. However, nearby states, including Kentucky, Alabama, and Mississippi, quickly authorized emergency temporary licensure, primarily for established patients. Notably, the licensure authorization often differed between physicians and advanced practice nurse practitioners, so our support staff worked to confirm both patient location and provider licensure status before each clinic session.

The vascular medicine team at VUMC includes 3 vascular medicine attending physicians, one vascular medicine nurse practitioner, one nurse, and 2 medical assistants. During the COVID-19 pandemic, our roles shifted to collaboratively launch TM. Before COVID-19 pandemic, the vascular medicine group would typically see up to 90 inpatient and outpatient visits each week. Once TM was activated, it became clear we needed a strategy to help patients receive care while minimizing exposure risk. As a team, we created a diagnosis-based triage protocol that was utilized by all providers for both outpatient (Figure 1) and inpatient (Figure 2) encounters. These protocols incorporated diagnosis, acuity, and need for diagnostic imaging and were modified based on medical complexity and logistical considerations for each patient.

Not surprisingly, the outpatient clinical volume declined acutely as the Safer at Home order was implemented. In the first week of TM, the vascular medicine team cared for 26 patients; 5 new outpatients, 18 established outpatients, and 1 inpatient consult. Patient volume peaked at week 3 with 34 total patients—11 new, 22 established, and 1 inpatient consult. In total, during the first 6 weeks of TM, the vascular medicine service treated 54 new outpatients, 104 established outpatients, and 5 inpatient consultations. Approximately, 50 patients were rescheduled for future dates once social distancing restrictions are relaxed with additional patients wishing to wait before rescheduling visits. A total of 10 patients were seen in person during this 6-week period because of critical vascular conditions that could not be managed appropriately with TM or rescheduled.

The most common diagnoses seen via TM were spontaneous coronary artery dissection (12.8%), ascending aortic aneurysm (11%), and venous thromboembolism (9%). Additional diagnoses included fibromuscular dysplasia, venous insufficiency, hypertension, CAD, PAD, lower extremity ulceration, digital ischemia, and arterial dissection affecting the carotid, vertebral, celiac, and renal vessels. The patients presenting for follow-up with ascending aortic aneurysm and arterial dissection underwent imaging before the TM appointment. Imaging was performed at an outpatient facility with symptom and temperature screening for all visitors at the building entrances as well as social distancing measures in place. After completing the imaging studies, patients returned home rather than remaining for an in-person evaluation to decrease the risk of COVID-19 exposure. The inpatient vascular medicine consult diagnoses included active Takayasu arteritis, polyarteritis nodosa, PAD, renal artery stenosis, and digital ischemia.

Incorporating telemedicine into future practice

In recent years, policymakers have sought to reinvent American health care by replacing its fee-for-service foundations with a value-based care framework. Although TM is a logical component of such a framework, there remain significant burdens to providing video TM visits, particularly surrounding reimbursement. Due, in part, to a lack of other viable options during the COVID-19 pandemic, policymakers implemented a number of temporary actions that ultimately relaxed regulations for TM and encouraged home- and community-based management. The adoption of TM may be an unanticipated silver lining of COVID-19 for patients and providers alike. It has reduced travel time, fuel costs, and parking annoyance for patients and providers alike and can be easily adapted to provide visits outside of typical clinic hours. In many cases, TM allows for more patient-clinician interaction as a result of less time needed for rooming, documentation, and some components of the physical examination. In addition, it allows providers to digitally share their computer screen and review laboratory findings and imaging.

Moving forward, the future of TM remains unclear. Policymakers have not yet made long-term decisions regarding reimbursement and emergency licensure. Many technology platforms still do not provide adequate privacy for health care interactions. In addition, there are issues surrounding patients' access to technology and reliable internet service, which may further health care disparities. Finally, we will not have data on the quality and efficacy of care provided by TM for many months.

Nonetheless, we have learned valuable lessons from this rapid expansion of TM in our hospital. It is shortsighted to only view this expansion of TM as a solution to barriers caused by COVID-19. Disruptions in patients' ability to receive care routinely occur after tornadoes, floods, and other natural disasters, and Middle Tennessee has already experienced several such disruptions this year alone. We hope that our collective experience will inform our response to these and other challenges in the future.

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