From the Society for Vascular Surgery

Efficacy and safety of sonographer discretion to terminate a venous duplex ultrasound for diagnosis of deep vein thrombosis in coronavirus disease 2019 patients

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ABSTRACT

Objective: Sonographers performing venous duplex ultrasound (VDUS) of patients with coronavirus disease 2019 (COVID-19) have an increased risk of exposure owing to their close contact with these patients for an extended period. The objective of the present study was to evaluate the efficacy of a modified COVID-19 VDUS protocol to reduce sonographer exposure to COVID-19 patients.

Methods: We performed a single-center retrospective review. Patients who had undergone VDUS under the modified COVID-19 protocol between March 1, 2020, and June 30, 2020, with a confirmed or presumed COVID-19 diagnosis at the VDUS were included. The modified COVID-19 protocol was defined as the ability of the sonographer to terminate the examination on detection of an acute deep vein thrombosis (DVT). The primary outcome measures were the number of anatomic deep venous segments recorded by the sonographer, which was used as a surrogate measure for sonographer exposure time, and the number of acute DVTs found on follow-up examinations in segments not visualized at the index VDUS.

Results: A total of 160 lower extremity VDUS (LEVDUS) scans and 72 upper extremity VDUS (UEVDUS) scans were performed using the modified COVID-19 protocol. The index VDUS had found an acute DVT for 44 of 160 patients (27.5%) who had undergone LEVDUS and 26 of 72 (36.6%) who had undergone UEVDUS. On follow-up imaging, 7 of 38 LEVDUS scans (17.9%) and 1 of 10 UEVDUS scans (10%) had demonstrated a new acute DVT. Malignancy and surgery 30 days before imaging were significantly associated with acute lower extremity DVT, and mechanical ventilation and extracorporeal membrane oxygenation were associated with acute upper extremity DVT. On the index VDUS, the average was 10.6 of 12 total visualized segments on LEVDUS and 6.4 of 10 total segments on UEVDUS. Of the index VDUS scans, 35.6% of the LEVDUS and 78.6% of the UEVDUS scans had been abbreviated. The index VDUS scans that were positive for acute DVT had had significantly fewer visualized segments for both lower (8.4 vs 11.5; $P < .0001$) and upper (4.2 vs 7.6) extremities ($P < .0001$). On the follow-up examinations, only one of eight new acute DVTs had been found in a patient whose index VDUS had been abbreviated and the corresponding segment not assessed. These findings did not affect the patient's clinical course.

Conclusions: The modified COVID-19 VDUS protocol reduced sonographers' potential exposure time to COVID-19. Additionally, the clinical efficacy was maintained, with no missed DVTs, despite the abbreviation of the VDUS examinations. (J Vasc Surg Venous Lymphat Disord 2022;■:1-9.)

Keywords: COVID-19; Duplex ultrasound; DVT; Technologist exposure

Coronavirus disease 2019 (COVID-19) has been linked to a high rate of coagulation abnormalities resulting from an underlying hypercoagulable state.[1] COVID-19 infection is thought to directly affect the entirety of Virchow's triad,

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including endothelial injury via direct invasion of endothelium, stasis from hospitalization, critical illness, change in activity level, and the hypercoagulable state.[2,3] Deep vein thrombosis (DVT) has remained a common finding in patients acutely ill with COVID-19, with both intensive care unit (ICU) and non-ICU populations demonstrating increased rates of DVT despite thromboprophylaxis.[4,5]

As the primary diagnostic modality of DVT remains venous duplex ultrasound (VDUS), vascular laboratories were required to adapt to the demand for screening and diagnostic uses for patients with active COVID-19 infection.[6-8] These evaluations, typically performed by a vascular sonographer at bedside, require close patient contact in enclosed quarters for ∼30 minutes and represent a potential source of exposure to COVID-19. Critically ill patients, often with numerous support devices and catheters, will frequently undergo evaluation of both lower and upper extremities, further prolonging such encounters. Despite mitigation strategies and screening protocols, risk reduction of transmission to health care workers has remained paramount. Vascular sonographers also represent a potential source of asymptomatic carriers because they routinely perform studies of both COVID-19 and non–COVID-19 patients.[9] Efforts to decrease risk have included algorithms to reduce the number of ordered VDUS scans and modified protocols to reduce sonographer exposure time.[8,10] However, although the Society for Vascular Ultrasound has permitted limited examinations for patients with COVID-19, the implications of this have not been formally evaluated.[11]

Any such protocol should ameliorate risk without compromising patient care in the form of missed venous thromboembolism (VTE) events. The objective of the present study was to evaluate the safety and efficacy of a modified COVID-19 VDUS protocol to reduce sonographer exposure to COVID-19 patients. Our hypothesis was that a modified COVID-19 VDUS protocol could decrease sonographer exposure time to COVID-19 and maintain the clinical efficacy of the examination.

METHODS

Study design. The present study was a single-center retrospective review of patients with COVID-19 who had undergone VDUS under the modified COVID-19 protocol from March 1, 2020 to June 30, 2020. The institutional review board of Northwestern University approved the present study and waived the requirement for patient informed consent. The patients were included if they had tested positive or had been presumed positive for COVID-19 at the VDUS order. The VDUS orders were reviewed by the vascular laboratory, and the patients who had met the criteria were scheduled to undergo VDUS with the modified COVID-19 protocol. Data were extracted from the medical records by three of us independently (J.W.H., K.E.H., C.L.C.). Data collection was completed by January 2021.

ARTICLE HIGHLIGHTS

- **Type of Research:** A single-center, retrospective study
- **Key Findings:** A modified coronavirus disease 2019 (COVID-19) duplex ultrasound protocol allowing sonographers to terminate the study early on findings of an acute deep vein thrombosis allowed for significantly abbreviated ultrasound sessions for both upper ($P < .0001$) and lower ($P < .0001$) extremities without clinically significant compromise.
- **Take Home Message:** A modified COVID-19 duplex ultrasound protocol can significantly decrease ultrasound sonographer exposure to COVID-19, with minimal effects to clinical management.

VDUS scanning and interpretation. All VDUS scans were performed by the institution's vascular laboratory, accredited by the Intersocietal Accreditation Commission. The institution has a well-established and periodically audited protocol for upper and lower extremity VDUS. Our institution's standard lower extremity VDUS (LEVDUS) protocol is to scan from proximally (common femoral vein [CFV]) to distally (peroneal vein), including muscular calf veins, with inclusion of the distal external iliac vein if a DVT was seen at the ipsilateral CFV. The standard upper extremity VDUS (UEVDUS) protocol is to scan from proximally (innominate vein) to distally (forearm). The greater saphenous, small saphenous, basilic, and cephalic veins were included. The upper and lower extremity veins visualized were divided into segments in accordance with the Intersocietal Accreditation Commission reporting standards for peripheral venous testing and the institutional vascular laboratory protocol.[12] Compression was performed every 2 to 3 cm in B mode, with images acquired in each segment in grayscale and color Doppler. The total number of images saved was also recorded. All vascular sonographers had registered vascular technologist credentials. The criteria used to distinguish acute DVTs have been previously described.[13]

Modified COVID-19 protocol. The modified COVID-19 protocol was defined by the ability of the sonographers to terminate the VDUS early if an acute DVT had been detected. If no acute DVT were detected, a complete VDUS examination was performed.

Both UEVDUS and LEVDUS were eligible for the modified COVID-19 protocol. Orders for VDUS were placed at the discretion of the health care provider, including intensivists, inpatient and outpatient internists, and emergency medicine providers. We did not routinely screen patients for DVT. All VDUS scans had been ordered because of symptoms or clinical status changes. Ultrasound orders were received directly by the vascular laboratory and reviewed. The vascular surgery team was consulted for a clinical review of indications at the discretion of the vascular laboratory. A vascular surgery review was typically requested for indications that were atypical or nonspecific for DVT, such as tachycardia. Emergent indications, including phlegmasia cerulea dolens or compartment syndrome, were also referred to the vascular surgery service for consultation. However, if the indication for the study was typical for DVT (eg, lower extremity edema or pain), the study was completed as ordered. Follow-up studies were conducted as clinically indicated by the ordering provider. No requirements were in place for follow-up VDUS scans owing to the goal of decreasing sonographer exposure to COVID-19.

The deep veins comprising a complete examination for the purposes of the present study are listed in the Supplementary Table (online only). A bilateral LEVDUS and UEVDUS scan was considered complete if 12 and 10 segments had been visualized, respectively. All saved images, including duplicates of the same segments, were counted toward the number of images acquired. All DVTs were treated at the discretion of the ordering provider, including infrapopliteal DVTs. Superficial veins (cephalic, basilic, saphenous veins) were not included in the number of segments for the present study. Proximal lower extremity DVTs were defined as proximal to and including the popliteal vein. Proximal upper extremity DVTs were defined as proximal to and including the axillary vein.

Outcomes and analysis. The primary outcomes of interest included the DVT rates, number of venous segments visualized, and number of "missed" DVTs. The number of segments visualized was used as a surrogate for the ultrasound scan time. A "missed" DVT was defined as an acute DVT that had been identified on follow-up VDUS in a segment not previously visualized on the index VDUS. Demographic information (eg, age, gender, race, ethnicity), comorbidities (ie, malignancy, prior DVT, prior pulmonary embolus [PE], stroke), PE rates, and mortality rates were collected. Additional patient characteristics collected were the body mass index, use of extracorporeal membrane oxygenation (ECMO), presence and location (ie, femoral, internal jugular, subclavian, peripheral) of central venous catheters (ie, triple lumen catheters, dialysis catheters, introducer sheaths, and peripherally inserted central catheters), the need for mechanical ventilation, surgery ≤30 days before VDUS, and anticoagulation therapy. Anticoagulation therapy was defined as therapeutic anticoagulation. Prophylactic doses of anticoagulation were not captured in this dataset. ECMO cannulation strategies varied. Protek Duo (Cardiac Assist, Pittsburgh, PA) cannulas were placed in the internal jugular vein. For a bicaval strategy, the second cannula was placed in a femoral vein, because all the patients in this cohort who had required ECMO had received venovenous ECMO.

The patients who had undergone UEVDUS and LEVDUS examinations were combined for the evaluation of the demographic information and cohort characteristics. For all additional analyses, we analyzed the LEVDUS and UEVDUS cohorts separately. Descriptive statistics were included for continuous outcomes. Dichotomous outcomes were recorded using counts and percentages. DVT was classified as acute, chronic, age indeterminant, resolved, or unchanged. Univariate odds ratios (ORs) and the Fisher exact test were used for analysis. The segments visualized and images acquired in each DVT group were compared using the Wilcoxon rank sum test. An alpha level of 0.05 was used to determine significance. Statistical analysis was performed using SAS, version 9.4 (SAS Institute, Cary, NC), R, version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria), and Microsoft Excel 2010 (Microsoft, Redmond, WA).

RESULTS

Cohort characteristics. From March 2020 to June 2020, 168 unique patients with COVID-19 had undergone VDUS, for a total of 160 LEVDUS studies and 72 UEVDUS studies. Overall, the population was predominantly male (58.3%), with a mean age of 56 years. The mean body mass index was 32.63 kg/m^2 (Table I). Most of these patients had been critically ill and treated in the ICU (70.6% of LEVDUS and 90.1% of UEVDUS), including 14% requiring ECMO at the VDUS.

DVT types and distribution. Of the LEVDUS cohort, 44 (27.5%) had had an acute lower extremity DVT found on the index VDUS. Of these patients, 38 had undergone a follow-up LEVDUS, with 7 (18.4%) showing a new acute DVT. Among the UEVDUS cohort, 26 (36.6%) had had an acute DVT on the index VDUS (Table II). Of these patients, 10 had undergone a follow-up UEVDUS, with 1 (10%) showing a new acute DVT. The average interval between the index and follow-up VDUS was 14 days for both UEVDU and LEVDUS.

The distribution of acute DVT found by the index VDUS is shown in Table III. One third of all acute DVTs had involved proximal segments (n = 20) and two thirds had involved distal segments (n = 40). Multiple DVTs (two or more segments) had been found in 40.9% with an acute DVT in the lower extremity and 15.4% with an acute DVT in the upper extremity. No patient in our cohort had undergone thrombolysis for an acute DVT found on either the index or follow-up VDUS.

Risk factors for DVT. The baseline demographics, such as gender, race, ethnicity, and age, were not significantly associated with acute DVT on the index VDUS in either cohort (Table IV). Significant risk factors for acute lower

Table I. Demographics for complete cohort

Variable	Patients (N = 168)
Gender	
Male	98 (58.3)
Female	70 (41.7)
Race	
White	50 (29.7)
Black	66 (39.2)
Asian	6 (3.6)
Other	42 (25)
Declined	4 (2.4)
Ethnicity	
Hispanic	61 (36.3)
Age, years	
Mean	56
Median (range)	56 (17-93)
BMI, kg/m^2	
Mean	32.63
Median (range)	31.15 (17.72-81.81)

BMI, Body mass index.
Data presented as number (%), unless noted otherwise.

extremity DVT included malignancy (OR, 3.51; 95% confidence interval [CI], 1.0-12.8; $P = .048$) and surgery within 30 days (OR, 4.98; 95% CI, 1.56-17.4; $P < .05$). For the UEVDUS cohort, mechanical ventilation (OR, 6.00; 95% CI, 1.5-40.5; $P = .025$) and ECMO (OR, 4.06; 95% CI, 1.29-13.8; $P = .02$) were associated with an increased risk of acute DVT. No correlation was found between the location of central venous catheter placement and acute DVT.

Sonographer exposure time. The number of segments visualized and images acquired were used as a surrogate for sonographer exposure time (Fig). Of the index LEVDUS and index UEVDUS scans, 57 (35.7%) and 55 (78.6%) were abbreviated, respectively. The patients with an acute DVT had had significantly fewer images acquired and segments visualized on average for both LEVDUS (images, 18.7 vs 21.9 [$P < .003$]; segments, 8.4 vs 11.5 [$P < .0001$]) and UEVDUS (images, 9.8 vs 17.0 [$P < .0001$]; segments, 4.2 vs 7.6 [$P < .0001$]).

For the patients with an abbreviated LEVDUS, 7.0% had had an acute PE diagnosed after VDUS vs 9.7% of those with a complete LEVDUS. The difference was not statistically significant ($P = .77$). No significant difference was found in mortality between the abbreviated and complete groups (19.2% vs 15.0%; $P = .77$). For the UEVDUS cohort, we also found no significant difference in the incidence of PE (0% vs 3.6%) or mortality (27.3% vs 13.3%; $P = .32$) between the abbreviated and complete VDUS cohorts.

The indications for follow-up VDUS scans were extremity pain, edema, and a change in clinical status including hypoxia, fever, and an increase in the D-dimer level. The purpose of a follow-up VDUS for those with an acute DVT on the index VDUS was to evaluate for thrombus extension. A total of eight new acute DVTs were found on follow-up VDUS (seven lower extremity and one upper extremity; Table V). Two patients with a new acute DVT on follow-up had undergone an abbreviated index VDUS. For one patient, the segments affected in the follow-up study (axillary, subclavian, brachial) were visualized without an acute DVT on the index VDUS. Because the acute DVT had occurred in a segment that had been visualized on the index VDUS, we considered this a new DVT and not a "missed" DVT. For the second patient, the acute DVT found on the follow-up study was in a segment that had not been visualized on the index VDUS. The DVT was in the gastrocnemius; however, a proximal DVT had been found in the CFV on the index VDUS, leading to an abbreviated examination per protocol. Thus, one DVT had been "missed" in the combined cohorts. The latter patient had been receiving anticoagulation therapy at the follow-up VDUS, owing to the index VDUS findings of a proximal acute DVT.

DISCUSSION

VDUS, the imaging modality of choice for evaluating extremity DVTs, requires close patient contact to perform, resulting in a potential occupational hazard for

Table II. Deep vein thrombosis (DVT) type stratified by venous duplex ultrasound (VDUS) location

	LEVDUS		UEVDUS	
DVT type	Index (n = 160)	Follow-up (n = 38)	Index (n = 72)	Follow-up (n = 10)
None	108 (67.5)	22 (57.9)	45 (62.5)	6 (60)
Acute	44 (27.5)	7 (18.4)	26 (36.6)	1 (10)
Chronic	8 (5.0)	2 (5.3)	0 (0)	0 (0)
Age indeterminant	0 (0)	0 (0)	1 (1.4)	0 (0)
Resolved	0 (0)	3 (7.9)	0 (0)	1 (10)
Unchanged	0 (0)	4 (10.5)	0 (0)	2 (20)

LEVDUS, Lower extremity venous duplex ultrasound; *UEVDUS*, upper extremity venous duplex ultrasound.
Data presented as number (%).

Table III. Acute deep vein thrombosis (DVT) stratified by segment found on index venous duplex ultrasound (VDUS)

Segment	Acute DVT, No.
Lower extremity	
Iliac	0
Common femoral	9
Femoral	5
Popliteal	6
Posterior tibial	13
Peroneal	10
Gastrocnemius	13
Soleus	24
Upper extremity	
Innominate/brachiocephalic	2
Internal jugular	13
Subclavian	1
Axillary	9
Brachial	5
Forearm	0

sonographers when scanning patients with COVID-19. We found that a modified COVID-19 VDUS protocol in which a VDUS can be terminated early on findings of an acute DVT can shorten sonographers' exposure time without adverse clinical consequences. We have provided a practical protocol for reducing sonographers' occupational hazard and maintaining the clinical integrity of VDUS examinations.

COVID-19 is associated with a hypercoagulable state with a multifactorial etiology related to endothelial injury, leading to microvascular thrombi formation and fibrinolysis.[14] The high DVT rates for COVID-19 patients have ranged from <10% to 35%, with studies of critically ill patients citing rates of ≤79%.[4,15,16] A systematic review reported a pooled VTE rate of 31.3%, with a rate of 29.4% for symptomatic patients and 37.1% for screened patients.[15] Our study found an overall acute DVT rate of 29.2%, with a 27.5% rate of acute lower extremity DVTs and a 36.6% rate of upper extremity DVTs. Studies evaluating screening have demonstrated no significant benefit for asymptomatic patients with COVID-19, which has been further supported by the finding that 67.6% of patients with a PE had not had a prior DVT.[17-19] The current guidelines from the National Institutes of Health and American College of Chest Physicians have not recommended routine screening.[20,21] However, clinicians should have a low threshold for performing VDUS examinations in patients with a clinical suspicion for a DVT.[20,21]

Given the existing body of literature reporting high DVT rates for patients with COVID-19, the goal of our study was to evaluate the effect of an abbreviated VDUS on clinical care and sonographer exposure. We recognize that significant ramifications exist regarding DVTs in COVID-19 patients; however, the occupational hazards that can accompany the mode of diagnosis should also be considered. Previous studies have demonstrated workplace exposure to be a risk for COVID-19 transmission among health care workers and patients.[22-26] Although, to the best of our knowledge, no specific prior

Table IV. Univariate analysis of risk factors for acute deep vein thrombosis (DVT)

	LE				UE			
Risk factor	No DVT (n = 108)	Acute DVT (n = 44)	OR (95% CI)	*P* value	No DVT (n = 46)	Acute DVT (n = 26)	OR (95% CI)	*P* value
Male gender	58 (53.7)	30 (68.2)	1.87 (0.91-3.97)	.10	25 (54.3)	19 (73.1)	2.17 (0.78-6.50)	.15
Non-White	80 (74.1)	27 (61.4)	0.67 (0.32-1.45)	.30	30 (65.2)	18 (69.2)	1.0 (0.34-3.10)	>.99
Hispanic	42 (28.9)	16 (36.4)	0.98 (0.47-2.01)	.95	20 (43.4)	10 (38.5)	0.72 (0.26-1.92)	.51
Age >65 years	31 (28.7)	13 (29.5)	0.90 (0.41-1.88)	.77	10 (21.7)	9 (34.6)	1.85 (0.63-5.46)	.26
Prior DVT	9 (8.3)	5 (11.4)	0.93 (0.29-2.63)	.90	3 (6.5)	1 (3.8)	0.56 (0.03-4.64)	.62
Prior PE	8 (7.4)	1 (2.3)	0.25 (0.01-1.35)	.19	1 (2.2)	0 (0)	NA	NA
Stroke	4 (3.7)	4 (9.1)	2.22 (0.53-8.79)	.25	3 (6.5)	0 (0)	NA	NA
Malignancy	4 (3.7)	6 (13.6)	3.51 (1.0-12.8)	**.05**	3 (6.5)	2 (7.7)	1.17 (0.15-7.52)	.87
ECMO	11 (10.2)	3 (6.8)	1.38 (0.49-3.59)	.52	6 (13.0)	10 (38.5)	4.06 (1.29-13.8)	**.02**
UE CVC	NA	NA	NA	NA	26 (56.5)	21 (80.8)	2.55 (0.85-8.76)	.11
LE CVC	1 (0.9)	3 (6.8)	4.17 (0.67-32.5)	.12	NA	NA	NA	NA
Mechanical ventilation	61 (56.5)	28 (63.6)	1.35 (0.66-2.80)	.42	30 (65.2)	24 (92.3)	6.00 (1.5-40.5)	**.03**
Surgery within 30 days	5 (4.6)	8 (18.2)	4.98 (1.56-17.4)	**.01**	3 (6.5)	1 (3.8)	0.55 (0.03-4.54)	.61
AC	2	4	0.79 (0.21-2.39)	.70	8	4	3.91 (0.71-29.8)	.13

AC, anticoagulation; *CI*, confidence interval; *CVC*, central venous catheter; *ECMO*, extracorporeal membrane oxygenation; *LE*, lower extremity; *NA*, not applicable; *OR*, odds ratio; *PE*, pulmonary embolism; *UE*, upper extremity.
Data presented as number (%), unless noted otherwise.
Boldface *P* values represent statistical significance.

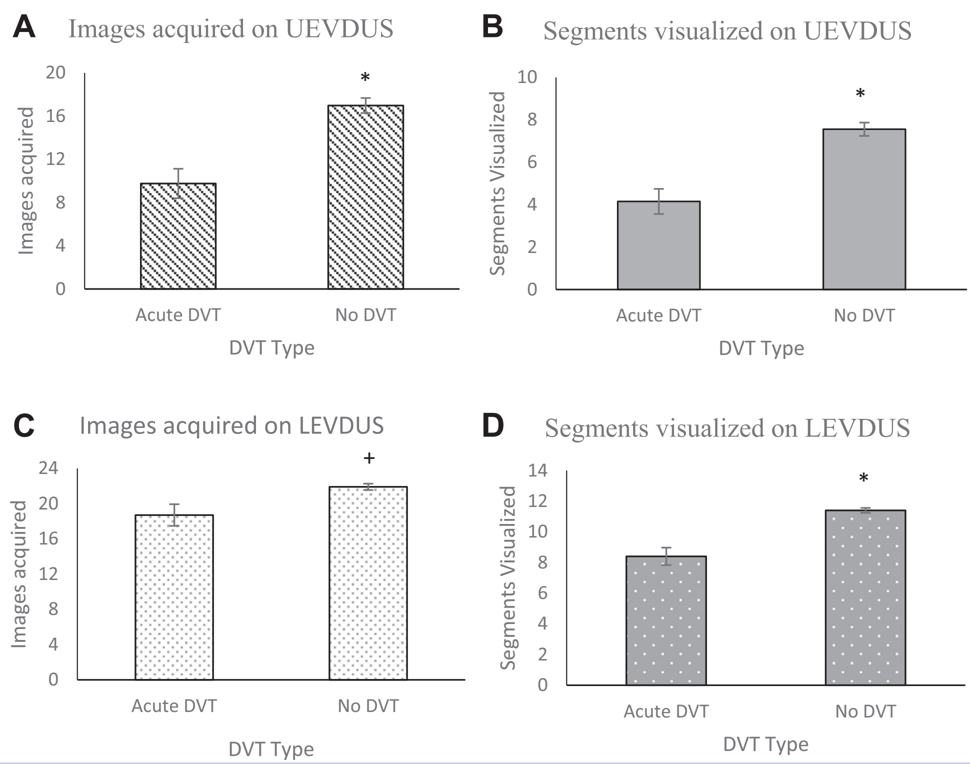

Fig. Segments visualized and images acquired in upper extremity venous duplex ultrasound (UEVDUS) and lower extremity venous duplex ultrasound (LEVDUS) stratified by deep vein thrombosis (DVT) type. **A,** Images acquired on UEVDUS stratified by DVT type (images, 9.8 vs 17.0; $^*P < .0001$). **B,** Segments visualized on UEVDUS stratified by DVT type (segments, 4.2 vs 7.6; $^*P < .0001$). **C,** Images acquired on LEVDUS stratified by DVT type (18.7 vs 21.9; $^+P < .003$). **D,** Segments visualized on LEVDUS stratified by DVT type (segments, 8.4 vs 11.5; $^*P < .0001$).

studies have evaluated the risks of COVID-19 exposure for sonographers, it has been demonstrated that an increased risk of transmission exists for nurses, staff working in COVID units, and those with high-risk exposure.[27]

Our standard institutional protocol has been to assess all vessels of interest at 2- to 3-cm intervals. This protocol will typically correlate with several images per segment and can require contact with patients for a variable period time. Typically, 45 minutes will be allotted for a LEVDUS and 60 minutes for an UEVDUS, including transit, scanning, annotation, and uploading. The scan and exposure time can vary considerably from 15 to

Table V. Segments visualized on index and follow-up imaging studies for patients with acute deep vein thrombosis (DVT) on follow-up study

Case No.	Segments with acute or chronic DVT, index study	Complete index study	Segments with acute DVT, follow-up study
1	None	Yes	Left, gastrocnemius
2	None	Yes	Right, popliteal, left common femoral vein
3	None	Yes	Right, posterior tibial
4	Right, common femoral vein	No	Right, gastrocnemius[a]
5	Right, gastrocnemius, peroneal, soleus; left, posterior tibial	Yes	Right, gastrocnemius, peroneal, soleus (unchanged); left, peroneal
6	Left, peroneal (chronic)	Yes	Left, gastrocnemius
7	Right, popliteal, gastrocnemius, peroneal (chronic); left, gastrocnemius, peroneal, soleus (chronic)	Yes	Right, peroneal, popliteal, gastrocnemius (chronic); left, peroneal, soleus (acute), gastrocnemius (chronic)
8	None	No	Left, subclavian, axillary, brachial[b]

[a]New acute DVT not visualized on index study.
[b]Segments with new acute DVT in segment previously visualized on index study.

45 minutes, depending on the patient's height, presence of indwelling catheters and/or cannulas, and model of ultrasound machine. Indwelling catheters and ECMO cannulas can also make VDUS more difficult, requiring increased time and positioning with close contact with the patient. This could also account for the abbreviated scans, especially for the upper extremities, because segments could not be scanned owing to the presence of catheters and/or cannulas. Although the Society for Vascular Ultrasound has permitted shortened examinations to decrease exposure, no standard recommendations or protocols have been established.

Dua et al[8] established an institutional protocol with the goal of decreasing the length of VDUS examinations and limiting the number of VDUS examinations performed. Their protocol triaged orders by suggesting the initiation of anticoagulation therapy for those with a high likelihood of VTE and attending physician discussion for those requesting a VDUS, resulting in cancellation of 72% of the orders. Their study found that examinations performed with their COVID-19 protocol required 50% less time to complete than a conventional examination, with a median examination time of 13 minutes vs 6 minutes for a conventional vs modified COVID-19 protocol, respectively.[8] To decrease the scan time, their protocol did not image infrapopliteal veins and limited color and/or spectral Doppler imaging to the proximal veins. In contrast, our protocol allowed for termination of the VDUS study if an acute DVT had been detected by the sonographer. Using the number of segments visualized as a surrogate for the scanning time, we found that implementation of the protocol decreased the segments visualized in both the upper (4.2 vs 7.6) and the lower (8.4 vs 11.5) extremity cohorts for the patients with an acute DVT. This finding has demonstrated that the protocol was effectively implemented and resulted in abbreviated examinations for those with an acute DVT. Although we found a significantly decreased number of segments visualized with VDUS with an acute DVT, we have also demonstrated a 31.4% rate of multiple DVTs, implying that more VDUS examinations had the potential to be abbreviated.

Few proximal lower extremity DVTs were detected in our study, with no patients requiring thrombolysis after VDUS. Most of the DVTs in lower extremities were distal DVTs. Although no definitive guidelines are available on the management of infrapopliteal DVTs, the results from a meta-analysis have indicated that anticoagulation therapy can decrease the recurrence of VTE and DVT, with no increase in clinically relevant non—major bleeding events.[28,29] Thus, value for management in detecting distal lower extremity DVTs could remain. Although the decision for the treatment of DVTs was by the ordering clinicians, our practice pattern has been to initiate anticoagulation therapy for patients with infrapopliteal DVTs.

Few DVTs were found during follow-up that had not been present in the index VDUS. Only one DVT was found in a follow-up VDUS in a segment that had not been previously imaged. If detected on the index VDUS, the finding, ultimately, would not have changed management because the patient had had an acute DVT in a more proximal segment and had received anticoagulation therapy as a result. The second patient with a DVT found after an abbreviated index VDUS was in a segment previously imaged and was interpreted as a new DVT. Thus, additional follow-up VDUS scans are unlikely to be necessary because of "missed" DVTs from an abbreviated examination. Furthermore, no significant differences were found in the incidence of PE and mortality between those with an abbreviated VDUS and those with a complete VDUS. Because the clinical value to performing a VDUS is the prevention of life-threatening PEs, it is critically important that the implementation of a new VDUS protocol will not increase PE rates. These findings have demonstrated that the modified COVID-19 VDUS protocol maintained the clinical integrity of the examination and allowed for shorter VDUS examination times.

Study limitations. The present study was inherently limited by its retrospective nature, small number of patients, and single-institution design. The study also had limitations because the data were obtained by a review of the medical records. We also might not have fully captured those patients who had had COVID-19 and had undergone VDUS. Additionally, we were unable to collect data on the outcomes for those who had not undergone ultrasound because of the triage system. Therefore, we were unable to distinguish whether patients had the VDUS deferred because of emergent vs insufficient clinical indications. Although other studies have described institutional triage systems,[8,10] these data were unavailable when our protocol was initiated, given the early implementation during the pandemic. Thus, the triage system had not been validated before implementation.

We also used the number of segments visualized and images acquired as surrogates for the time spent exposed to the patient. Although fewer segments visualized or images acquired strongly suggests less contact, we did not record the scan or in-room time. Thus, the scan time could not be compared between individual sonographers or trends determined throughout the protocol period. Given that the decision to terminate the scan was made by the sonographer, the sonographers could have had varied levels of scanning experience and might have consistently chosen to complete the scan despite findings of an acute DVT, as evidenced by scans with findings of multiple DVTs. Although the reason for completing such scans was unclear, sonographers might benefit from education or encouragement that a complete scan might not alter management. Although we did not consider this a protocol violation requiring remediation, the deviation requires evaluation for the underlying rationale and will be a target for future improvement.

Finally, if on a follow-up VDUS, proximal extension of the thrombus was found, this would be detected, because the images were collected from proximally to distally. This allowed for the detection of treatment failure owing to proximal extension. However, in an abbreviated VDUS, the distal extent of the thrombus will be unknown; thus, distal extension of thrombus because of an increased distal thrombus burden could not be evaluated with our protocol. If the distal extent of the thrombus presents value regarding the possible need for thrombolysis, it is likely that further imaging would be completed before or at the time of thrombolysis.

Future work should evaluate the risk reduction for sonographers associated with abbreviated examinations. This would require a larger cohort of sonographers to collect data on the incidence of COVID-19 infections with anonymity maintained. At present, the protocol has become optional owing to the decreasing rates of COVID-19 infection. We have continued to advocate for minimizing COVID-19 exposure for sonographers and will reinstate promotion and education for sonographers regarding the protocol if a resurgence of COVID-19 rates occurs. The protocol could also be used if a future pandemic or contact transmissible disease affects our population in large numbers. A specific population prevalence of COVID-19 has not yet been set as a trigger for reinstituting the protocol; however, this could be considered in the future.

CONCLUSIONS

The findings from the present study contribute to the paucity of literature addressing sonographer occupational hazards during the COVID-19 pandemic. We have reported the successful implementation of a modified COVID-19 VDUS protocol that could allow for decreased workplace exposure to COVID-19 for sonographers. Furthermore, these findings have demonstrated that the efficacy of the examination can be maintained without changes to clinical management despite abbreviation of the VDUS.

AUTHOR CONTRIBUTIONS

Conception and design: JH, AD, AV, ME, KH, TT
Analysis and interpretation: JH, IH, KH, TT
Data collection: JH, CC, KH
Writing the article: JH, CC, KH, TT
Critical revision of the article: JH, CC, IH, AD, AV, ME, KH, TT
Final approval of the article: JH, CC, IH, AD, AV, ME, KH, TT
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Overall responsibility: TT

KH and TT contributed equally to this article and share co-senior authorship.

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Supplementary Table (online only). Veins visualized via complete lower extremity and upper extremity venous duplex ultrasound (VDUS)

Venous segment
Lower extremity
Common femoral
Femoral
Popliteal
Posterior tibial
Peroneal
Gastrocnemius
Upper extremity
Internal jugular
Innominate
Subclavian
Axillary
Brachial