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An Educational Intervention on the Clinical Utility of Point-Of-Care Ultrasound (POCUS) in the Timely Detection of Perioperative Thromboembolic Complications in COVID-19 Patients Undergoing Noncardiac Surgery

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ABSTRACT

Background: Venous thromboembolism (VTE), including deep vein thrombosis (DVT) and pulmonary embolism (PE), is a rare but most likely fatal perioperative complication associated with increased patient morbidity and mortality. COVID-19-positive patients with VTE who present for surgery are predominantly asymptomatic and do not meet the conventional definition and traditional diagnostic criteria. This presents a challenge in identifying VTE in this patient population without proper surveillance and monitoring.

Objectives: The purpose of this study is to improve anesthesia providers' knowledge of the value of POCUS modality in preventing perioperative VTE in patients with COVID-19 undergoing noncardiac surgical procedures and improve recognition of associated risk factors that predispose patients to the development of VTE. Investigators used CINAHL, MEDLINE, and EMBASE databases to answer the PICO (i.e., population, intervention, comparison, outcome) question: "*In the adult patients with COVID-19 (P), does the use of the POCUS modality as an adjunct to preoperative screening for DVT (I), compared to its non-use (C), improve the early identification of perioperative VTE (O)?* The literature review provides the educational framework to improve provider knowledge. The overall objective of the project is to increase the quality of healthcare delivery to improve healthcare outcomes for patients with COVID-19 undergoing noncardiac surgery.

Methodology: The primary methodology of the proposed project is to administer an online educational intervention to providers which focuses on the benefits of perioperative POCUS utilization in the early identification of VTEs. Pre- and post-assessment surveys will be used to measure the improvement of provider knowledge before and after the intervention.

Results: Overall, there was an improvement in provider knowledge following the education intervention. Additionally, the likelihood of utilizing the perioperative POCUS modality increased among anesthesia providers.

Conclusion: The perioperative incorporation of the POCUS modality has been shown to accurately assess the presence of DVT. The educational intervention provided effectively improved anesthesia provider knowledge on the value of POCUS modality in preventing perioperative VTE in patients with COVID-19 undergoing noncardiac surgical procedures and improving recognition of associated risk factors that predispose patients to the development of these events. Increasing awareness of the high incidence of thromboembolic events in patients with COVID-19 and the role of POCUS in their early detection can reduce mortality and improve postoperative outcomes.

Keywords: *venous thromboembolism, deep vein thrombosis, pulmonary embolism, COVID-19, coagulopathy, POCUS, point-of-care ultrasound, perioperative management*

Introduction

Description of the Problem

A novel Severe Acute Respiratory Syndrome Coronavirus type-2 (SARS-CoV-2), the culprit of the COVID-19 pandemic, has been an ongoing public health threat, accounting for millions of deaths worldwide. A cluster of unexplained pneumonia cases was first reported from Wuhan, China, on December 31, 2019. The World Health Organization (WHO) declared COVID-19 a public health emergency of international concern of January 30, 2020, and by March 11, the spread of the infection had reached an alarming milestone of a global pandemic.[2] The United States reported its first confirmed case of SARS-CoV-2 infection on January 20, 2020.[1] It is currently one of the leading causes of mortality in the United States, accounting for over 34 million cases and over 600,000 deaths as of this writing.[1] Although the overall incidence of COVID-19 has decreased since the rollout of the vaccine, the new variants of SARS-CoV-2 continue to emerge and circulate across the globe, threatening to overturn the progress made so far in halting the spread of the pandemic.[1,2]

Amid an ongoing pandemic, anesthesia providers routinely encounter and manage patients with COVID-19 infection presenting for surgery. Perioperative management of COVID-19-positive patients presents a myriad of unique challenges for anesthesia professionals, as the surgery in this population is considered high-risk and is associated with a greater incidence of viral transmission, cross-contamination of the perioperative environment as well as the hazard of self-exposure during aerosol-generating procedures.[3] Additionally, patients with COVID-19 undergoing a surgical procedure are found to have a greater incidence of perioperative adverse events and hemodynamic instability, unplanned postoperative ICU admissions, increased length of hospital stay, and substantial long-term morbidity.[3,4] According to the recent autopsy series the incidence of unexpected perioperative mortality among COVID-19 patients undergoing a surgical procedure has been estimated as

high as 20 %.[5] The evidence suggests the high mortality rates observed among COVID-19 patients are largely due to unrecognized thromboembolic complications, including deep vein thrombosis (DVT) and pulmonary embolism (PE).[4,5] Several case reports corroborate the high incidence of venous thrombosis and pulmonary embolism in the setting of COVID-19 pneumonia despite prophylactic anticoagulation. While the exact estimate of the incidence of venous thromboembolism (VTE) in COVID-19 patients remains unclear, the accumulating evidence reports rates varying between 4.8% and 85%, with pulmonary embolism being the most common thromboembolic complication.[7] VTE is often an unrecognized asymptomatic event that may be detected early through appropriate monitoring. Early detection can lead to better outcomes; thus, the importance of close monitoring and screening for DVTs in patients with COVID-19 is gaining widespread recognition. Additionally, a lack of consensus in the literature regarding optimal anticoagulation regimen, time of initiation, and duration of the therapy in this high-risk patient population further contribute to the development of acute VTE, risking a potentially fatal outcome.[9] As the key members of the perioperative arena who provide the majority of the direct patient care, anesthesia providers, must be knowledgeable of the risks and associated complications of VTE as well as the available safety measures and recommendations for the surgical patient population with COVID-19.

Diagnosis of VTE, challenging under usual circumstances, is even more complex when associated with COVID-19. Traditionally D-dimer cutoff levels are used to decide whether further imaging, such as Computed Tomography Angiogram (CTA), is warranted. In COVID-19 patients, D-dimer levels seem to be intrinsically elevated, thereby making it a less useful tool to risk-stratify COVID-19 patients.[7,8] Furthermore, access to the CTA may be limited due to risk transmission and cross-contamination. Alternatively, the use of point-of-care ultrasound (POCUS) of the lower extremity has been shown to be a safe, rapid, and accurate method for the detection of DVT when integrated in the preoperative assessment for

patients with COVID-19.[8, 10-14] Generally, the concept of POCUS refers to the use of portable ultrasonography at a patient's bedside for therapeutic, procedural, and diagnostic purposes. Growing evidence suggests that POCUS contributes to earlier and improved diagnosis, helps to reduce the cost of care, and improves patient outcomes.[9] It represents an attractive option during the Covid-19 pandemic since it is portable technology helps to reduce exposure and transmission of infection. The use of POCUS in Covid-19 patients has been endorsed and encouraged by the American College of Chest Physicians (ACCP) expert panel and the American College of Emergency Physicians (ACEP). The ACCP suggested using lower extremity POCUS as part of screening in COVID-19 patients with suspected pulmonary embolism, unexplained right ventricular dysfunction, or unexplained refractory hypoxemia.[2,3,5] The American Association of Nurse Anesthetists (AANA) recognizes the importance of POCUS as a critical core skill that CRNAs should possess. Gavazzi et al[5] in their report, strongly suggested a close vein ultrasound screening and monitoring to be performed in all COVID-19 patients to screen for DVTs.

In patients with COVID-19, the POCUS exam for lower extremity DVT consists of two-dimensional venous compression and yields results similar to formal vascular studies.[10,1] Because proximal lower extremity thrombi have the highest risk of embolization, evaluation of the common femoral vein, femoral vein, and popliteal vein is most important. Either inability to compress a vein completely with wall-to-wall apposition or visualization of echogenic thrombus within the vein is diagnostic of DVT.[8.12,15] Acute thrombi are gelatinous and may appear anechoic, while subacute or chronic thrombi are echogenic, but all veins with a DVT will not compress complete [10,12,13]

Published reports revealed 91% sensitivity and 98 % specificity of the compression POCUS exam in detecting lower extremity DVT.[16,17] Additionally, the literature suggests that using POCUS in the diagnosis of lower extremity DVT may help avoid unnecessary medical

interventions and diagnostic tests, therefore representing the potential quality of care and cost-saving improvements.[13-17]

Despite the literature demonstrating the positive outcomes of the compression POCUS exam, published consensus guidelines have not yet included its implementation as a standard intervention for preventing VTE. Determining the value and clinical utility of POCUS in a preoperative setting could as the initial step toward establishing objective, evidence-based clinical implications for reducing the adverse outcomes of theCOVID-19-associated coagulopathy. This literature review will present a synthesis of the current evidence regarding point-of-care ultrasonography's utility in preventing of VTE in patients with confirmed COVID-19 undergoing surgical procedures.

Background and Pathophysiology

The pathophysiological mechanisms of the VTE formation can be traced back to Virchow's Triad, which proposes that venous thrombosis is the result of at least one of three etiologic factors: hypercoagulability, endothelial injury, and venous stasis.[4,5] Patients suffering from COVID-19 are at particularly high risk for developing VTE as the emerging evidence postulates that all three contributing factors of the Virchow's triad apply in COVID-19 [10,12,16] (Figure 1). The viral interaction of SARS-CoV-2 with angiotensin-converting enzyme (ACE-2) receptors has been suggested to cause the injury and consequent dysfunction of the vascular endothelium.[4-6] Research has shown that SARS-CoV-2, the causative pathogen for COVID-19, enters cells through ACE-2 receptors located in type two alveolar cells, intestinal epithelium, and vascular endothelium. [3-6] Specifically, the viral surface spike (S) protein binds to ACE2 on host cells, triggering viral endocytosis.[6] The fusion peptide of the S subunit inserts into the host cell membrane. Once inserted, the S protein folds upon itself, bringing its two heptad repeat regions together, which fuses the cell membranes and releases the viral package into the host cell.[6,8] Once inside host cells, the

virus induces cell injury that activates a highly inflammatory process of the host cell death known as pyroptosis, ultimately causing the widespread damage and dysfunction of the vascular endothelium.[3-6] The inflamed and injured vascular endothelial cells facilitate the recruitment of leukocytes, macrophages, and mast cells, which have important roles in immunity.[6] An aggressive viral infection induces apoptosis of lymphocytes and consequent lymphopenia.. The protective immune system leads to the release of molecules such as C-reactive protein, fibrinogen, ferritin, D-dimer, and pro-inflammatory cytokines, including interleukin-6 (IL-6).[6] A progressive dysregulated immune response to SARS-CoV-2 viral infection with the synthesis of IL-6 and other inflammatory mediators, the so-called cytokine storm, contributes in turn to activate the complement system, clotting cascade, thus causing a state of hypercoagulability.[5,6]

Additional anesthesia-related factors contributing to venous stasis and stimulation of coagulation include prolonged operative/anesthetic exposure time, vasodilatory effects of anesthesia medications, muscle relaxation, and decreases in core body temperature.[7] Finally, mechanical ventilation, central venous catheterization, and surgery cause additional vascular endothelial injury, nearly doubling the risk of developing vessel thrombosis.[7]

Purpose of the Study

The purpose of this study is to improve anesthesia provider knowledge on the use of POCUS in the prevention of perioperative VTE in patients with COVID-19 undergoing noncardiac surgical procedures, as well as improve recognition of associated risk factors that predispose patients to the development of VTE. An educational intervention will be provided to certified registered nurse anesthetists as part of a quality improvement project. The goal is to improve provider knowledge and the likelihood of utilizing POCUS to prevent perioperative VTE in patients with COVID-19 undergoing noncardiac surgical procedures. An increased participants' knowledge surrounding the pathophysiological

mechanisms of VTE formation in COVID-19 patients, the pitfalls of the current VTE prevention practices and recommendations, and the benefits of perioperative use of POCUS modality may help in the early identification of VTE and potentially reduce the risk of perioperative thromboembolic events. The overall objective of the project is to increase the quality of healthcare delivery and improve healthcare outcomes for surgical patients with COVID-19 undergoing noncardiac surgery.

THE LITERATURE REVIEW

Purpose of the Literature Review

This literature review will present a synthesis of the current evidence regarding Point-Of-Care Ultrasonography's utility in the preventing VTE in patients with confirmed COVID-19 undergoing surgical procedures. The literature review includes primary research studies answering the PICO question: "*In the adult patients with COVID-19 (P), does the use of the POCUS modality as an adjunct to preoperative screening for DVT (I), compared to its non-use (C), improve the early identification of perioperative VTE (O)?* The literature review is used to provides the educational framework to improve provider knowledge. The results obtained from the literature review will be used to formulate an educational intervention to improve anesthesia provider knowledge on the use of the POCUS modality for screening for DVT. The overall objective of the project is to increase the quality of healthcare delivery with the intention of improving healthcare outcomes for patients with COVID-19 undergoing noncardiac surgery

METHODOLOGY

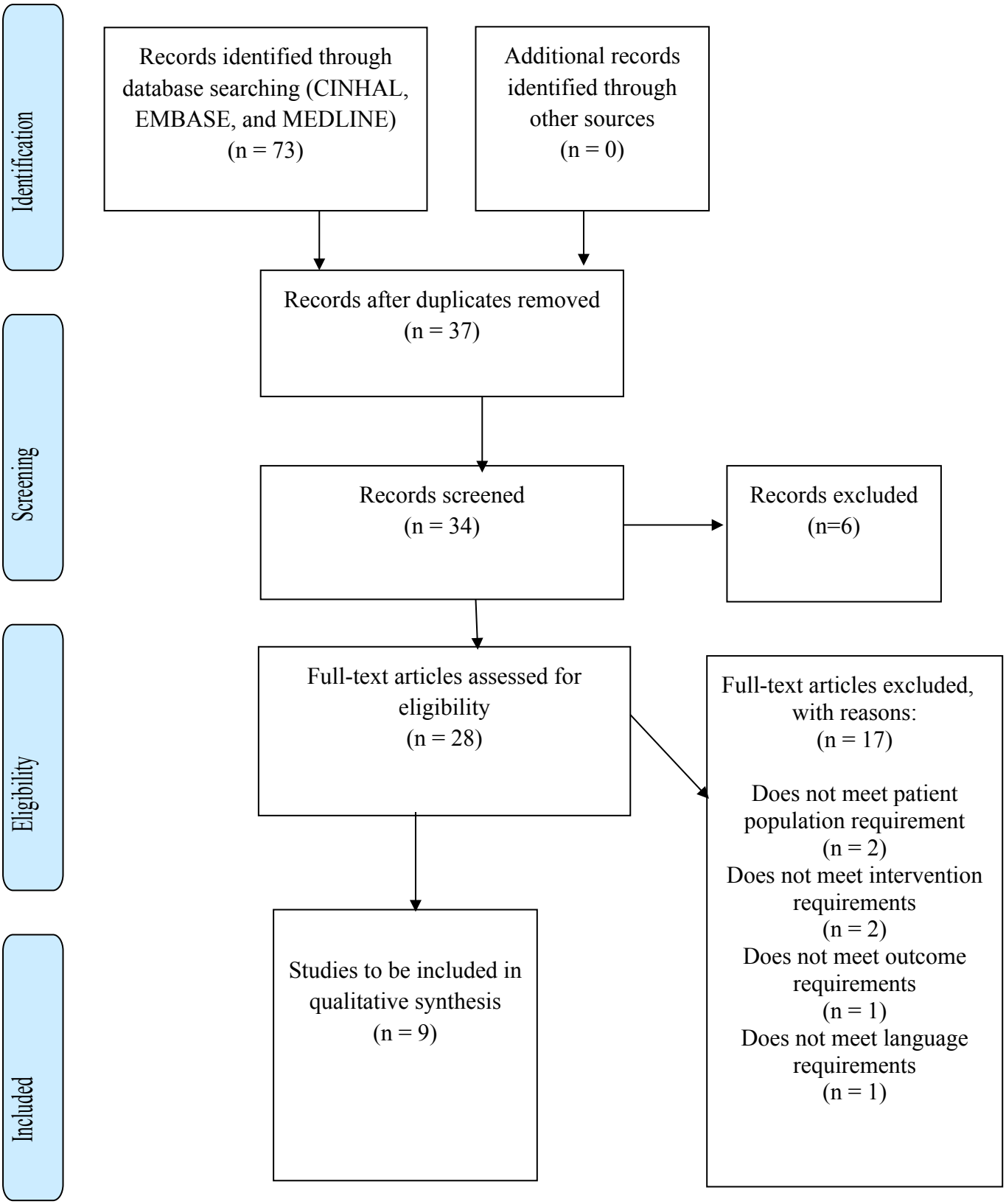
Strategy and Study Selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist was used to guide the search and format of the literature review.[9] Below is a PRISMA flow diagram in Figure 1 that provides a visual representation of this literature

review screening process phases. A comprehensive search was conducted on several electronic databases, including Medline (ProQuest), Excerpta Medica Database (EMBASE), and Cumulative Index of Nursing and Allied Health Literature (CINAHL) electronic databases. The following Medical Subject Headings and free-text terms were used alone and in combination with the appropriate Boolean filters: *venous thromboembolism, deep vein thrombosis, pulmonary embolism, surgery, Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2), COVID-19, point-of-care ultrasound, perioperative management, anesthesia considerations*. Filters included English text, full-text availability, scholarly peer-reviewed journals, academic journals, and studies published after December 31, 2019. After studies were gathered through the databases, additional publications were discovered by finding the primary sources in an article's reference list. For the identification of additional and potentially relevant data sources, each article that matched the PICO criteria was examined along with its respective reference lists. Studies referenced in matching articles were reviewed for relevance and were included if matching the PICO criteria. Gray literature databases, including www.clinicaltrials.gov, conference abstracts, and poster presentations, were explored to reduce reporting bias. The titles and abstracts of relevant results were evaluated using predetermined inclusion criteria. The search yielded 46 articles related to the previously mentioned criteria. Of the 46 articles, 9 were found to be relevant and subsequently included in this literature review.

Full text of each relevant article was obtained, and data were extracted for analysis. Information extracted from each study included population, study design, type of procedure, intervention, and primary outcome measures. Published guidelines and current recommendations from the ACCP and the ASPS were also included in this literature review.

Figure 1. PRISMA Flow Diagram



Data Collection and Analysis

The selected studies were evaluated using John Hopkin's Nursing Evidence-based Practice process to determine the strength and quality of research. According to John Hopkin's strength of research evidence rating scheme, level I evidence comprising of evidence obtained from an experimental study, randomized controlled trial, or systematic review of randomized controlled trials, with or without meta-analysis, is considered the strongest level of evidence.[13] Level II evidence includes evidence obtained from a quasi-experimental study or a systematic review which includes quasi-experimental studies, with or without meta-analysis.[13] Level III evidence obtained from a quantitative non-experimental study (e.g., observational cohort study), qualitative study, or a systematic review consisting of either, is considered the lowest level of evidence.[13]

Research evidence is further evaluated and determined to be of high-quality, good - quality, or low-quality evidence. "High" quality evidence contains consistent and generalizable results, a sufficient sample size, adequate control, definitive conclusions, and consistent recommendations based on a thorough literature review established from scientific evidence.[1] "Good" quality evidence contains reasonably consistent results, a sufficient sample, some degree of control, fairly definitive conclusions, and reasonably consistent recommendations based on a fairly comprehensive literature review.[13] "Low" quality evidence contains little evidence with inconsistent results, an insufficient sample size, and lacks any definitive conclusions.[13]

The selected studies were also evaluated for relevant information consistent with the purposes of the literature review and stated PICO question. The information obtained and evaluated from each observational cohort study included: (1) the study design and method, (2) sample size and characteristics, (3) sample setting, (4) measurement tool and abnormal threshold value, (5) results of the study, (6) associated risk factors for VTE, (7) limitations of

the study, and (8) study conclusions. A matrix table was created to summarize the characteristics and findings from each study, and an evidence rating was assigned to each study based on John Hopkin's research evidence appraisal tool.

RESULTS

Several studies have assessed the usefulness of POCUS to diagnose VTE in patients with COVID-19. Lerardi et al.[21] report a deep venous thrombosis (DVT) incidence of 1.6% among 60 COVID-19 patients routinely screened by bedside ultrasound. In a prospective study of 156 COVID-19 patients with D-dimer levels > 1000 ng/ml, compression ultrasound screening for asymptomatic DVT showed an incidence of 14.7%.[22] Similar findings have been reported with another systematic screening for the diagnosis of deep vein thrombosis (DVT) by lower limb vein compression ultrasonography in 84 consecutive patients despite uniform pharmacological thromboprophylaxis incidence of 11.9%; 2.4% proximal DVT.[23]

D-dimer is a laboratory indicator that reputedly predicts fatal outcomes from PE. In some studies, patients with D-dimers levels of $1.0 mg/L had an 18- fold increased mortality risk,2 and patients who had died of COVID-19 had had higher levels of D-dimer on admission compared with those who had survived. In our review, 13 of the included studies had reported significantly higher D-dimer levels in COVID-19 patients with VTE than in those without VTE. Therefore, a higher D-dimer level could be an indicator of predicting VTE and a poor prognosis for VTE patients.

In a retrospective cohort study of 71 treated COVID-19 patients on anticoagulant thromboprophylaxis, who underwent systematic low limb venous duplex ultrasonography at hospital discharge or earlier if DVT was clinically suspected, 16 patients developed VTE (22.5%) and 7 PE (10%).[24]

Cross-sectional study in Wuhan, China, in 48 patients on low molecular weight heparin (LMWH) thromboprophylaxis detected lower extremity DVTs in 41 patients

(85.4%), with 36 (75%) isolated distal DVTs and 5 (10.4%) proximal DVT.[25] In another retrospective study from Wuhan, all 88 patients on LMWH thromboprophylaxis underwent compression ultrasonography. Here, the overall incidence of DVT was 46%, comprising proximal DVT in 9 % and distal DVT in 46% .[26]

Kariyanna *et al*. retrospectively reviewed a single case of a thrombus in transit in a critically ill patient with COVID-19 pneumonia, where the initial diagnosis was made with POCUS. [12] The findings of the study demonstrated that POCUS could be used as an alternative for screening patients with COVID-19 who are at risk of PE. Similarly, several other reports confirmed that POCUS could be used to rapidly diagnose pulmonary embolism and guide management and intervention.[5,6,8,12]

DISCUSSION

Summary of Evidence

Point-of-care ultrasound (POCUS) is the concept of bedside utilization of ultrasound to expeditiously receive imaging information that guides appropriate diagnoses, medical interventions, and acute procedures.[11-14,15] POCUS examination enables anesthesia providers to bring portable ultrasound imaging to the patient's bedside and perform a study in real time.[11-17] Perioperative ultrasound has been widely used in anesthesiology due to its simplicity, rapidity, practicality, low cost, absence of radiation, and reproducibility. POCUS modality has become an indispensable tool for anesthesiologists to evaluate cardiopulmonary status, guide procedures, and manage emergencies.[11,14-16]

For diagnostic purposes, POCUS is a safe, fast, effective, and relatively inexpensive tool that helps address a specific clinical question to guide the evaluation and management of the patient and is often complementary to the physical examination.[18,19] Its ability to diagnose potentially life-threatening conditions in a timely manner is especially beneficial for

anesthesia providers in resource-poor settings where access to other types of imaging is not available.[13,14]

Point of care ultrasound is a diagnostic modality growing in popularity due to its non-invasive nature and quick application. Its utility lies in its non-invasive application, direct user interface, and portability, especially in handheld devices, allowing for quick assessment and triage. Gaps exist in the evidence to guide the choice among available anticoagulants, dosing, optimal timing of initiation, and duration of therapy for VTE prevention. No prospective randomized controlled trials exist on the preoperative use of POCUS for VTE prevention in the COVID-19 patient population This delineates the need to gather high-quality clinical evidence by designing large-*scale studies im*plementing ultrasound as a real-time diagnostic and navigation tool for management. Further assessment is needed of the potential positive or negative implications of using a focused methodology, handheld technology, and its application by practitioners with limited POCUS training. Larger studies could provide useful and practice-changing information that, importantly, could be translated into the management of new emerging respiratory infection outbreaks with a high risk of human-to-human transmission.

Limitations

There are several noteworthy limitations in our study. First, the studies included in our analysis are observational. This review included observational cohort studies and thus were not classified as the highest level of evidence. All studies had defined inclusion and exclusion criteria, but such criteria were not consistent among the studies. Most of the studies included in this review were prospective in nature which allowed for a more complete study design; however, four studies were classified as retrospective. There is limited control over data collection in retrospective studies, and data may be incomplete, inaccurate, or inconsistently measured between subjects.[31]

Given that there are no randomized clinical trials, it is difficult to eliminate confounding variables when assessing VTE and clinical associations. Furthermore, the included studies are heterogeneous with respect to reporting patient demographics, clinical characteristics, method of VTE diagnosis, and strategy for anticoagulation. These studies suggest an increased incidence of late or delayed VTE risk [6]. Further, the studies did not consistently report the duration of illness, the severity of illness, hospital length of stay, risk factors for VTE, or presence of other non-VTE indications for anticoagulation.

Future potential areas of research include arterial thrombosis, the impact of hypercoagulability risk factors, the occurrence of late-term thrombosis post-discharge, and the presence of long-term coagulopathy. As worldwide cases continue to surge, VTE risk in non-hospitalized patients with less acute and non-pneumonia COVID-19 infection also warrants further investigation.

CONCLUSION

Perioperative thromboembolic event, including deep vein thrombosis or pulmonary embolism, is a complication that can result in substantial patient morbidity and mortality. Traditionally, D-dimer cutoff levels are used to decide whether further imaging, such as Computed Tomography Angiogram (CTA) is warranted. In COVID-19 patients, D-dimer levels seem to be intrinsically elevated, thereby making it a less useful tool to risk-stratify COVID-19 patients.[7,8] Furthermore, access to the CTA may be limited due risk transmission and cross-contamination. The preoperative incorporation of POCUS modality has been shown to accurately assess for the presence of DVT. Examination with POCUS provides anesthesia providers with relevant clinical information and can be performed in real-time at the bedside. Point-of-care ultrasound screening for DVT may be a resource-sparing alternative in the setting of the COVID-19 pandemic.

METHODOLOGY OF QUALITY IMPROVEMENT

Setting and Participants

The primary objective of this quality improvement (QI) project is to improve healthcare provider knowledge on the role of Point-Of-Care Ultrasonography (POCUS) in the prevention of perioperative Venous Thromboembolism (VTE) in patients with COVID-19 undergoing noncardiac-surgical procedures and to determine the efficacy of a PowerPoint educational intervention to meet this objective. To successfully achieve the goals of this quality improvement project, a series of actions will be conducted that involve a specific group of study participants receiving an educational intervention on the utility of POCUS in preventing perioperative VTE in patients with COVID-19. The setting of this QI project will take place across four hospitals located in Broward County, Florida. Broward Health Medical Center contains 716 beds, Broward Health North contains 409 beds, Broward Health Coral Springs contains 250 beds, and Broward Health Imperial Point contains 204 beds. The Salah Foundation Children's Hospital within Broward Health Medical Center contains 125 beds. Primary participants include all certified registered nurse anesthetists (CRNAs) employed by Anesco Broward North Anesthesia Group, LLC (Anesco), which provides anesthesia services for all four hospitals in the district. The participants will be recruited voluntarily, and the anticipated sample size will be between 5-15 participants.

Description of Approach and Project Procedures

The primary methodology of the proposed project is to administer an online educational intervention to anesthesia providers which focus on the benefits of POCUS utilization in the prevention of perioperative VTE in patients with COVID-19. A virtual pre-test/post-test design will be used to evaluate outcomes. The target population will comprise approximately 10 anesthesia providers working for Broward Health. With their virtual consent, participants will complete a virtual, anonymous pre-test survey to assess their

knowledge, perceptions, and current clinical practices regarding the use of Point-Of-Care Ultrasonography (POCUS) in the prevention of perioperative venous thromboembolism (VTE) in patients with COVID-19 undergoing noncardiac surgical procedures. The virtual pre-test survey is to be completed individually and is expected to take up to 5 minutes. Then, the participants will view a virtual 10-minute educational PowerPoint based on the results of a related systematic review. Participants will be asked to complete a virtual post-test, which will be identical to the pre-test. A virtual post-test survey is expected to take 5 minutes to complete. Data will be collected using the pre-test/post-test survey form attached. No identifiable private information is to be collected. Demographic data, including gender, age, ethnicity, and title, will be obtained as part of the survey. Additionally, the pre-test/post-test survey will be used to collect data related to participants' knowledge, perceptions, and practices related to using POCUS in the prevention of perioperative VTE in COVID-19 patients. All data analysis will be completed virtually. No face-to-face contact will be required. The participants will watch the educational module and take the pre and post-test from the electronic device they use to open the survey. As a result of this project, it is expected that participants will gain increased knowledge of the uses and benefits surrounding the utilization of the POCUS modality for the prevention of perioperative VTE. Furthermore, it is expected that this project will benefit COVID-19-positive patients presenting for a surgical procedure.

Protection of Human Subjects

As this is an educational intervention, there is no to minimal risk to participants. Risks are outlined in the consent (see Appendix B). Participation is voluntary, and there is no penalty if participants decide to withdraw from the QI project. Anonymity will be ensured under the Qualtrics survey platform, and the investigator will obtain no personal factors that could identify the subjects. Additionally, Institutional Review Board (IRB) approval will be

gained before any intervention will be carried out (see Appendix C). The anonymous results will be secured via the utilization of randomized code identifiers. The electronic data collected from pre-, and post-test will be maintained on a password-protected laptop.

Data Collection

The primary data collection instruments will include a pre-assessment and post-assessment questionnaire to determine the effects of the education intervention. Both assessments will be conducted using surveys of approximately 10 questions focusing on knowledge and practice using Qualtrics. The pretest will gauge knowledge and current perspectives on the educational material, while the post-test survey will determine if the participants gained knowledge from the intervention and will apply their knowledge to the practice environment. Demographic data, including gender, age, ethnicity, and title will be obtained as part of the survey. Additionally, the pre-test/post-test survey will be used to collect data related to participants' knowledge, perceptions, and practices related to the use of POCUS in the prevention of perioperative VTE in COVID-19 patients. The data will be exported from Qualtrics to the Statistical Package for the Social Sciences (SPSS), and an analysis will be conducted. The data collected will be confidential and no subject identifiers will be recorded during any component of the study.

Data Management and Analysis Plan

The co-investigator DNP student will extrapolate statistically significant data from SPSS, utilizing this to establish patterns of change from participants. Growth or decline in knowledge from pre-test to post-test will be compared using random identification numbers (ID) allocated by the Qualtrics platform to preserve anonymity. Each question will be assessed, and measurements will be taken to establish personal change, change amongst the group, and the overall effectiveness of the educational intervention. Data collected will remain on a password-protected computer.

RESULTS OF QUALITY IMPROVEMENT

Pre-test and Post-test Demographics

The pre-test and post-test demographics are identified in Table 1, shown below.

Table 1. Participant Demographics

Demographics	N (%)
Total Participants	8 (100%)
Gender	
Male	5 (40%)
Female	7 (60%)
Age	
<18 yr	0 (0%)
18 – 29 yr	4 (30%)
30 – 49yr	8 (70%)
> 50 yr	0 (0%)
Ethnicity	
Hispanic	1 (8%)
Caucasian	9 (75%)
African American	1 (8%)
Asian/Pacific-Islander	1 (8%)
Other	0 (%)
Education	
Masters	2 (16%)
Doctorate	10 (84%)
Years of CRNA Practice	
0 – 2 yr	3 (25%)
2 – 5 yr	7 (58%)
5 – 10 yr	1 (8%)
10 – 20 yr	1 (8%)
> 20 yr	0 (0%)
Title	
CRNA	8 (100%)
MD	0 (0%)

Twelve participants initially started the pre-test survey, three of whom failed to complete the post-test survey. One CRNA neglected to enter their random ID number to allow the project's co-investigator to assign pre and post-test scores to the right surveyor. Subsequently, their data was omitted during dissemination. Eight anesthesia providers accurately followed the pre-test and post-test instructions, and their demographics are presented in Table 1. Most participants were female (n=5, 62.5%), instead of male (n=3,

37.5%). Most individuals were also in the 25 to 35 age group (n=5, 62.5%). The remaining participant's ages were as follows: 36 to 45 years old (n=1, 12.5%), 46 to 55 years old (n=2, 25%), and no individuals from the 55 to 66-year age group. Various ethnicities were also represented amongst the surveyors Hispanic (n=4, 50%), African American (n=1, 12.5%), Asian (n=1, 12.5%), and other (n=1, 12.5%). There were no participants who identified as Caucasian. Information was obtained about the participant's level of education, and it was found that the majority had a doctorate degree (n=6, 84%), and only a few had a master's degree (n=2, 16%). All participants in this quality improvement project were CRNAs (n=8, 100%). Finally, individuals were asked about their years of CRNA practice: 0 - 2 years (n=4, 50%), 2 - 5 years (n=1, 12.5%), 5 - 10 years (n = 1, 12.5%), 10 - 20 years (n=2, 25%).

Table 4. Difference in Pre-Test and Post-Test Knowledge

Correct Responses	Pre-Test	Post-Test	Difference
Depending on patient risk factors, the incidence of VTE in covid-19 can be as high as: **80%**	12.5%	62.5%	50%
Which of the following statements best defines venous thromboembolism? **A blood clot that manifests as a spectrum of sequelae, including deep vein thrombosis (DVT) and/or when it dislodges and migrates, a pulmonary embolism (PE).**	12.5%	50%	37.5%
Which of the following is NOT associated with VTE? **Reduced costs of care and earlier discharge**	100%	87.5%	-12.5%
Which of the following is NOT considered a significant risk factor for VTE? **Female gender**	100%	87.5%	-12.5%
What is the most common anatomic site of venous thrombosis formation? **Lower extremities**	75%	87.5%	12.5%
The use of point-of-care ultrasound (POCUS) of the lower extremity has been shown to be a safe, rapid, and accurate method for detecting DVT when integrated into the preoperative assessment for patients with COVID-19: **True**	62.5%	62.5%	0%

What makes POCUS an attractive option in preventing perioperative VTE complications in COVID-19? **All of the above**	100%	100%	0%
Which of the following is TRUE? **All of the above**	100%	87.5%	-12.5%

Pre-test and Post-test Knowledge and Perspective of Use in Practice

If the modality was offered at their facility, the participants were asked how likely they would utilize the POCUS modality to screen for DVT in COVID-19 patients undergoing noncardiac surgery. A positive correlation was found between the pre and post-test data. Pre-education, 37.5% of CRNAs said they were extremely likely to use it, while 62.5% of CRNAs were extremely likely to use it post-education. The same amount of CRNAs (n = 3 or 37.5%) was somewhat likely to use before and after the educational intervention. 25% of participants were neither likely nor unlikely to use the POCUS modality to screen for DVT in the pre-test but changed their perspective to extremely likely in the post-test. Table 2 depicts the likelihood of CRNAs using the POCUS modality to screen for DVT in COVID-19 patients at their facility.

Table 2. Differences in Pre-Test and Post-Test Perspective

If available at your facility, how likely are you to utilize the POCUS modality to screen for DVT in COVID-19 patients undergoing noncardiac surgery?	**PRE-TEST**	**POST-TEST**	**DIFFERENCE**
Extremely likely	37.5%	62.5%	25%
Somewhat likely	37.5%	37.5%	0%
Neither likely nor unlikely	25%	0%	-25%
Somewhat unlikely	0%	0%	0%
Extremely unlikely	0%	0%	0%

If the modality was offered at their facility, the participants were asked how likely they were to recommend the use of the POCUS modality to screen for DVT in COVID-19 patients undergoing noncardiac surgery. A positive correlation was found between the pre and post-test data following the educational intervention. Two participants (25%) were somewhat likely to recommend the utilization of POCUS modality to screen for DVT in COVID-19 patients, as opposed to no participants prior to the intervention. However, 62.5% of participants exhibited no change in perspective, and one participant (12.5%) exhibited a negative change in perspective. Overall, 50% of participants were either somewhat unlikely (n=3, 37.5%) or extremely unlikely (n=1, 12.5%) to recommend the POCUS modality, an improvement from 62.5% before educational intervention. Two participants (25%) remained indifferent and were neither likely nor unlikely to recommend POCUS modality to screen for DVT in COVID-19 patients undergoing surgery. Table 3 depicts the likelihood of the participants recommending the use of POCUS modality to screen for DVT in COVID-19 patients if available at their facility.

Table 3. Differences in Pre-Test and Post-Test Perspective

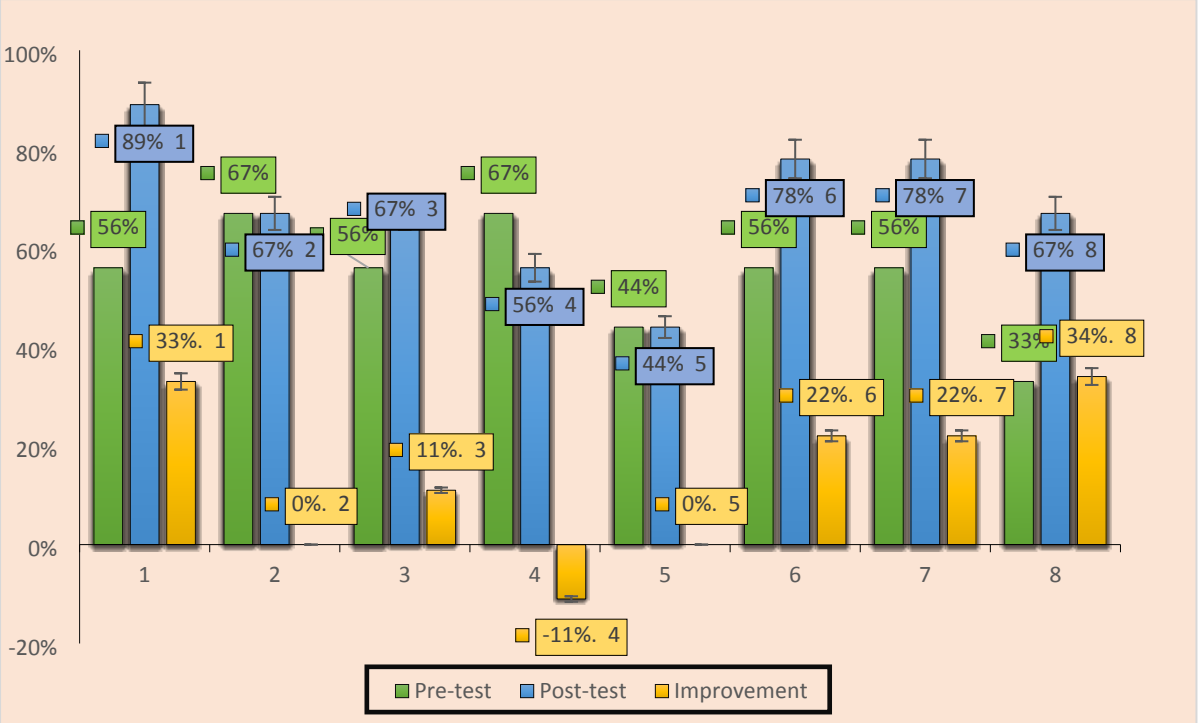
How likely are you to recommend POCUS modality to screen for DVT in COVID-19 patients undergoing noncardiac surgery?	PRE-TEST	POST-TEST	DIFFERENCE
Extremely likely	*0%*	*0%*	*0%*
Somewhat likely	*0%*	*25%*	*25%*
Neither likely nor unlikely	*37.5%*	*25%*	*-12.5%*
Somewhat unlikely	*50%*	*37.5%*	*-12.5%*
Extremely unlikely	*12.5%*	*12.5%*	*0%*

Summary of Data

The results demonstrate an overall gain in knowledge between pre- and post-testing, with only one participant with a lower post-test than from pre-test score. A bar graph comparing results is depicted below in Table 4. In general, pre-test assessments show an

average score of 54% compared to 68% on post-test assessments. The overall average improvement between pre-and post-test assessments was 14%. Only 5 out of the 8 participants (62.5%) who completed the study showed an improvement in knowledge following the intervention, with an average increase of 24.4% between pre- and post-assessment scores. The remaining participants either had no change in knowledge (n=2, 22%) or had a decrease in knowledge (n=1, 11%) despite the education provided.

Table 4. Pre and Post-Test Scores



Out of the participants who showed improvement in knowledge between pre- and post-test assessments (n=5), one participant (20%) was more likely to utilize following the intervention. Two participants (40%) remained somewhat unlikely to employ the POCUS modality, one participant (20%) remained neither likely nor unlikely to employ, the POCUS modality and one participant (20%) was less likely to employ the POCUS modality after the intervention, despite improvement in knowledge.

DISCUSSION

Limitations

One limitation of this project is the small sample size. Many subjects that were eligible to participate in the study chose not to. Twenty-eight members of the Broward Health anesthesia department distributed the survey via e-mail, and only twelve people participated in the project. A small sample size can impact the reliability and validity of a study. In the future, the survey could be distributed to more subjects across different hospital systems to increase the sample size. Also, the survey link, which contained both surveys and the PowerPoint presentation, was only available online for two weeks, perhaps increasing the time allotted to review the material and surveys could have increased the number of responses. Lastly, the project was implemented completely online, hindering its delivery by other methods. A more controlled, in-person setting could have yielded more accurate results. As this project was volunteer based, there is an inherent risk of self-selection bias. Finally, sample attrition occurred, which could have potentially impacted the final results of the study. Though the investigators strived for concise instructions on the survey link, three participants who completed the pre-test failed to finish the post-test. Further, one individual who finished their pre-and post-testing neglected to enter their random ID number to allow the project's co-investigator to assign pre and post-test scores to the right surveyor.

Future Implications for Advanced Nursing Practice

Early identification of VTE through POCUS surveillance allows appropriate interventions to occur, reducing morbidity and mortality in the COVID-19 patient population undergoing noncardiac surgery. Despite the literature demonstrating the positive outcomes of the clinical utility of POCUS in the early identification of thromboembolic events, published guidelines have not yet included its implementation as a standard intervention in the prevention of VTE.[5,6,9-12] The outcomes of this study are important in determining strategies available to participants that will increase knowledge and potentially change practice to improve patient outcomes in COVID-19 patients undergoing noncardiac surgery. According

to the data collected, the educational intervention provided was effective in improving the knowledge of anesthesia providers on the role of POCUS in the prevention of perioperative VTE in patients with COVID-19. Participants have demonstrated stronger attitudes and beliefs regarding the high incidence of VTE in COVID-19-positive patients and the significance of its early identification. Furthermore, there was an increase in the likelihood of using POCUS screening in this high-risk surgical patient population. The results of this study can be applied to a wider audience of Certified Registered Nurse Anesthetists. As research continues to be conducted on the management strategies for COVID-19, increasing awareness of the high incidence of VTE as well as the role of POCUS in their prevention, can reduce mortality and improve overall patient outcomes.

Conclusion

Diagnosis of VTE, challenging under usual circumstances, is even more complex when occurring in association with COVID-19.[2,3,8] Traditionally D-dimer cutoff levels are used to decide whether further imaging, such as Computed Tomography Angiogram (CTA), is warranted. In COVID-19 patients, D-dimer levels seem to be intrinsically elevated, thereby making it a less useful tool to risk-stratify COVID-19 patients.[3,4] The unrecognized thromboembolic event, including deep vein thrombosis or pulmonary embolism, is a complication that can result in substantial patient morbidity and mortality. It has serious consequences as unrecognized PE is associated with increased morbidity and mortality within 30 days of surgery, resulting in significant utilization of healthcare resources.[4-6] As the new variants of COVID-19 continue to emerge, it becomes essential for anesthesia providers to be informed of the unique anesthetic considerations for this population, including the management and prevention of VTE. Furthermore, anesthesia providers must be knowledgeable of the preventable measures that can reduce the incidence of perioperative PE. Implementing an educational module on POCUS for reducing perioperative VTE can

enhance anesthesia provider knowledge, strengthen the beliefs and attitudes of anesthesia providers, and increase the likelihood of using this modality in the COVID-19 population to improve the quality of care and patient outcomes.

REFERENCES

1. Centers for Disease Control and Prevention. CDC COVID Data Tracker. Accessed July 2, 2020. https://www.cdc.gov/coviddata-tracker/#cases
2. Moores LK, Tritschler T, Brosnahan S, et al. Prevention, diagnosis, and treatment of VTE in patients with coronavirus disease 2019: CHEST Guideline and Expert Panel Report. Chest. 2020;158(3): 1143-1163.
3. Middeldorp S, Coppens M, van Haaps TF, et al. Incidence of venous thromboembolism in hospitalized patients with COVID-19. J Thromb Haemost. 2020;18(8):1995-2002
4. Klok FA, Kruip MJHA, van der Meer NJM, et al. Incidence of thrombotic complications in critically ill ICU patients with COVID-19. Thromb Res. 2020;191: 145-147.
5. Bikdeli B, Madhavan MV, Jimenez D, et al. COVID-19 and thrombotic or thromboembolic disease: implications for prevention, antithrombotic therapy, and follow-up. J Am Coll Cardiol. 2020;75(23): 2950-2973.
6. Poissy J, Goutay J, Caplan M, et al; Lille ICU Haemostasis COVID-19 group. Pulmonary embolism in COVID-19 patients: awareness of an increased prevalence. Circulation. 2020;142(2):184- 186.
7. Hernandez S, Valdes J, Salama M. Venous Thromboembolism prophylaxis in Plastic surgery: A Literature Review. AANA J. 2016 Jun; 84(3):167-72. PMID:27501651
8. Deshpande C. Thromboembolic Findings in COVID-19 Autopsies: Pulmonary Thrombosis or Embolism? Ann Intern Med. 2020;173(5):394-395. doi:10.7326/M20-3255
9. Piliego C, Strumia A, Stone MB, Pascarella G. The ultrasound guided triage: a new tool for prehospital management of COVID-19 pandemic. Anesth Analg. 2020;131: e 93–e94.
10. Shakiba B, Irani S. Covid-19, and perioperative mortality; where do we stand? EClinicalMedicine. 2020; 22:100364. doi: 10.1016/j.eclinm.2020.100364
11. Deshpande C. Thromboembolic Findings in COVID-19 Autopsies: Pulmonary Thrombosis or Embolism? Ann Intern Med. 2020;173(5):394-395. doi:10.7326/M20-3255
12. Kariyanna PT, Hossain NA, Jayarangaiah A, et al. Thrombus in Transit and Impending Pulmonary Embolism Detected on POCUS in a Patient with COVID-19 Pneumonia. Am J Med Case Rep. 2020;8(8):225-228.
13. Piliego C, Strumia A, Stone MB, Pascarella G. The Ultrasound-Guided Triage: A New Tool for Prehospital Management of COVID-19 Pandemic. Anesth Analg. 2020 Aug;131(2): e93-e94. doi: 10.1213/ANE.0000000000004920. PMID: 32345853; PMCID: PMC7202119.
14. Anile A, Castiglione G, Zangara C, Calabrò C, Vaccaro M, Sorbello M. COVID: the new ultrasound alphabet in SARS-CoV-2 era. Anesth Analg. 2020 Jul 21:10.1213/ANE.0000000000005142. doi: 10.1213/ANE.0000000000005142. Epub ahead of print. PMID: 32739958; PMCID: PMC7389191.
15. Litjos JF, Leclerc M, Chochois C, Monsallier JM, Ramakers M, Auvray M, et al. High incidence of venous thromboembolic events in anticoagulated severe COVID-19 patients. J Thromb Haemost. (2020) 18:1743–6. 10.1111/jth.14869
16. Kariyanna PT, Celenza-Salvatore J, Jayarangaiah A, Punnakudiyil GJ, McFarlane IM. A Case of Thrombus in Transit: Role of POCUS in Early Diagnosis of Pulmonary Thromboembolism. Am J Med Case Rep. 2020;8(2):67-69. doi:10.12691/ajmcr-8-2-7
17. Rubulotta F, Soliman-Aboumarie H, Filbey K, et al. Technologies to Optimize the Care of Severe COVID-19 Patients for Health Care Providers Challenged by Limited Resources. Anesth Analg. 2020;131(2):351-364. doi:10.1213/ANE.0000000000004985

18. Zhang P, Qu Y, Tu J, et al. Applicability of bedside ultrasonography for the diagnosis of deep venous thrombosis in patients with COVID-19 and treatment with low molecular weight heparin. J Clin Ultrasound. 2020;48(9):522-526. doi:10.1002/jcu.22898
19. Sebuhyan M, Mirailles R, Crichi B, Frere C, Bonnin P, Bergeron-Lafaurie A, Denis B, Liegeon G, Peyrony O, Farge D; Saint-Louis CORE (COVID-19 RESEARCH) group. How to screen and diagnose deep venous thrombosis (DVT) in patients hospitalized for or suspected of COVID-19 infection, outside the intensive care units. J Med Vasc. 2020 Dec;45(6):334-343. doi: 10.1016/j.jdmv.2020.08.002. Epub 2020 Sep 4. PMID: 33248536; PMCID: PMC7473249.
20. Longchamp A, Longchamp J, Manzocchi-Besson S, Whiting L, Haller C, Jeanneret S, et al. Venous Thromboembolism in Critically Ill Patients withCovid-19: Results of Screening Study for Deep Vein Thrombosis. Res PractThromb Haemost. 2020; Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7272794/. [cited 2020 Oct 22].
21. Lerardi AM, Coppola A, Fusco S et al. (2020). Early detection of deep vein thrombosis in patients with coronavirus disease 2019: to screen and who not to with Doppler ultrasound? J Ultrasound. https:// doi. org/ 10. 1007/ s40477- 020- 00515-1
22. Demelo-Rodriguez P, Cervilla-Munoz E, Ordieres-Ortega Let al (2020) Incidence of asymptomatic deep vein thrombosis in patients with COVID-19 pneumonia and elevated D-dimer levels. Thromb Res 192:23–26. https:// doi. org/ 10. 1016/j. throm res. 2020.05.0188.
23. Minuz P, Mansueto G, Mazzaferri F et al (2020) High rate of pulmonary thromboembolism in patients with SARS-CoV-2 pneumonia. Clin Microbiol Infect 26:1572–1573. https:// doi. org/ 10.1016/j. cmi. 2020. 06. 011
24. Artifoni M, Danic G, Gautier G et al (2020) Systematic assessment of venous thromboembolism in COVID-19 patients receiving thromboprophylaxis: incidence and role of D-dimer as predictive factors. J Thromb Thrombolysis 50:211–216. https:// doi. org/10. 1007/ s11239- 020- 02146-z
25. 10. Ren B, Yan F, Deng Z et. Al. (2020) Extremely high incidence of lower extremity deep venous thrombosis in 48 patients with severe COVID-19 in Wuhan. Circulation 142:181–183. https:// doi. org/10. 1161/ CIRCU LATIO NAHA. 120. 047407
26. Chen S, Zhang D, Zheng T et al (2020) DVT incidence and risk factors in critically ill patients with COVID-19. J Thromb Thrombolysis. https:// doi. org/ 10. 1007/ s11239- 020- 02181-w
27. Narinx N, Smismans A, Symons R, Frans J, Demeyere A, Gillis M. Feasibility of using point-of-care lung ultrasound for early triage of COVID-19 patients in the emergency room. Emerg Radiol. 2020 Dec;27(6):663-670. doi: 10.1007/s10140-020-01849-3. Epub 2020 Sep 10. PMID: 32910323; PMCID: PMC7481756.
28. Karimzadeh S, Raut A, Huy NT. COVID-19 and Pulmonary Embolism: Diagnostic Imaging Trends. J Nucl Med. 2020;61(8):1102. doi:10.2967/jnumed.120.248518
29. Kapoor S, Chand S, Dieiev V, et al. Thromboembolic Events and Role of Point of Care Ultrasound in Hospitalized Covid-19 Patients Needing Intensive Care Unit Admission. *J Intensive Care Med*. 2021;36(12):1483-1490. doi:10.1177/0885066620964392
30. Galien S, Hultström M, Lipcsey M, et al. Point of care ultrasound screening for deep vein thrombosis in critically ill COVID-19 patients, an observational study. *Thromb J.* 2021;19(1):38. Published 2021 Jun 2. doi:10.1186/s12959-021-00272-z
31. Dubois-Silva, Á., Barbagelata-López, C., Mena, Á. *et al.* Pulmonary embolism and screening for concomitant proximal deep vein thrombosis in noncritically ill hospitalized patients with coronavirus disease 2019. *Intern Emerg Med* **15,** 865–870 (2020). https://doi.org/10.1007/s11739-020-02416-x

32. Zhang L, Feng X, Zhang D, et al. Deep Vein Thrombosis in Hospitalized Patients With COVID-19 in Wuhan, China: Prevalence, Risk Factors, and Outcome [published correction appears in Circulation. 2020 Jul 14;142(2): e33]. *Circulation*. 2020;142(2):114-128. doi:10.1161/CIRCULATIONAHA.120.046702
33. Vandenbriele, C., Gorog, D.A. Screening for venous thromboembolism in patients with COVID-19. *J Thromb Thrombolysis* **52,** 985–991 (2021). https://doi.org/10.1007/s11239-021-02474-8

Appendix A: Overview of Literature Review Results

Evidence Source	Design/ Method	Subject Selection/ Sample Size and setting	Measurement Tool/ Scanning technique	Results	Conclusions
Lerardi et al. (2020) [21]	Retrospective single center observational cohort study.	234 patients with COVID-19, diagnosed according to the World Health Organization guidelines, hospitalized between March 15th and April 7th, 2020, with the mean age of 61.63 years, including 164 females (70%) and 70 males (30%), screened for asymptomatic DVT.	3-point compression US examinations of bilateral legs (common femoral vein, saphenofemoral junction, and popliteal vein). Ultrasound examinations were performed using portable US machines with the linear probe. The lack of vein compression was the diagnostic criterion for the diagnosis of DVT.	Overall incidence of DVT was 10.7% (25/234): 1.6% (1/60) among moderate cases, 13.8% (24/174) in severely and critically ill patients. Prolonged bedrest and intensive care unit admission were significantly associated with the presence of DVT (19.7%). Fraction of inspired oxygen, P/F ratio, respiratory rate, heparin administration, D-dimer, IL-6, ferritin, and CRP showed correlation with DVT.	DUS may be considered a useful and valid tool for early identification of DVT. High rate of DVT found in severe patients and its correlation with respiratory parameters and some significant laboratory findings suggests that these can be used as a screening tool for patients who should be getting DUS.
Demelo-Rodríguez et al. (2020) [22]	Prospective single center observational cohort study.	156 patients, $\geq$ 18 years old (65.4% male), mean age of the sample 68, hospitalized in the first half of April 2020, in non-intensive care units with diagnosis of COVID-19 pneumonia, screened for asymptomatic DVT. COVID-19 diagnosis defined by positive PCR or by the presence of radiological and analytical findings.	4-point compression ultrasound examination of bilateral legs, including proximal (common femoral vein, saphenofemoral junction, femoral vein, popliteal vein) and distal area (calf veins). Ultrasound examinations performed using portable US machines with the linear probe. The lack of	CUS was positive for DVT in 23 patients (14.7%), of whom only one was proximal DVT. Seven patients (4.5%) had bilateral distal DVT. Patients with DVT had higher median D-dimer levels: 4527 ng/ml vs 2050 ng/ml; D-dimer levels > 1570 ng/ml were associated with asymptomatic DVT.	In patients admitted with COVID-19 pneumonia and elevated D-dimer levels, the incidence of asymptomatic DVT is similar to that described in other series. Higher cut-off levels for D-dimer might be necessary for the diagnosis of DVT in COVID-19 patients.

			vein compression was the diagnostic criterion for the diagnosis of DVT.		
Pieralli et. al. (2020) [23]	Prospective multicenter observational cohort study.	227 consecutive patients admitted between March 21st and May 25th, 2020, ≥ 18 years old, with a definitive diagnosis of SARS-CoV-2 pneumonia. The diagnosis of SARS--CoV-2 infection was made by PCR.	A 3-point US compression examination of bilateral legs (the common and superficial femoral veins, and the popliteal veins). The lack of vein compression was the diagnostic criterion for the diagnosis of DVT.	The incidence of DVT was 13.7% (6.2% proximal, 7.5% distal), mostly asymptomatic. All patients received anticoagulation (enoxaparin 95.6%) at the following doses: low 57.3%, intermediate 22.9%, high 19.8%. Patients with and without DVT had similar characteristics, and no difference in anticoagulant regimen was observed. DVT patients were older (mean 77±9.6 vs 71±13.1 years) and had higher peak D-dimer levels (5403 vs 1723 ng/mL). Peak D-dimer level >2000 ng/mL was the most accurate cut-off value able to predict DVT.	The incidence of DVT in acutely ill patients with COVID-19 pneumonia is relevant. A surveillance protocol by serial CUS of the lower limbs is useful to timely identify DVT that would go otherwise largely undetected.
Artifoni et al. (2020) [24]	Retrospective multicenter observational cohort	71 consecutive patients with confirmed COVID-19 admitted for more than 48 hours in non-intensive care units between March 25, 2020, and April 10, 2020, screened by US for DVT. COVID-19 diagnosis defined by positive PCR or typical pattern on chest CT-scan.	A 4-point US compression examination of bilateral legs for DVT at hospital discharge or earlier if thrombosis was clinically suspected. Chest angio-CT scan was performed in case of suspicion of pulmonary embolism.	Out of 71 patients, 16 developed VTE (22.5%) and 7 PE (10%) despite adequate thromboprophylaxis. D-dimers at baseline were significantly higher in patients with DVT. Demographics, comorbidities, disease manifestations, severity score, and other biological parameters, including inflammatory markers, were similar in patients with and without VTE. The negative predictive value of a baseline D-dimer level < 1.0 µg/ml was 90% for VTE and 98% for PE.	The positive predictive value for VTE was 44% and 67% for D-dimer level ≥ 1.0 µg/ml and ≥ 3 µg/ml, respectively. The association between D-dimer level and VTE risk increased by taking into account the latest available D-dimer level prior to US examination for the patients with monitoring of D-dimer.

Franco-Moreno et al. (2021) [25]	Prospective observational cohort study	26 consecutive patients ≥ 18 years old, with mean median age of 60 years old, admitted in the internal medicine ward with a diagnosis of COVID-19 between March 30, 2020, to May 6, 2020, screened for DVT in the lower extremities with compression ultrasound.	A 3-point US compression examination of both legs, which included the proximal area (common femoral vein, saphenofemoral junction, and popliteal vein). The ultrasound examination was considered pathological if compression did not cause complete collapse of the examined vein.	Compression ultrasound findings were positive for DVT in 2 patients (7.7%; 95% confidence interval, 3.6%-11.7%). Patients with DVT had central and bilateral PE. In both, venous thromboembolism was diagnosed in the emergency department, so they did not receive previous prophylactic therapy with low-molecular-weight heparin. Patients without DVT had higher median d-dimer levels: 25,688 µg/dL versus 5310 µg/dL.	Study showed a low incidence of DVT in a cohort of patients with COVID-19 and PE. This observation suggests that PE in these patients could be produced mainly by a local thromboinflammatory syndrome induced by severe acute respiratory syndrome coronavirus 2 infection and not by a thromboembolic event.
Garcia-Ceberino et al. (2021) [26]	Retrospective single center observational cohort study	87 patients older than 18 years with a confirmed diagnosis of COVID-19 admitted to a hospital in Granada, Spain, between April 22nd and 30th 2020. Diagnosis of COVID-19 pneumonia was defined as a positive PCR test along with radiological findings consistent with pneumonia.	Lower extremity ultrasound (US) performed at the bedside using a 2-point technique consisting of assessing compressibility of common femoral vein (CFV) and popliteal vein (PV). Lack of vein compression was the diagnostic criterion for the diagnosis of DVT.	DVT was found in 4 patients (3 femoral, 1 popliteal), of which 1 had not received low molecular weight heparin (LMWH) prophylaxis. 21 CT pulmonary angiograms were performed, being positive for PE in 5 cases (23.8%); only 2 of these patients suffered DVT.	POCUS is a helpful tool detecting DVT in COVID-19 patients. Study found a DVT prevalence of 4.6%. However, the absence of DTV did not exclude the presence of PE.

Appendix B: Recruitment Letter

Nicole Wertheim College of Nursing and Health Sciences
Department of Nurse Anesthetist Practice

Educational Module on the Clinical Utility of Point-Of-Care Ultrasonography (POCUS) in the Early Identification of the Perioperative Thromboembolic Complications in COVID-19 Patients Undergoing Noncardiac Surgery

Dear Broward Health Nurse Anesthetist,

My name is Olga Gay, and I am a student from the Anesthesiology Nursing Program Department of Nurse Anesthetist Practice at Florida International University. I am writing to invite you to participate in my quality improvement project. The goal of this project is to improve health care provider knowledge on the uses of Point-Of-Care Ultrasonography in the early identification of the perioperative thromboembolic complications in covid-19 patients undergoing noncardiac surgery. You are eligible to take part in this project because you are a member of the ANESCO Nurse Anesthetist group currently employed by Broward Health Medical Center.

If you decide to participate in this project, you will be asked to complete and sign a consent form for participation. Next, you will complete a pre-test questionnaire, which is expected to take approximately 5 minutes. You will then be asked to view an approximately 15-minute-long educational presentation online. After watching the video, you will be asked to complete the post-test questionnaire, which is expected to take approximately 5 minutes. No compensation will be provided.

Remember, this is completely voluntary. You can choose to be in the study or not. If you'd like to participate or have any questions about the study, please email or contact me at ogay001@fiu.edu or 6317456642

Thank you very much.

Sincerely,

Olga Gay, SRNA, FIU

Appendix C: IRB Exemption Letter

FIU | FLORIDA INTERNATIONAL UNIVERSITY

Office of Research Integrity
Research Compliance, MARC 414

MEMORANDUM

To: Dr. Jorge Valdes

CC: Olga Gay

From: Elizabeth Juhasz, Ph.D., IRB Coordinator

Date: April 8, 2022

Protocol Title: **"An Educational Module on the Clinical Utility of Point-Of-Care Ultrasound (POCUS) in the Timely Detection of Perioperative Thromboembolic Complications in COVID-19 Patients Undergoing Noncardiac Surgery: A Quality Improvement Project"**

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #: IRB-22-0143 **IRB Exemption Date:** 03/22/22
TOPAZ Reference #: 111504

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
3) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A

For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix D: QI Project Consent

Nicole Wertheim College of Nursing and Health Sciences
Department of Nurse Anesthetist Practice

CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT
"An Educational Intervention on the Clinical Utility of Point-Of-Care Ultrasonography (POCUS) in the Early Identification of Perioperative Thromboembolic Complications in COVID-19 Patients Undergoing Noncardiac Surgery"

SUMMARY INFORMATION
Things you should know about this study:

Purpose: Educational module concerning the utilization of POCUS in the prevention of perioperative VTE in patients with COVID-19 undergoing noncardiac surgical procedures.
Procedures: If you choose to participate, you will be asked to complete a pretest, watch a voice PowerPoint, and then complete a posttest.
Duration: This will take about a total of 20 minutes.
Risks: The main risk or discomfort from this research is minimal.
Benefits: The main benefit to you from this research is an increase in knowledge on the perioperative use of POCUS modality.
Alternatives: There are no known alternatives available to you other than not taking part in this study.
Participation: Taking part in this research project is voluntary.

Please carefully read the entire document before agreeing to participate.

PURPOSE OF THE PROJECT
You are being asked to participate in a quality improvement project. The goal of this project is to improve anesthesia provider knowledge on the use of POCUS in the prevention of perioperative VTE in patients with COVID-19 undergoing noncardiac surgical procedures, as well as improve recognition of associated risk factors that predispose patients to the development of VTE. The overall objective of the program is to increase the quality of healthcare delivery and improve healthcare outcomes for surgical patients with COVID-19 undergoing noncardiac surgery.

DURATION OF THE PROJECT
Your participation will require approximately 20 minutes of your time. You will be asked to complete a pre-test questionnaire, which is expected to take approximately 5 minutes. You will then be asked to view a short 10-minute educational presentation online. After watching the video, you will be asked to complete the post-test questionnaire, which should take

approximately 5 minutes.

PROCEDURES
If you agree to be in the study, we will ask you to do the following:

1. Complete an online pre-test survey via Qualtrics.
2. Review the educational PowerPoint Module lasting 10 minutes.
3. Complete an online post-test survey via Qualtrics.

RISKS AND/OR DISCOMFORTS
Minimal risk, risk not greater than if participant was conducting similar activity. Physical, psychological, social, legal, and economic risks minimal and no greater than if a participant was participating in a similar activity. Similar activity such as filling out an online survey and watching voice over PowerPoint.

BENEFITS
The main benefit from this research is an increase in participants knowledge surrounding the pathophysiological mechanisms of the VTE formation in COVID-19 patients, the pitfalls of the current VTE prevention practices and recommendations, and how perioperative use of POCUS modality can prevent the occurrence of VTE in COVID-19 patients.

ALTERNATIVES
There are no known alternatives available to you other than not taking part in this project. However, if you would like to receive the educational material given to the participants in this project, it will be provided to you at no cost.

CONFIDENTIALITY
The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, we might publish, we will not include any information that will make it possible to identify you as a participant. Records will be stored securely, and only the project team will have access to the records.

PARTICIPATION
Taking part in this research project is voluntary.

COMPENSATION & COSTS
There is no cost or payment to you for receiving the health education and/or for participating in this project.

RIGHT TO DECLINE OR WITHDRAW
You are free to participate in the project or withdraw your consent at any time during the project. Your withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest.

RESEARCHER CONTACT INFORMATION
If you have any questions about the purpose, procedures, or any other issues relating to this research project, you may contact Olga Gay at 631-745-6642/ ogay001@fiu.edu or Dr. Jorge Valdes at 305-348-7729/jvalde@fiu.edu.

IRB CONTACT INFORMATION

If you would like to talk with someone about your rights pertaining to being a subject in this project or about ethical issues with this project, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

PARTICIPANT AGREEMENT
By clicking the button below, you acknowledge that your participation in the study is voluntary, you are 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason.

Please note that this survey will be best displayed on a laptop or desktop computer. Some features may be less compatible for use on a mobile device.

(Insert Consent to Participate Button Here on the Website)

Appendix E: QI Project Survey

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QI PROJECT SURVEY

Clinical utility of Point-Of-Care Ultrasound (POCUS) in the early detection of perioperative thromboembolic complications in COVID-19 patients undergoing noncardiac surgery: A Quality Improvement Project

INTRODUCTION

The primary aim of this QI project is to improve the knowledge of anesthesia providers on the role of POCUS in the prevention of perioperative VTE in patients with COVID-19 undergoing noncardiac surgical procedures.

Please answer the question below to the best of your ability. The questions are either in multiple-choice or true/false format and are meant to measure knowledge and perceptions on the identification and management of perioperative VTE using the POCUS modality.

PERSONAL INFORMATION

1. Gender: Male Female Prefer not to answer_____
2. Age in years: 25 to 30 31 to 40 41 to 50 51 to 60 61 & older
3. Ethnicity: Hispanic Caucasian African American Asian Other_____
4. Position/Title: _____
5. Level of Education: Associates Bachelors Masters Doctoral (DNP, DNAP, EdD, PhD) Other _____
6. Years of experience: Less than 1 year 1 to 5 6 to 10 more than 10 years

QUESTIONNAIRE

1. **Depending on patient risk factors, the incidence of VTE in COVID-19 can be as high as:**
    A. 5%
    B. 12%
    C. 20%
    D. 80%
2. **Which of the following statements best defines venous thromboembolism?**
    E. An autoimmune disorder that primarily targets the respiratory and cardiovascular systems.
    F. An adverse event that generally occurs due to a prolonged imbalance between myocardial oxygen supply and demand.
    G. A blood clot that manifests as a spectrum of sequelae, including deep vein thrombosis (DVT) and/or when it dislodges and migrates, a pulmonary embolism (PE).
    H. A common perioperative complication requires the presence of an ischemic feature such as chest pain or EKG changes
3. **Which of the following is NOT associated with VTE?**
    a. Increased 30-day mortality
    b. Greater incidence of perioperative adverse events and hemodynamic instability
    c. Increased unplanned postoperative ICU admissions and prolonged hospital stay, substantial long-term morbidity
    d. Reduced costs of care and earlier discharge
4. **Which of the following is NOT considered a significant risk factor for VTE?**
    A. Surgery
    B. Immobility
    C. Advanced stages of cancer
    D. Inherited thrombophilia
    E. Female gender
5. **What is the most common anatomic site of venous thrombosis formation?**
    A. Lower extremities
    B. Coronary Arteries
    C. Forearm

D. Coronary Arteries
E. Temple

6. **The use of point-of-care ultrasound (POCUS) of the lower extremity has been shown to be a safe, rapid, and accurate method for detecting DVT when integrated into the preoperative assessment for patients with COVID-19.**

   True or False

7. **What makes POCUS an attractive option in preventing perioperative VTE complications in COVID-19?**

   A. its portable technology helps to reduce exposure and transmission of infection
   B. helps to avoid unnecessary medical interventions and diagnostic tests
   C. contributes to earlier and improved diagnosis, helps to reduce the cost of care, and improves patient outcomes
   D. All of the above

8. **Which of the following is TRUE?**

   A. In patients with COVID-19, POCUS exam for lower extremity DVT consists of two-dimensional venous compression alone and yields results similar to formal vascular studies.
   B. Because proximal lower extremity thrombi have the highest risk of embolization, evaluation of the common femoral vein, femoral vein, and popliteal vein is most important.
   C. Either inability to compress a vein completely with wall-to-wall apposition or visualization of echogenic thrombus within the vein is diagnostic of DVT.
   D. Acute thrombi are gelatinous and may appear anechoic, while subacute or chronic thrombi are echogenic, but all veins with a DVT will not compress completely
   E. All of the above

9. **If available at your facility, how likely are you to utilize POCUS modality to screen for DVT in COVID-19 patients undergoing noncardiac surgery?**

   A. Extremely likely
   B. Somewhat likely
   C. Neither unlikely nor likely
   D. Somewhat unlikely
   E. Very unlikely

10. **How likely are you to recommend POCUS modality to screen for DVT in COVID-19 patients undergoing noncardiac surgery?**

A. Most likely
B. Somewhat likely
C. Somewhat unlikely
D. Most unlikely
E. Very unlikely

Appendix F: QI Educational Module

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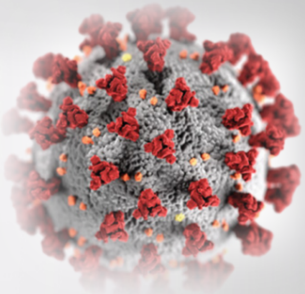
EDUCATIONAL MODULE ON THE CLINICAL UTILITY OF POINT-OF-CARE ULTRASONOGRAPHY IN THE EARLY IDENTIFICATION OF PERIOPERATIVE THROMBOEMBOLIC COMPLICATIONS IN COVID-19 PATIENTS UNDERGOING NONCARDIAC SURGERY



By:
Olga Gay, BSN, RN
Jorge A. Valdes, DNP, CRNA, APRN

FLORIDA INTERNATIONAL UNIVERSITY

LEARNING OBJECTIVES:

Discuss	Describe	Identify	Understand	Acknowledge
the background of COVID-19 pandemic	the pathophysiological mechanisms of the VTE formation in COVID-19	the risk factors most associated with VTE in COVID-19 patients	the pitfalls of the current practice	the role of POCUS in the prevention of perioperative VTE in COVID-19 patients

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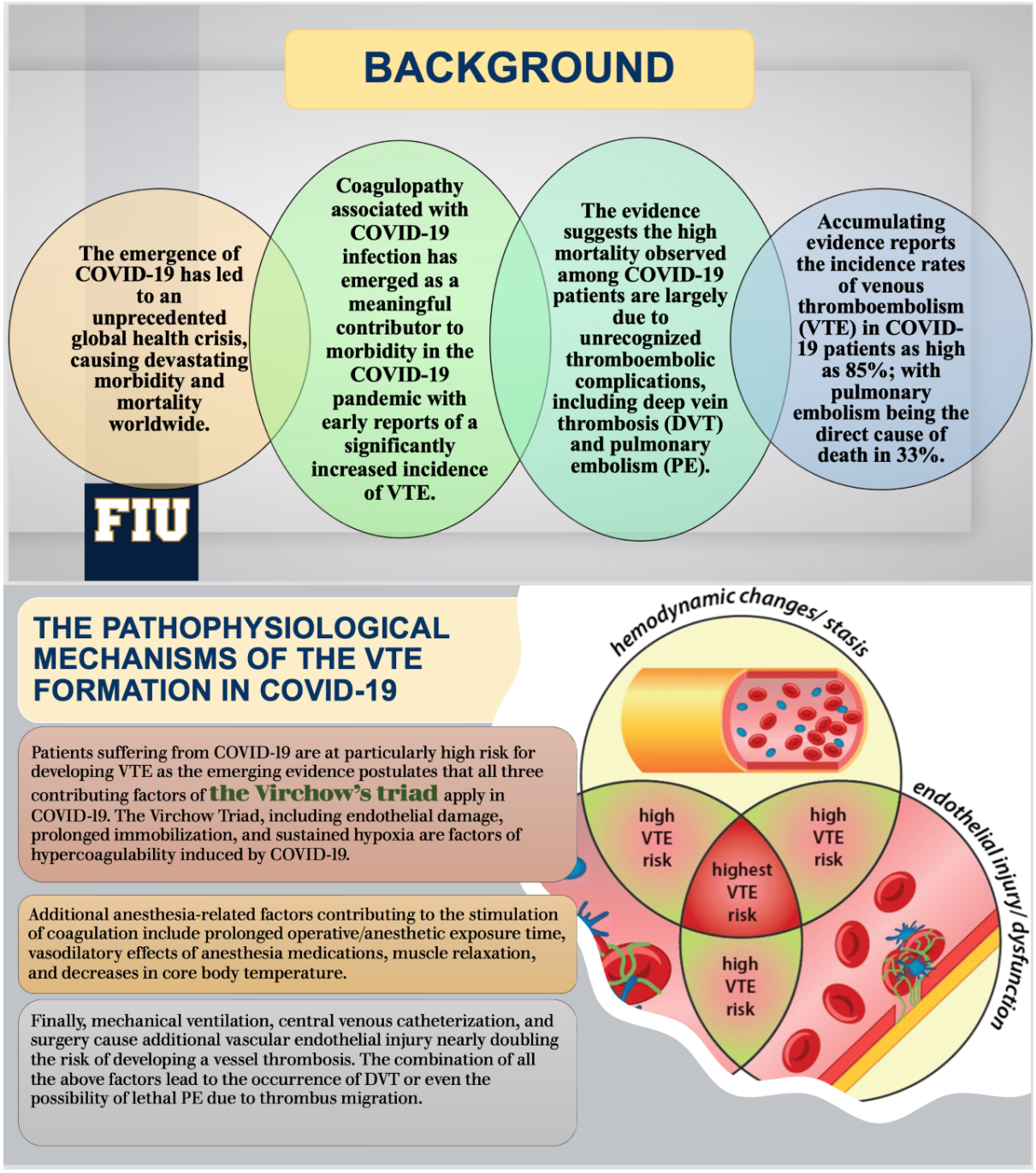
BACKGROUND
The emergence of COVID-19 has led to an unprecedented global health crisis, causing devastating morbidity and mortality worldwide.
Coagulopathy associated with COVID-19 infection has emerged as a meaningful contributor to morbidity in the COVID-19 pandemic with early reports of a significantly increased incidence of VTE.
The evidence suggests the high mortality observed among COVID-19 patients are largely due to unrecognized thromboembolic complications, including deep vein thrombosis (DVT) and pulmonary embolism (PE).
Accumulating evidence reports the incidence rates of venous thromboembolism (VTE) in COVID-19 patients as high as 85%; with pulmonary embolism being the direct cause of death in 33%.
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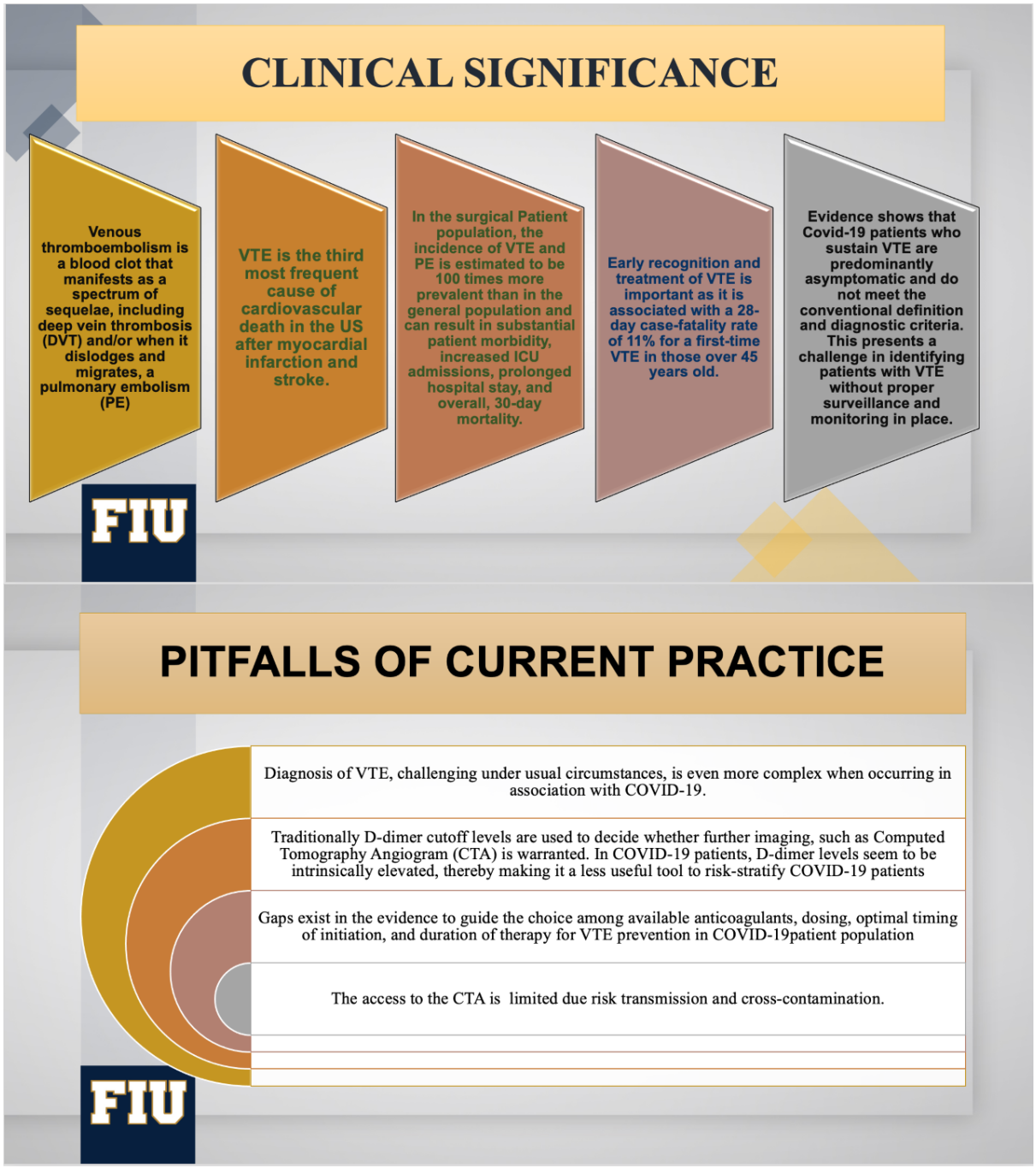
THE PATHOPHYSIOLOGICAL MECHANISMS OF THE VTE FORMATION IN COVID-19
Patients suffering from COVID-19 are at particularly high risk for developing VTE as the emerging evidence postulates that all three contributing factors of the Virchow's triad apply in COVID-19. The Virchow Triad, including endothelial damage, prolonged immobilization, and sustained hypoxia are factors of hypercoagulability induced by COVID-19.
Additional anesthesia-related factors contributing to the stimulation of coagulation include prolonged operative/anesthetic exposure time, vasodilatory effects of anesthesia medications, muscle relaxation, and decreases in core body temperature.
Finally, mechanical ventilation, central venous catheterization, and surgery cause additional vascular endothelial injury nearly doubling the risk of developing a vessel thrombosis. The combination of all the above factors lead to the occurrence of DVT or even the possibility of lethal PE due to thrombus migration.
hemodynamic changes/ stasis
endothelial injury/ dysfunction
high VTE risk
high VTE risk
highest VTE risk
high VTE risk


CLINICAL SIGNIFICANCE
Venous thromboembolism is a blood clot that manifests as a spectrum of sequelae, including deep vein thrombosis (DVT) and/or when it dislodges and migrates, a pulmonary embolism (PE)
VTE is the third most frequent cause of cardiovascular death in the US after myocardial infarction and stroke.
In the surgical Patient population, the incidence of VTE and PE is estimated to be 100 times more prevalent than in the general population and can result in substantial patient morbidity, increased ICU admissions, prolonged hospital stay, and overall, 30-day mortality.
Early recognition and treatment of VTE is important as it is associated with a 28-day case-fatality rate of 11% for a first-time VTE in those over 45 years old.
Evidence shows that Covid-19 patients who sustain VTE are predominantly asymptomatic and do not meet the conventional definition and diagnostic criteria. This presents a challenge in identifying patients with VTE without proper surveillance and monitoring in place.
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PITFALLS OF CURRENT PRACTICE
Diagnosis of VTE, challenging under usual circumstances, is even more complex when occurring in association with COVID-19.
Traditionally D-dimer cutoff levels are used to decide whether further imaging, such as Computed Tomography Angiogram (CTA) is warranted. In COVID-19 patients, D-dimer levels seem to be intrinsically elevated, thereby making it a less useful tool to risk-stratify COVID-19 patients
Gaps exist in the evidence to guide the choice among available anticoagulants, dosing, optimal timing of initiation, and duration of therapy for VTE prevention in COVID-19patient population
The access to the CTA is limited due risk transmission and cross-contamination.
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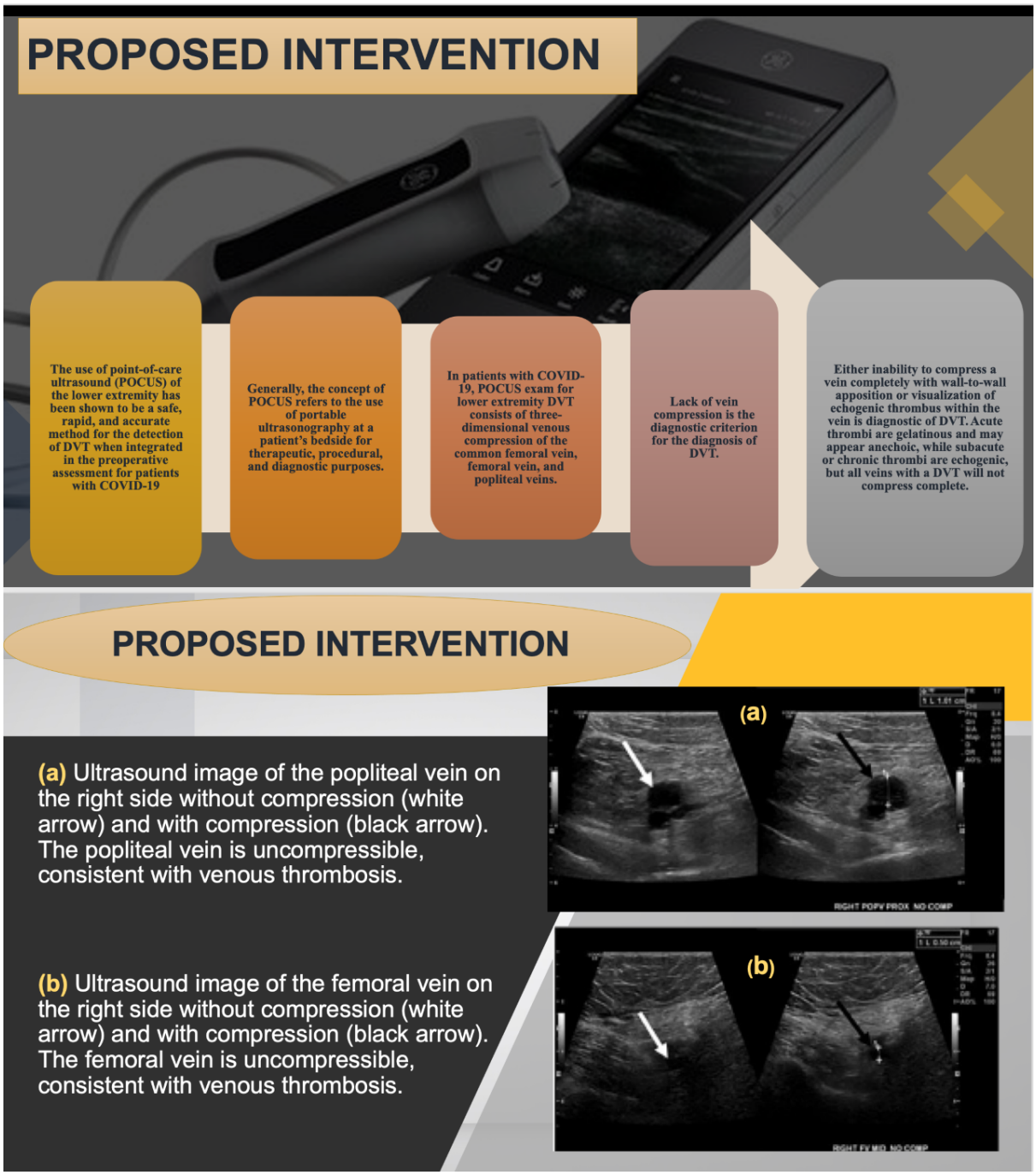
PROPOSED INTERVENTION
The use of point-of-care ultrasound (POCUS) of the lower extremity has been shown to be a safe, rapid, and accurate method for the detection of DVT when integrated in the preoperative assessment for patients with COVID-19
Generally, the concept of POCUS refers to the use of portable ultrasonography at a patient's bedside for therapeutic, procedural, and diagnostic purposes.
In patients with COVID-19, POCUS exam for lower extremity DVT consists of three-dimensional venous compression of the common femoral vein, femoral vein, and popliteal veins.
Lack of vein compression is the diagnostic criterion for the diagnosis of DVT.
Either inability to compress a vein completely with wall-to-wall apposition or visualization of echogenic thrombus within the vein is diagnostic of DVT. Acute thrombi are gelatinous and may appear anechoic, while subacute or chronic thrombi are echogenic, but all veins with a DVT will not compress complete.
PROPOSED INTERVENTION
(a) Ultrasound image of the popliteal vein on the right side without compression (white arrow) and with compression (black arrow). The popliteal vein is uncompressible, consistent with venous thrombosis.
(a)
(b) Ultrasound image of the femoral vein on the right side without compression (white arrow) and with compression (black arrow). The femoral vein is uncompressible, consistent with venous thrombosis.
(b)

RESEARCH FINDINGS

- A number of studies have assessed the usefulness of POCUS to diagnose VTE in patients with COVID-19.
- Published reports revealed 91% sensitivity and 98 % specificity of the compression POCUS exam in detecting lower extremity DVT and yields results similar to formal vascular studies.
- Growing evidence suggests that POCUS contributes to earlier and improved diagnosis, helps to reduce the cost of care, and improves patient outcomes.[9] It represents an attractive option during the Covid-19 pandemic since it is portable technology helps to reduce exposure and transmission of infection.
- The use of POCUS in Covid-19 patients has been endorsed and encouraged by The American College of Chest Physicians (ACCP) expert panel and the American College of Emergency Physicians. ACCP suggested using lower extremity ultrasound as part of POCUS screening in Covid-19 patients with suspected pulmonary embolism, unexplained right ventricular dysfunction, or unexplained refractory hypoxemia.[2,3,]
- The American Association of Nurse Anesthetists (AANA) recognizes the importance of POCUS as a critical core skill that CRNAs should possess.
- Literature suggests that the use of POCUS in the diagnosis of lower extremity DVT may help avoid unnecessary medical interventions and diagnostic tests, therefore representing the potential quality of care and cost-saving improvements.[13-]
- In the presence of older age 65&> and D-dimer levels exceeding 2000 ng/mL a high suspicion of DVT should be raised.

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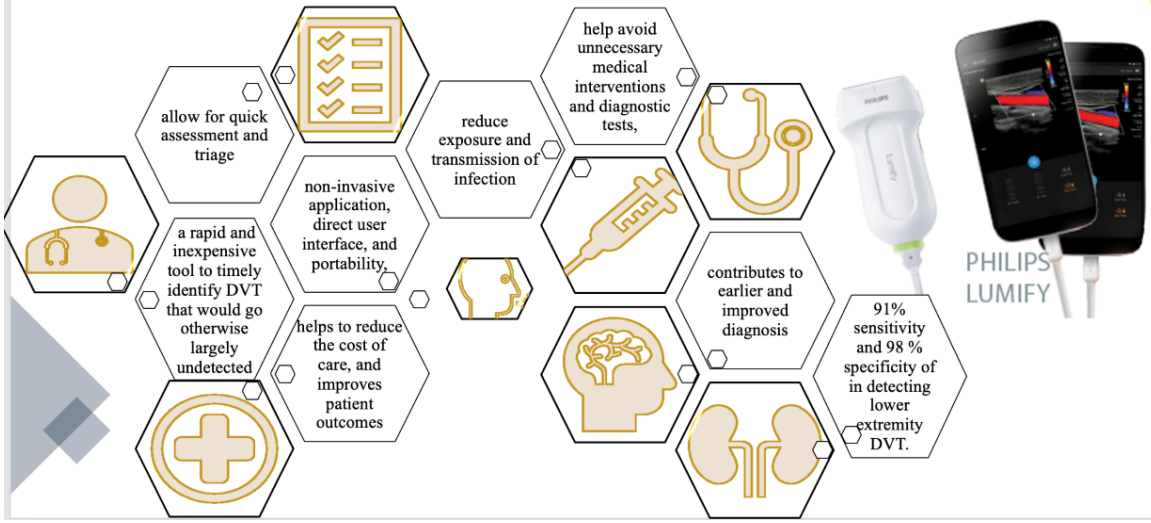
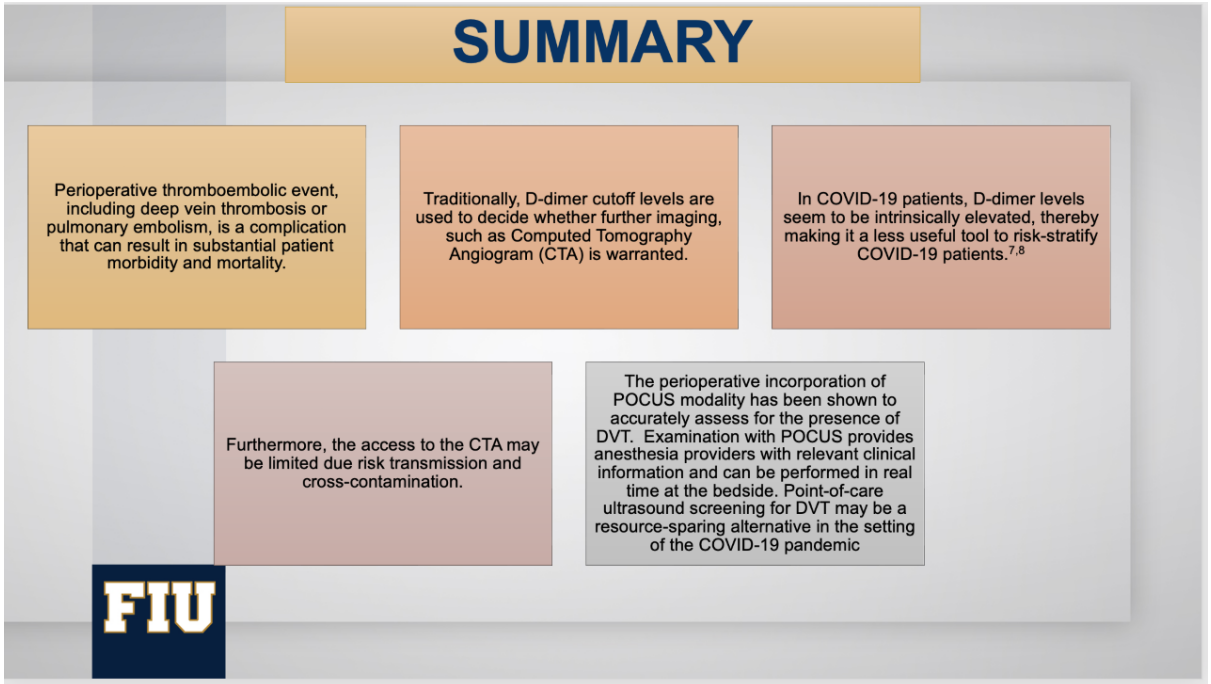
CLINICAL STRENGTH




SUMMARY
Perioperative thromboembolic event, including deep vein thrombosis or pulmonary embolism, is a complication that can result in substantial patient morbidity and mortality.
Traditionally, D-dimer cutoff levels are used to decide whether further imaging, such as Computed Tomography Angiogram (CTA) is warranted.
In COVID-19 patients, D-dimer levels seem to be intrinsically elevated, thereby making it a less useful tool to risk-stratify COVID-19 patients.[7,8]
Furthermore, the access to the CTA may be limited due risk transmission and cross-contamination.
The perioperative incorporation of POCUS modality has been shown to accurately assess for the presence of DVT. Examination with POCUS provides anesthesia providers with relevant clinical information and can be performed in real time at the bedside. Point-of-care ultrasound screening for DVT may be a resource-sparing alternative in the setting of the COVID-19 pandemic
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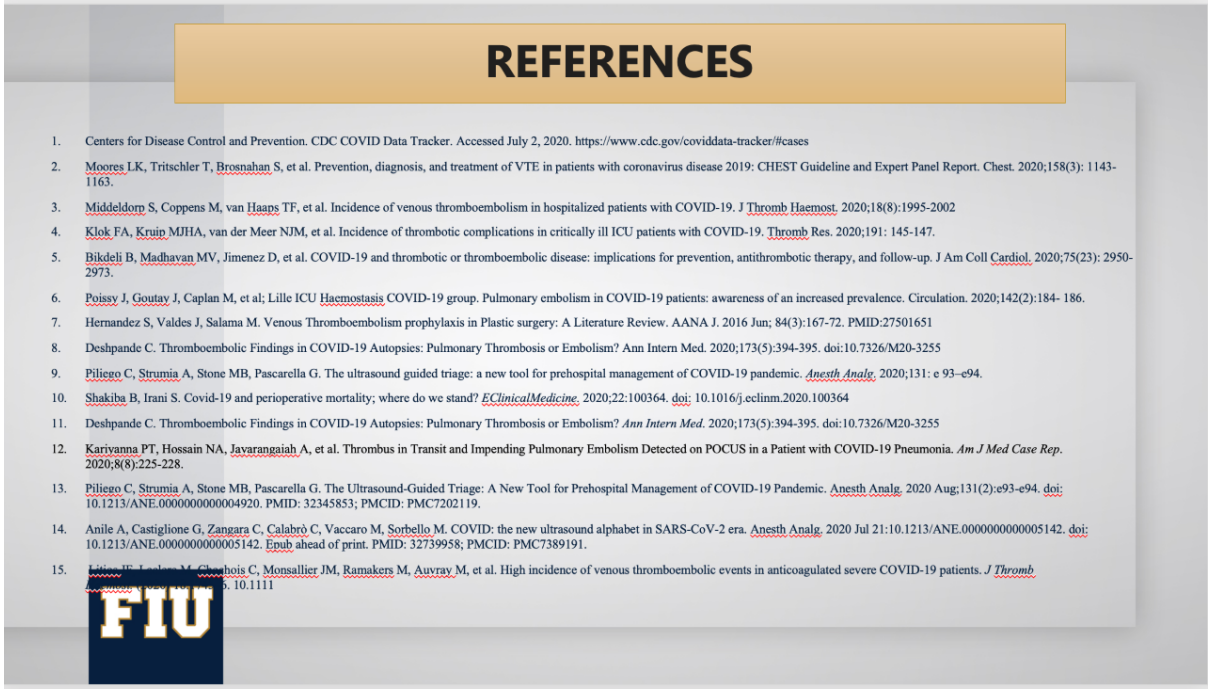
REFERENCES
1. Centers for Disease Control and Prevention. CDC COVID Data Tracker. Accessed July 2, 2020. https://www.cdc.gov/coviddata-tracker/#cases
2. Moores LK, Tritschler T, Brosnahan S, et al. Prevention, diagnosis, and treatment of VTE in patients with coronavirus disease 2019: CHEST Guideline and Expert Panel Report. Chest. 2020;158(3): 1143-1163.
3. Middeldorp S, Coppens M, van Haaps TF, et al. Incidence of venous thromboembolism in hospitalized patients with COVID-19. J Thromb Haemost. 2020;18(8):1995-2002
4. Klok FA, Kruip MJHA, van der Meer NJM, et al. Incidence of thrombotic complications in critically ill ICU patients with COVID-19. Thromb Res. 2020;191: 145-147.
5. Bikdeli B, Madhavan MV, Jimenez D, et al. COVID-19 and thrombotic or thromboembolic disease: implications for prevention, antithrombotic therapy, and follow-up. J Am Coll Cardiol. 2020;75(23): 2950-2973.
6. Poissy J, Goutay J, Caplan M, et al; Lille ICU Haemostasis COVID-19 group. Pulmonary embolism in COVID-19 patients: awareness of an increased prevalence. Circulation. 2020;142(2):184- 186.
7. Hernandez S, Valdes J, Salama M. Venous Thromboembolism prophylaxis in Plastic surgery: A Literature Review. AANA J. 2016 Jun; 84(3):167-72. PMID:27501651
8. Deshpande C. Thromboembolic Findings in COVID-19 Autopsies: Pulmonary Thrombosis or Embolism? Ann Intern Med. 2020;173(5):394-395. doi:10.7326/M20-3255
9. Piliego C, Strumia A, Stone MB, Pascarella G. The ultrasound guided triage: a new tool for prehospital management of COVID-19 pandemic. Anesth Analg. 2020;131: e 93–e94.
10. Shakiba B, Irani S. Covid-19 and perioperative mortality; where do we stand? EClinicalMedicine. 2020;22:100364. doi: 10.1016/j.eclinm.2020.100364
11. Deshpande C. Thromboembolic Findings in COVID-19 Autopsies: Pulmonary Thrombosis or Embolism? Ann Intern Med. 2020;173(5):394-395. doi:10.7326/M20-3255
12. Karivanna PT, Hossain NA, Javarangaiah A, et al. Thrombus in Transit and Impending Pulmonary Embolism Detected on POCUS in a Patient with COVID-19 Pneumonia. Am J Med Case Rep. 2020;8(8):225-228.
13. Piliego C, Strumia A, Stone MB, Pascarella G. The Ultrasound-Guided Triage: A New Tool for Prehospital Management of COVID-19 Pandemic. Anesth Analg. 2020 Aug;131(2):e93-e94. doi: 10.1213/ANE.0000000000004920. PMID: 32345853; PMCID: PMC7202119.
14. Anile A, Castiglione G, Zangara C, Calabrò C, Vaccaro M, Sorbello M. COVID: the new ultrasound alphabet in SARS-CoV-2 era. Anesth Analg. 2020 Jul 21:10.1213/ANE.0000000000005142. doi: 10.1213/ANE.0000000000005142. Epub ahead of print. PMID: 32739958; PMCID: PMC7389191.
15. [illegible] C, Monsallier JM, Ramakers M, Auvray M, et al. High incidence of venous thromboembolic events in anticoagulated severe COVID-19 patients. J Thromb [illegible]. 10.1111
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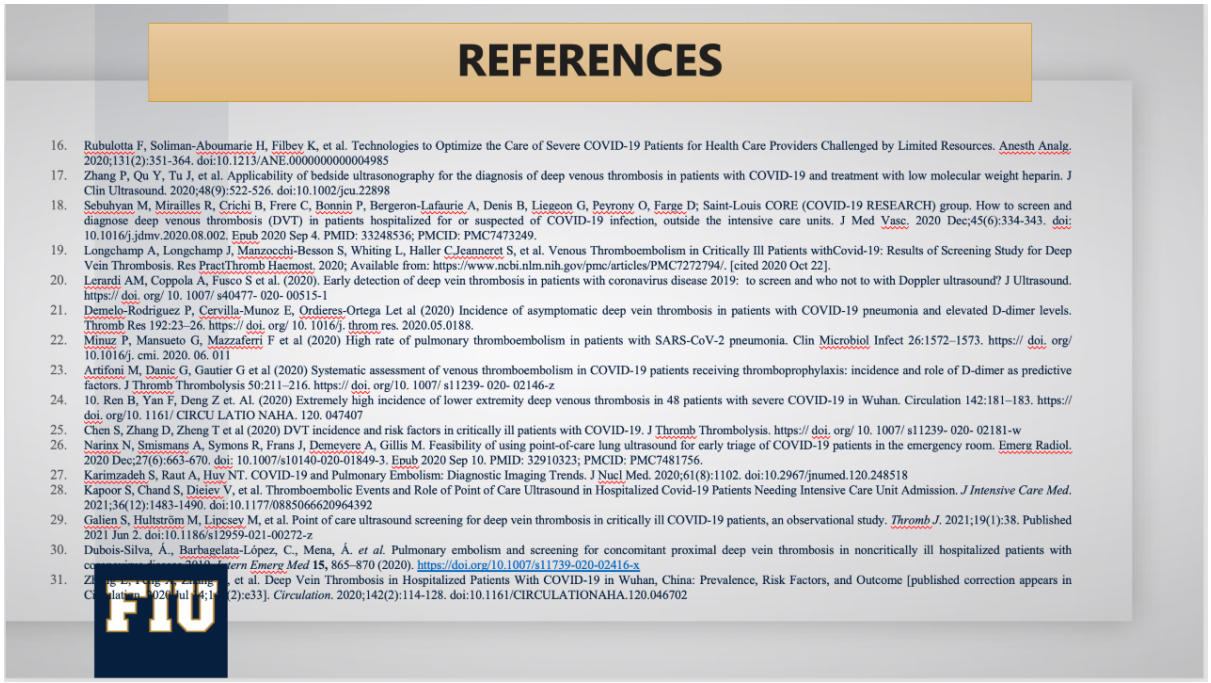

REFERENCES

16. Rubulotta F, Soliman-Aboumarie H, Filbey K, et al. Technologies to Optimize the Care of Severe COVID-19 Patients for Health Care Providers Challenged by Limited Resources. Anesth Analg. 2020;131(2):351-364. doi:10.1213/ANE.0000000000004985
17. Zhang P, Qu Y, Tu J, et al. Applicability of bedside ultrasonography for the diagnosis of deep venous thrombosis in patients with COVID-19 and treatment with low molecular weight heparin. J Clin Ultrasound. 2020;48(9):522-526. doi:10.1002/jcu.22898
18. Sebuhyan M, Mirailles R, Crichi B, Frere C, Bonnin P, Bergeron-Lafaurie A, Denis B, Liegeon G, Peyrony O, Farge D; Saint-Louis CORE (COVID-19 RESEARCH) group. How to screen and diagnose deep venous thrombosis (DVT) in patients hospitalized for or suspected of COVID-19 infection, outside the intensive care units. J Med Vasc. 2020 Dec;45(6):334-343. doi: 10.1016/j.jdmv.2020.08.002. Epub 2020 Sep 4. PMID: 33248536; PMCID: PMC7473249.
19. Longchamp A, Longchamp J, Manzocchi-Besson S, Whiting L, Haller C,Jeanneret S, et al. Venous Thromboembolism in Critically Ill Patients withCovid-19: Results of Screening Study for Deep Vein Thrombosis. Res PractThromb Haemost. 2020; Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7272794/. [cited 2020 Oct 22].
20. Lerardi AM, Coppola A, Fusco S et al. (2020). Early detection of deep vein thrombosis in patients with coronavirus disease 2019: to screen and who not to with Doppler ultrasound? J Ultrasound. https:// doi. org/ 10. 1007/ s40477- 020- 00515-1
21. Demelo-Rodriguez P, Cervilla-Munoz E, Ordieres-Ortega Let al (2020) Incidence of asymptomatic deep vein thrombosis in patients with COVID-19 pneumonia and elevated D-dimer levels. Thromb Res 192:23–26. https:// doi. org/ 10. 1016/j. throm res. 2020.05.0188.
22. Minuz P, Mansueto G, Mazzaferri F et al (2020) High rate of pulmonary thromboembolism in patients with SARS-CoV-2 pneumonia. Clin Microbiol Infect 26:1572–1573. https:// doi. org/ 10.1016/j. cmi. 2020. 06. 011
23. Artifoni M, Danic G, Gautier G et al (2020) Systematic assessment of venous thromboembolism in COVID-19 patients receiving thromboprophylaxis: incidence and role of D-dimer as predictive factors. J Thromb Thrombolysis 50:211–216. https:// doi. org/10. 1007/ s11239- 020- 02146-z
24. 10. Ren B, Yan F, Deng Z et. Al. (2020) Extremely high incidence of lower extremity deep venous thrombosis in 48 patients with severe COVID-19 in Wuhan. Circulation 142:181–183. https:// doi. org/10. 1161/ CIRCU LATIO NAHA. 120. 047407
25. Chen S, Zhang D, Zheng T et al (2020) DVT incidence and risk factors in critically ill patients with COVID-19. J Thromb Thrombolysis. https:// doi. org/ 10. 1007/ s11239- 020- 02181-w
26. Narinx N, Smismans A, Symons R, Frans J, Demeyere A, Gillis M. Feasibility of using point-of-care lung ultrasound for early triage of COVID-19 patients in the emergency room. Emerg Radiol. 2020 Dec;27(6):663-670. doi: 10.1007/s10140-020-01849-3. Epub 2020 Sep 10. PMID: 32910323; PMCID: PMC7481756.
27. Karimzadeh S, Raut A, Huv NT. COVID-19 and Pulmonary Embolism: Diagnostic Imaging Trends. J Nucl Med. 2020;61(8):1102. doi:10.2967/jnumed.120.248518
28. Kapoor S, Chand S, Dieiev V, et al. Thromboembolic Events and Role of Point of Care Ultrasound in Hospitalized Covid-19 Patients Needing Intensive Care Unit Admission. *J Intensive Care Med*. 2021;36(12):1483-1490. doi:10.1177/0885066620964392
29. Galien S, Hultström M, Lipcsey M, et al. Point of care ultrasound screening for deep vein thrombosis in critically ill COVID-19 patients, an observational study. *Thromb J*. 2021;19(1):38. Published 2021 Jun 2. doi:10.1186/s12959-021-00272-z
30. Dubois-Silva, Á., Barbagelata-López, C., Mena, Á. *et al.* Pulmonary embolism and screening for concomitant proximal deep vein thrombosis in noncritically ill hospitalized patients with co[illegible] *Intern Emerg Med* **15,** 865–870 (2020). https://doi.org/10.1007/s11739-020-02416-x
31. Zh[illegible] et al. Deep Vein Thrombosis in Hospitalized Patients With COVID-19 in Wuhan, China: Prevalence, Risk Factors, and Outcome [published correction appears in Ci[illegible]2020 Jul 14;142(2):e33]. *Circulation*. 2020;142(2):114-128. doi:10.1161/CIRCULATIONAHA.120.046702