Duplex Ultrasonography Has Limited Utility in Detection of Postoperative DVT After Primary Total Joint Arthroplasty

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Received: 15 August 2015/Accepted: 12 October 2015/Published online: 12 February 2016
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Abstract *Background:* Duplex ultrasound is routinely used to evaluate suspected deep venous thrombosis after total joint arthroplasty. When there is a clinical suspicion for a pulmonary embolism, a chest angiogram (chest CTA) is concomitantly obtained. *Questions/Purposes:* Two questions were addressed: First, for the population of patients who receive duplex ultrasound after total joint arthroplasty, what is the rate of positive results? Second, for these patients, how many of these also undergo chest CTA for clinical suspicion of pulmonary embolus and how many of these tests are positive? Furthermore, what is the correlation between duplex ultrasound results and chest CTA results? *Methods:* A retrospective chart review was conducted of total joint replacement patients in 2011 at a single institution. Inclusion criteria were adult patients who underwent a postoperative duplex ultrasonography for clinical suspicion of deep venous thrombosis (DVT). Demographic data, result of duplex scan, clinical indications for obtaining the duplex scan, and DVT prophylaxis used were recorded. Additionally, if a chest CTA was obtained for clinical suspicion for pulmonary embolus, results and clinical indication for obtaining the test were recorded. The rate of positive results for duplex ultrasonography and chest CTA was computed

and correlated based on clinical indications. *Results:* Two hundred ninety-five patients underwent duplex ultrasonography of which only 0.7% were positive for a DVT. One hundred three patients underwent a chest CTA for clinical suspicion of a pulmonary embolism (PE) of which 26 revealed a pulmonary embolus, none of which had a positive duplex ultrasound. *Conclusion:* Postoperative duplex scans have a low rate of positive results. A substantial number of patients with negative duplex results subsequently underwent chest CTA for clinical suspicion for which a pulmonary embolus was found, presumably resulting from a DVT despite negative duplex ultrasound result. A negative duplex ultrasonography should not rule out the presence of a DVT which can embolize to the lungs and thus should not preclude further workup when clinical suspicion exists for a pulmonary embolus.

Keywords duplex · Doppler ultrasound · deep venous thrombosis · pulmonary embolus · postoperative joints

Introduction

Postoperative deep venous thrombosis (DVT) in the lower extremity as a potential source of pulmonary embolism is a life-threatening complication for patients undergoing total joint arthroplasty (TJA) [5]. Mechanoprophylaxis and chemoprophylaxis have been shown to be efficacious and cost-effective [3, 10, 13], but fail to prevent DVT in some patients. Postoperatively, extremity swelling, local tenderness, erythema, and/or temperature change are seen in some but not all patients with a DVT. The recognition of DVT as a postoperative complication is of paramount importance. Although a deep venous thrombosis in itself may not be life-threatening, its predilection for embolizing to the lung (pulmonary embolism (PE)) is a well-known cause of mortality [16]. Approximately 90% of pulmonary emboli originate

Level of Evidence: Diagnostic Study Level III.

Electronic supplementary material The online version of this article (doi:10.1007/s11420-015-9476-2) contains supplementary material, which is available to authorized users.

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from preformed clots in the lower extremities, and it has been shown that patients with combined DVT and PE have higher mortality rates than those patients with PE alone [12].

Duplex lower extremity ultrasound is routinely used to aid in the diagnosis of a DVT when clinical suspicion exists. However, controversy exists as to the utility of this testing method in orthopedic patients who are clinically suspected of having either a DVT with or without a concomitant pulmonary embolism [5, 9, 19]. Issues relate to the ultrasonography sensitivity to calf clots and whether surveillance should be done prior to surgery. In randomized control trials, both Anderson et al. [1] and Robinson et al. [17] showed that routine postoperative surveillance fails to reduce posthospital thromboembolic complications. The implicit assumption of surveillance testing is that a significant number of unexpected positive findings will be discovered. The National Health Service's Health Technology Assessment considers duplex ultrasound cost-effective when applied to patients with high clinical suspicion or findings of positive D-dimer or in patients with comorbidities that predispose to hypercoagulability [8]. However, the rate of positive tests when clinical suspicion exists for a DVT is not as well characterized. Many clinicians, including orthopedic surgeons and physicians in other medical specialties, fear potentially missing a diagnosis of DVT and often times have low clinical threshold for ordering duplex ultrasounds whenever a patient complains of relevant symptoms in order to rule out DVT. This has led to a large increase in the number of studies done. However, because the protocols for DVT prophylaxis and patient management have changed substantially over the past years, this practice may not be optimal in terms of efficacy and cost [20].

The rate of positive duplex ultrasonography in symptomatic patients undergoing total joint arthroplasty is not well quantified in the literature. Furthermore, the relationship between the outcome of this test and CT angiography which is ordered in the context of clinical suspicion for pulmonary embolism is not well characterized. We sought to answer the following two questions: First, what is the rate of positive Doppler tests for symptomatic patients in the perioperative period following a primary total joint arthroplasty? Second, in cases where a duplex ultrasound was ordered, how many of these subsequently underwent chest CTA and what was the rate of positive results? Our hypothesis is that a large majority of the duplex ultrasounds done for symptomatic patients are negative and there is a substantial number of cases in which a patient will have a pulmonary embolism despite having negative duplex test. Understanding the limitations of duplex ultrasonography in the workup of a patient with a potentially fatal pulmonary embolism can aid clinicians in remaining vigilant and pursuing further workup when clinical suspicion remains after a negative duplex ultrasound result.

Patients and Methods

This study retrospectively reviewed the medical records of all patients undergoing primary total hip and knee

arthroplasty at our institution from January to December 2011. Inclusion criteria for this study were patients who underwent duplex ultrasonography in the postoperative period during hospital stay and were over 18 years old. Exclusion criteria included revision surgery, prior DVT or pulmonary emboli, placement of IVC filter, active malignancy, or genetic hypercoagulable disorders that would predispose a patient to developing a DVT. Only ultrasounds performed during the patient's hospital stay postoperatively were recorded. The study size was arrived at by the above inclusion and exclusion criteria. Patients from all surgeons performing arthroplasty at our institution were candidates to reduce bias of any single surgeon's particular indications for ordering a test. Data were extracted from electronic hospital medical records including vascular laboratory reports. Patient age, medical history, type of operation, date of duplex, length of stay, and postoperative complications were noted. No patients in this series had undergone either duplex ultrasonography or CT angiography without the presence of clinical symptoms.

During the selected timeframe, 910 primary total knee and 883 total hip arthroplasties were performed at our institution. Of these, 295 patients (16.5%) met the inclusion criteria with a TKA/THA distribution of 174:121 (59.0%:41.0%) and a M/F distribution of 94:201 (31.9%:68.1%). There was no missing data for these 295 included patients. The mean age was 64.2 ± 11.5 years. Ultrasound was performed at an average of 3.4 days after surgery (SD 2.3). The most common indications for performing the duplex study were tachycardia (27.1% of patients), desaturation (25.4%), calf or thigh pain (20.0%), and calf swelling (16.3%). Table 1 delineates the number of patients who reported each symptom. Less common indications included altered mental status, chest pain, syncope, incisional drainage, or fever. Many patients had a combination of symptoms that was commonly reported. DVT prophylaxis used is as follows: Out of 295 patients, 241 (81.7%) received Lovenox 30 mg bid, 35 (11.9%) received warfarin titrated to an INR of 1.8–2.2, 18 (6.1%) received aspirin 325 mg BID, and one patient (0.3%) received Arixtra.

If a chest angiogram (chest CTA) was concomitantly obtained during workup to evaluate for pulmonary embolism, clinical indications and results were documented. One hundred three patients underwent chest CTA and the most common clinical indications were desaturation (50.5% of patients), tachycardia (26.2%), chest pain (4.9%), and calf swelling (2.9%). All venous studies were performed under the supervision of certified technologists and standard protocols for duplex scanning were utilized. An ACUSON S2000 duplex machine (Siemens, Erlangen, Germany) and a Somatom Sensation CT scanner multi-detector, 40 slice (Siemens, Erlangen, Germany), were utilized. The diagnosis of DVT was made by demonstration of filling defects in veins and/or incompressibility of vessels. Ultrasound technicians received appropriate training and certification according to regulatory mandates and all studies were read by a board-certified radiologist. Each venous segment from the common femoral vein at the inguinal ligament to the popliteal vein distally was evaluated by ultrasound for the

presence of echogenic thrombus and compressibility, with the addition of color flow Doppler imaging to confirm spontaneous flow. Augmentation of flow with calf compression or toe dorsiflexion was used to exclude major distal occlusion, and demonstration of respiratory phasicity and cessation of flow with the Valsalva maneuver were considered as indirect indicators of abdominal and pelvic venous patency. DVT prophylaxis was used for all patients with agent depending on surgeon preference and established evidence-based protocols. In addition, sequential compression devices or foot pumps were used.

Standard descriptive statistics (mean, standard deviation) were applied to the data. Approval for this clinical research study was obtained from the Institutional Review Board.

Results

Only 2 of the 295 ultrasounds performed were positive for a DVT (0.7%), the indications being thigh pain and swelling in 1 patient and chest pain in 1 patient. The patient with thigh pain and swelling had a chest CTA negative for a PE and the other patient with chest pain did not undergo CTA due to self-resolving symptoms and negative cardiac work-up. Both patients were treated with therapeutic doses of anticoagulation agents as deemed appropriate in consultation with a medical ICU team per our institutional policy.

In 103 of the 295 cases, a chest CTA was also performed in addition to the duplex ultrasound. Of these, 26 (8.8% of total population of 295) revealed a PE. None of these 26 patients had a positive duplex ultrasound. The symptoms that each patient presented with for which a positive chest CTA were as follows: desaturation (65.4%), tachycardia (30.8%), arrhythmia/EKG changes (11.5%), chest pain (11.5%), troponin bump (7.7%), hypotension (7.7%), calf/thigh pain (3.8%), and shortness of breath (3.8%). Both patients with positive duplex ultrasound were on Lovenox. Out of the 26 patients who were found to have a PE, 22 (84.6%) were on Lovenox and 4 (15.4%) were on warfarin.

Discussion

Duplex ultrasound is frequently used in the workup of various symptoms that patients have in the postoperative period after undergoing total joint replacement. We aimed to quantify the frequency of positive results of this test in patients that have clinical suspicion for a DVT and correlate the result of this test with that of CTA in cases where clinical suspicion existed for a PE. We hypothesized that many duplex ultrasounds are negative. Moreover, when clinical suspicion remains high after a negative duplex, a chest CTA will detect pulmonary emboli from a DVT that was not detected by duplex ultrasound. In this study, we found that only 0.7% of duplex results are positive and of the 99.3% of patients with negative studies, 8.8% of those were found to have a pulmonary embolus on CTA.

We appreciate several limitations. First, this retrospective study does not lend itself to calculate sensitivity or specificity of duplex ultrasonography. However, it can be inferred

that a negative duplex ultrasound can give false reassurance to clinicians who routinely care for perioperative primary joint replacement patients. There could be several reasons for this finding. One reason is that certain thromboembolic events may not be adequately assessed by venous duplex ultrasound. The weighted mean sensitivity and specificity of venous ultrasound in detecting symptomatic DVT are both above 90% [22]. Others have also shown duplex ultrasound and color Doppler sensitivities for detecting isolated calf vein thrombosis to be greater than 90% [4, 14, 18]. It is possible that the Doppler ultrasounds are false negative because the source of the identified PE is due to pelvic DVTs that cannot be reliably detected with duplex ultrasonography. The evaluation of pelvic thromboses may also prove problematic, however, and some believe that ultrasound is limited in its ability to identify isolated pelvic thromboses. Patient factors may also limit these examinations. These include, but are not limited to, the inability of the patient to cooperate with positioning for the examination, presence of extrinsic factors (bandages, wounds, etc.), or intolerance to compression or ultrasound testing by the technician. Finally, another reason for duplex ultrasounds failing to detect a clot are issues regarding the technical expertise of hospital staff performing the ultrasound. This topic has been written about extensively with the overall conclusion being that lack of technical expertise can severely reduce the quality of the study, which could contribute to low positive rates. Although the staff conducting these studies receive appropriate certification and training, it is reasonable to state that a certain proportion of these studies were compromised by technical accuracy. These limitations underscore the concept that duplex ultrasound cannot be used alone to provide reassurance to the surgeon who suspects DVT or PE in a postoperative arthroplasty patient. We do not imply that chest CTAs should be used in lieu of duplex ultrasound as these tests have different indications and aim to detect different pathologies, albeit pulmonary emboli presumably arise from DVTs. DVTs, independent of a pulmonary embolism, need to be treated to prevent future embolization as well as postphlebotic syndrome. Rather, when clinical suspicion of a PE exists, further imaging should be pursued and the clinician should not presume that a PE cannot possibly exist because a duplex failed to detect a DVT.

Second, all patients who underwent chest CTA at our institution were not reviewed as part of this study, and positive rates were not calculated for all arthroplasty patients. We solely evaluated chest CTA data for patients undergoing duplex ultrasound. Third, this is a retrospective chart review and thus the only reported symptoms as documented in notes were identified. It is possible that the patients had more symptoms than what physician notes documented. Fourth, it was not possible to ascertain whether some duplex ultrasounds were ordered as part of a pulmonary embolism workup or solely to evaluate for a DVT. One can infer from the patients who primarily had symptoms that would suggest a DVT such as the 20% and 16% of patients who underwent duplex for calf/thigh pain and calf swelling, respectively, that the positive rate for these patients was also low: only one patient with thigh pain had a DVT.

This study's finding that most duplex ultrasounds are negative is in accordance with the literature for both arthroplasty and non-arthroplasty patients. Della Valle et al. reviewed postoperative total joint patients who had clinical suspicion of a pulmonary embolism (PE) and found that of the patients who had a confirmed PE, only 5.7% had a DVT diagnosed by duplex ultrasonography. They advocated that a negative duplex ultrasound should not preclude further workup and evaluation in symptomatic patients [6]. Similarly, Iorio et al. found that in patients undergoing total knee replacements, routine use of duplex ultrasonography was of limited clinical benefit and recommended that this diagnostic modality only be employed when high clinical suspicion exists [11]. Unay et al. reported in a proposed protocol for DVT prophylaxis that out of a group of 1326 patients undergoing a wide range of orthopedic procedures including arthroplasty (217 patients), trauma, arthroscopy, and congenital and acquired deformities, 58 (4.4%) met predefined criteria (pain, swelling, patchy/venous appearance, tenderness, temp increase, pain) for ordering a Doppler ultrasound, and only six of those were positive [21]. The study did not specify the diagnoses of the 58 patients who underwent Doppler ultrasound.

In non-arthroplasty patients, Ciccone et al. describe that in the postoperative setting, ultrasound is an unreliable modality when used for surveillance of asymptomatic DVT and should not be used in screening all orthopedic patients [5]. Similarly, Schwarcz et al. retrospectively reviewed surveillance duplex for primary total joint arthroplasty patients concomitantly taking enoxaparin. Patients who underwent routine postoperative duplex (median POD 4) had a 1.3% incidence of ipsilateral DVT and one patient who did not have surveillance duplex scan returned 6 weeks postoperatively with an ipsilateral DVT. Two other patients were diagnosed with DVT within 30 days of discharge. This study routinely performed ultrasounds on all patients as opposed to focusing the use of ultrasounds on symptomatic patients. The conclusion was that routine postoperative venous duplex scans rarely found DVT after total joint arthroplasty when effective prophylaxis was used and surveillance scanning did not facilitate the prediction of the potential occurrence of PE [19]. Similar findings have been found regardless of referring physician specialization (internal medicine vs. general surgery) [15] and one study in the vascular surgery literature even noted that the overuse of duplex ultrasound hindered attempts at cost savings in the authors' practice [7]. Our study extends the arguments made by these previous works by demonstrating that even when clinical suspicion does exist, the utility of duplex ultrasound is quite limited in detecting a DVT that requires prompt detection and appropriate treatment to prevent pulmonary emboli and other sequelae such as postphlebotic syndrome.

In addition, it is also important to better understand the costs of duplex ultrasound. Bendayan and Boccalon performed a prospective cost-effectiveness study of duplex scanning of 511 in patients with unspecified diagnoses (presumably mostly non-orthopedic) in a French public hospital with suspected DVT of lower extremity, demonstrating 144 (28%) positive results, 6 false negatives, and 3 false

positives [2]. Clinical examination alone was not found to be cost-effective, nor was venography. Compared to venographic exploration, use of non-invasive tests (echography + plethysmography) provided a 1-year cost reduction of up to 70% of total costs. However, the authors note that any potential reduction in expenditure must be balanced by the risk of not diagnosing a DVT in a patient at risk of a life-threatening PE. Long-term follow-up of patients without positive studies demonstrated that the absence of further intervention did not constitute a risk since only one patient out of 286 not undergoing treatment who did not have a follow-up duplex study had a nonfatal DVT.

To evaluate the utility of duplex ultrasound from a financial perspective, the cost of this test must be considered. With a 0.7% positive rate in our study and a Medicare reimbursement rate of \$218 per duplex, the "number needed to detect" a single DVT was 143 and the total cost of "detecting" each DVT can be estimated at over \$31,000. These results suggest using duplex ultrasound routinely to look for DVT in symptomatic patients contributes to excessive costs in arthroplasty patient care. This reality furthers our claim that duplex ultrasound is an expensive test that has a limited role in postoperative management of arthroplasty patients. We recommend obtaining a chest CTA in patients with high pretest probability of a pulmonary embolus despite a negative duplex ultrasound, especially given that the most common symptoms reported in our population were desaturation and tachycardia.

In conclusion, duplex ultrasonography, when used routinely to workup symptomatic patients who recently underwent primary total joint arthroplasty, is an expensive test with limited utility. We conclude from this experience that when evaluating patients presenting with suspicion of a postop DVT/PE event, if the duplex ultrasound is negative and the clinical scenario is consistent with a high pretest probability of developing a PE, then chest CTA should be performed.

Acknowledgments We would like to thank Leon Rybak, MD, for providing the ultrasound images for this study. We sadly report the passing of Frederick Jaffe, MD, senior author on this manuscript. This is his final contribution to the orthopedic field and marks the culmination of a distinguished career as an orthopedic surgeon as well as a mentor and a role model to the junior authors of this study.

Compliance with Ethical Standards

Conflict of Interest: Shaleen Vira, MD; Austin J. Ramme, MD, PhD; Michael J. Alaia, MD; David Steiger, MD; Jonathan M. Vigdorchik, MD; and Frederick Jaffe, MD, have declared that they have no conflict of interest.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Informed Consent: Informed consent was waived from all patients for being included in the study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

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