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Venous Duplex Scanning for Suspected Deep Vein Thrombosis: Results Before and After Elimination of After-Hours Studies

George J Arnaoutakis, MD[1], James Pirrucello, BA[1], Benjamin S Brooke, MD[1], and Thomas Reifsnyder, MD[1]

Abstract

Objective: A 24-hour venous duplex ultrasound (VDU) for suspected deep vein thrombosis (DVT) imposes significant resource burdens on a hospital. We hypothesize that termination of after-hours services increases empiric therapy without affecting clinical outcomes. Methods: A retrospective review of patients evaluated by the emergency department (ED) for suspected DVT in 2005 and 2007. Demographics, empiric treatment, and complications were compared using propensity scores and multivariate regression models. Results: In 2005 and 2007, 318 and 365 patients, respectively, had VDU after referral by the ED. In all, 49 (16%) tests during 2005 were after-hours, with 31 and 25 acute DVTs in 2005 and 2007, respectively. More patients received empiric treatment in 2007: 51 (14%) vs 26 ([8%]; $P = .019$) and tended to be more likely to have acute DVT: 7 (28%) vs 3 ([10%]; $P = .08$). We detected no complications from empiric anticoagulation and no difference in outcome. Estimated annual savings were $11 864. Conclusions: Elimination of around-the-clock VDU can render substantial savings to hospitals without adverse consequence in the management of acute DVT.

Keywords

vascular laboratory, deep vein thrombosis, duplex ultrasonography

Introduction

Acute deep vein thrombosis (DVT) is a major source of patient morbidity and presents a diagnostic challenge for health care providers. Because the clinical assessment for DVT is notoriously unreliable, clinicians frequently rely on venous duplex ultrasonography (VDU) for confirmatory testing.[1,2] Venous duplex ultrasonography is the gold standard for diagnosis of acute DVT, with sensitivity and specificity greater than 95%.[3] Since the widespread introduction of VDU several decades ago, the use of this imaging modality for detecting DVT has increased dramatically throughout US hospitals.[4]

Although the use of VDU has made the diagnosis of DVT easier and more efficient, there are challenges associated with its use. In particular, retention of experienced vascular laboratory technologists has been a common problem and providing the service of on-call vascular laboratory studies contributes to technologist dissatisfaction.[5]

Given the current climate of cost containment in health care, there is interest in more effectively using vascular laboratory services. Other centers have designed algorithms that the emergency department (ED) and other departments can use to stratify patients according to the likelihood of having an acute DVT. Such algorithms espouse a rational, systematic method whereby referring physicians can guide their need for obtaining a VDU study after-hours. These studies cite improved DVT detection by VDU and also greater technologist retention and satisfaction.[5-8]

Johns Hopkins Bayview Medical Center is a university-affiliated teaching hospital where the vascular laboratory is the sole provider of VDU. Between 2500 and 3000 venous duplex studies are performed annually. Until 2005, technologists were required to take vascular laboratory call. However, after 2005 this system was discontinued and the vascular laboratory no longer provides after-hours services. This systematic change provides the opportunity to examine clinical outcomes and rates of empiric therapy for patients presenting to the ED with suspected acute DVT before and after introduction of this policy. We hypothesize that termination of after-hours services

[1] Division of Vascular Surgery, Johns Hopkins Bayview Medical Center, The Johns Hopkins Medical Institutions, Baltimore, MD, USA

Corresponding Author:
George Arnaoutakis, Division of Vascular Surgery, The Johns Hopkins Medical Institutions, 600 N Wolfe Street, Blalock 1263, Baltimore, MD 21287, USA
Email: gja10@jhmi.edu

would lead to higher rates of empiric therapy but no significant difference in clinical outcomes.

Methods

Patient Data

A retrospective cross-sectional study was performed to examine ultrasound results of all patients evaluated in the ED of the Johns Hopkins Bayview Medical Center for suspected DVT during the calendar years 2005 and 2007. The hospital-based vascular laboratory performed all VDU studies requested by the ED. The medical records and ultrasound results of these patients were each individually reviewed and data extracted, including baseline demographics, reason for examination, and results.

For ease of identification of after-hours studies, only referrals from the ED were included in the study population. Additional inclusion criteria were patients 18 years of age or older, initial presentation occurring in the ED, and referral for VDU initiated by the ED. Patients who underwent an incomplete examination for any reason were excluded from this study. An after-hours examination was defined as any study performed before 7 AM or after 6 PM from Monday to Friday or during the weekend.

In the Bayview ED, there is no explicit protocol for the evaluation of a patient with suspected DVT. However, the standard course is for a patient with significant clinical concern to undergo diagnostic studies, which begins with a VDU study. Since 2006, VDU studies are only available during weekdays and from 7 AM to 6 PM. In patients who present with suspected DVT after-hours, ED physicians either (1) admit the patients to perform VDU the following day; (2) provide empiric therapy; (3) perform computerized tomography or; (4) appropriately trained ED staff perform bedside duplex ultrasound examinations. There is no rapid D-dimer assay in the Bayview ED, and because of variable turnaround times, this test is not routinely performed in the workup of an ED patient with suspected DVT.

Risk factors for DVT available for collection included age, recent surgery, recent trauma, history of cancer, and prior DVT. In addition, the medication administration record was reviewed to identify patients receiving empiric therapy, defined as an anticoagulant medication ordered, dosed with therapeutic intention, and administered prior to performance of VDU. In patients requiring empiric anticoagulation and who were to be discharged from the ED to follow-up for a VDU study, an education program was in place so that nursing supervisors observed patients self-administering subcutaneous injections of anticoagulation therapy. Adverse reactions to anticoagulation were defined as bleeding, local skin reaction, or development of heparin-induced thrombocytopenia (HIT). To identify adverse reactions, the medical records of all patients receiving anticoagulation were reviewed, and patients were contacted by telephone to assess for potential adverse reactions.

Ultrasound Technique

The vascular laboratory technologists routinely record patient name, medical record number, presenting complaint, and reason for examination. Ultrasonographic criteria diagnostic of acute DVT were an incompressible vein, direct identification of intraluminal clot, absence of spontaneous and phasic venous blood flow, and lack of flow augmentation with distal extremity compression. Chronic DVT was determined by the presence of one or more of the following: visualization of bright echogenic thrombus in the vein, increased vein wall thickness, evidence of recanalization, marked venous collaterals, and partial compressibility.

Cost Analysis

Costs were determined by calculating the hourly rate to have a vascular laboratory technologist perform after-hours studies in 2005 multiplied by the number of after-hours studies. Weekend studies were occasionally batched so overall cost savings may be modestly overestimated. In addition, technologists were paid a low hourly rate to carry an on-call pager. To estimate the maximal cost of more empiric therapy in 2007, we assumed that the additional patients would receive the most expensive form of empiric therapy, enoxaparin. An average weight of 70 kg was used to calculate the total cost of administering a single dose of therapeutic enoxaparin. Professional fees for physician interpretation of the tests and hospital costs were not included in the calculation. The assumption is that patients treated empirically would ultimately receive an ultrasound, either as an outpatient or from direct referral through their primary care physician. To account for the cost of empiric treatment-related complications and readmissions the medical record was reviewed for all pertinent readmissions and patients receiving empiric therapy were selectively called.

Statistical Analysis

Baseline characteristics between patients in 2005 and 2007 were compared using the Mann-Whitney *U* test for continuous variables and chi-square analysis for categorical variables. *P* values $<.05$ were considered statistically significant. The primary outcome of interest was acute DVT as defined above. Rates of empiric therapy were determined as well, and we compared the rate of empiric therapy in patients testing positive for acute DVT in 2005 versus 2007. After matching patients using propensity scoring, a multivariate logistic regression model was created to determine the odds of receiving empiric therapy if patients were at high or low risk of acute DVT. A separate model was created to evaluate acute or chronic DVT. Propensity scores account for the probability of a given patient being assigned a particular condition taking into consideration a known set of covariates. This methodology mitigates the effects of confounding variables. All statistical testing was performed using STATA v10.1 Special Edition software (StataCorp, College Station, Texas).

Table 1. Baseline Demographics and Clinical Variables

Variables	2005, N = 318	2007, N = 365	*P* Value[a]
Mean age (SD)	52.3 (17.6)	55.5 (17.8)	.025
Male gender, no (%)	119 (38)	160 (44)	.095
African-American race	83 (26)	107 (29)	.363
Presenting symptom, no (%)			.217
Pain	158 (50)	188 (51)	
Edema	148 (47)	172 (47)	
Other	11 (3)	5 (2)	
Prior DVT, no (%)	39 (12)	35 (10)	.244
Peripheral vascular disease, no (%)	12 (4)	12 (3)	.713
History of cancer, no (%)	17 (5)	21 (6)	.840
Recent trauma, no (%)	3 (1)	17 (5)	.004
Recent surgery, no (%)	10 (3)	15 (4)	.523

NOTES: DVT = deep vein thrombosis; SD = standard deviation.
[a] Bivariate testing performed with nonparametric and chi-square analysis as appropriate, and *P*value < .05 considered significant.

Results

There were 683 duplex ultrasound studies performed on patients referred directly from the ED for suspected DVT during the 2 years studied. In 2005, 318 studies were completed and the mean age of the patients was 52.3 (17.6) years. In 2007, 365 studies were performed and the mean age was 55.5 (17.8) years. There were 49 after-hours studies performed in 2005, and the majority of these were performed during the weekend (93%). In 2007, 2 studies were performed after-hours; however these were performed as an extension to the regular weekday hours for the vascular laboratory.

Baseline demographics and reason for examination for both time periods are presented in Table 1. During both years studied, women predominated representing 62% and 56% of the cohort in 2005 and 2007, respectively (P =.095). Limb pain was the most common presenting complaint in both years studied, with 50% and 51% of patients reporting this symptom in 2005 and 2007, respectively. When comparing risk factors for DVT, the only significant difference between the 2 groups was patients more commonly had a recent history of trauma in 2007 (1% vs 5%; $P < .05$). For prior history of DVT, peripheral vascular disease, cancer, and recent surgery, there were no significant differences.

Overall, there were 31 (10%) positive studies for acute DVT in 2005 and 25(7%) in 2007 (P =.165; Table 2). There were 26 (8%) and 11 (3%) chronic DVT studies in 2005 and 2007, respectively ($P < .05$). Of the 49 after-hours studies conducted in 2005, 5 (10%) were positive for acute DVT. The number of patients treated empirically was significantly higher in 2007 (14% vs 8%; $P < .05$). In addition, there was a nonsignificant trend toward empiric treatment being more frequent in 2007 in patients confirmed to have acute DVT (28% vs 10%; P = .08). When combining patients with an ultrasound diagnosis of either acute or chronic DVT, patients were more likely to receive empiric anticoagulation in 2007 (28% vs 7%; $P <$ .05; Table 2).

Table 2. Clinical Outcomes and Empiric Treatment Rates

Outcomes	2005	2007	*P* Value
Acute DVT, no (%)	31 (10)	25 (7)	.165
Chronic DVT, no (%)	26 (8)	11 (3)	.003
Either acute or chronic DVT, no (%)	57 (18)	36 (10)	.002
Empiric treatment, no (%)	26 (8)	51 (14)	.019
Empiric treatment with + acute DVT, no (%)	3 (10)	7 (28)	.085
Empiric treatment with – acute DVT, no (%)	22 (9)	41 (12)	.127
Empiric when either acute or chronic DVT+	4 (7)	10 (28)	.007
Adverse effect from empiric treatment, no (%)	0 (0)	0 (0)	.5

NOTE: DVT = deep vein thrombosis.

Table 3. Multivariate Regression Models With Propensity Score Matching

	Odds Ratio (95% CI)	*P* Value
Acute DVT		
Overall	3.09 (0.68-14.07)	.143
Low propensity	1.18 (0.14-9.82)	.877
High propensity	8.80 (0.77-99.8)	.080
Acute or chronic DVT		
Overall	4.61 (1.30-16.28)	.018
Low propensity	2.96 (0.63-13.87)	.168
High propensity	10.0 (0.92-108.8)	.059

NOTE: DVT = deep vein thrombosis.

After matching patients by propensity scores, multivariate logistic regression models for acute DVT revealed a nonsignificant trend toward increased likelihood of empiric treatment if patients had risk factors known to indicate high risk for DVT (Odds Ratio = 8.80, 95% CI 0.77-99.8, P = .080). For acute or chronic DVT, multivariate logistic regression models with propensity score matching showed that overall patients had greater likelihood of empiric therapy with an odds ratio of 3.09 (95% CI 1.30-16.28, P = .018; Table 3).

Of the 26 patients who received empiric therapy in 2005, 18 (69%) patients received enoxaparin and 8 (31%) got intravenous heparin. In 2007, 44 (86%) of the 51 patients receiving empiric treatment were given enoxaparin. The remaining 7 patients received either fondaparinaux or intravenous heparin. There were no documented adverse reactions from empiric therapy, including no bleeding complications or development of cellulitis.

During the period 2001-2006, there were 6 full-time vascular laboratory technologists at Bayview Medical Center, with an average tenure of 3.5 years. Of the 6, 1 is currently still employed in the vascular laboratory. From 2006 until the present, there have been 5 full-time vascular laboratory technologists with no attrition. All 4 new hires were experienced and when recruited stated that having no call was important in their decision to change jobs.

In 2005, vascular laboratory technologists were paid one and a half their usual hourly rate for a minimum of 4 hours when they performed an after-hours study. The 49 after-hours studies performed in 2005 amount to $5880 in payment for after-hours vascular laboratory technologist services to perform studies. In addition, to carry the on-call pager, technologists were paid $4/hr, totaling $9984 per year. Total costs for on-call technologist services were $15 864. The total cost of empiric therapy in 2007 was estimated at $4,000, assuming all empiric treatment was administered with enoxaparin therapy and using an average dosage of 70 mg. Subtracting the cost of empiric therapy in 2007 from savings in no after-hours studies in 2005 yields an estimated annual cost savings of $11 864 annually to the hospital.

Discussion

Improving the use of VDU and the vascular laboratory is an important undertaking. This is the first study that examines the effect no after-hours VDU has on the clinical outcomes of patients evaluated in the ED for suspected DVT. The intention was to compare the outcomes before and after eliminating after-hours VDU, not to establish ED protocols to minimize its use. That has been the aim of previous studies.

Between the 2 study years, 2005 and 2007, there was no significant difference with respect to acute DVT rates. Acute DVT rates of 10% and 7% are consistent with previously published reports.[9] Patients who underwent an after-hours study in 2005 had the same prevalence of acute DVT as all patients undergoing VDU in our laboratory that year. Other studies that have evaluated algorithms to guide efficient use of vascular laboratory services have detected an improvement in the yield of positive after-hours studies for acute DVT. There was no such algorithm in place at Bayview Medical Center in 2005. Hence, the yield of VDU in detecting an acute DVT was no different after-hours. A study by Langan et al details a specific algorithm that significantly reduced the number of after-hours studies performed, reporting an 89% reduction. Importantly, after introduction of this program, their vascular laboratory experienced 100% technologist retention in the ensuing 2 years.[5] Since discontinuing call for vascular laboratory personnel at the Johns Hopkins Bayview Medical Center, there has been 100% retention while hiring 4 additional full-time technologists. The system in the Bayview model is unique from the Langan study in that it precludes the need to have technologists on call.

Changes in treatment patterns by ED physicians before and after implementation of this policy were examined. The metric to assess these patterns was the rate of use of empiric anticoagulation therapy. Consistent with our hypothesis, there was a higher rate of patients receiving empiric anticoagulation therapy in 2007. Whereas in 2005, when a study could be performed after-hours, ED physicians were less likely to offer empiric therapy because a confirmatory diagnostic test would have been readily available. Although not statistically significant, there was a trend toward more patients with acute DVT receiving empiric treatment in 2007. This finding suggests that ED physicians' clinical acumen for acute DVT improved or they had a lower threshold to order empiric therapy when unable to reflexively order VDU. Statistical significance may have been reached if the sample size was larger.

Since more patients were receiving empiric anticoagulation in the era when no after-hours studies were available, it is important to detect adverse reactions to the treatment. Despite culling the electronic records and calling the patients, no adverse reactions were detected. This method introduces the potential of recall bias. To rule out conclusively the possibility of a small difference in adverse reaction rates would require a large, prospective multi-institutional effort since adverse reactions from a single dose of therapeutic anticoagulation occur infrequently. In a large cohort study by Imberti et al studying empiric anticoagulation there was not a single episode of bleeding or HIT.[10]

As centers move away from 24-hour vascular laboratory services, there may be a tendency to use other modalities to detect DVT that are available at all times. Venous phase computerized tomography (CT) is a new application of this imaging modality that has high diagnostic accuracy for detecting DVT.[11] This change in modality should be discouraged as it will have the inadvertent effect of increasing costs and radiation exposure to the patient.

In an effort to obviate after-hours vascular laboratory services, a trial by Bernardi et al evaluated the diagnostic accuracy of 2-point ultrasonography performed by ED staff to detect acute DVT. They found equivalent diagnostic accuracy compared with whole leg ultrasonography, although significant physician training was required to achieve these results.[12] Before widespread application of this technique, these results should be replicated in other centers. If satisfactory results persist, this could be an acceptable alternative to empiric therapy. Currently, whole-leg ultrasound remains the gold standard for the diagnosis of acute DVT.

The current study is limited by its retrospective nature; however, this study in combination with other published reports and the infrequency of adverse reactions lead us to conclude that the option of after-hours VDU can be minimized. An added limitation of this study is that only referrals from the ED were included in this analysis, and therefore no inpatients are represented in the 2 cohorts studied. However, from these results we suspect similar findings would be present in an inpatient population as well. These data support the practicality and safety of a system without after-hours VDU.

We concede that overall annual cost savings of $11 000 to a single institution is a modest figure. A previous study using an after-hours algorithm showed savings of $17 000 per year.[5] However, if amounts in this range were applied to the 5815 hospitals across the country, elimination or reduction of after-hours vascular laboratory services would lead to considerable savings. These results are especially poignant in the current economic state of health care in the United States.

Conclusion

In conclusion, this is the first study to evaluate the results when a hospital discontinues after-hours VDU. No difference in

clinical outcomes for patients presenting to ED with suspected DVT were found. While there was an increased rate of empiric anticoagulation therapy this was not associated with an increase in adverse events. The system of no after-hours studies for the vascular laboratory is safe, practical, and may afford significant cost savings to medical institutions.

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Declaration of Conflicting Interests

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