



## Research Article

# Analysis of Upper Extremity Arterial Duplex Indications May Reduce Unnecessary Tests

Mounir J Haurani\*, Michael R Go, Jean E Starr, Patrick S Vaccaro and Bhagwan Satiani

Division of Vascular Diseases and Surgery, Ohio State University, Prior Hall, Columbus, USA

### Abstract

**Introduction and Objectives:** There is constant pressure on Vascular Laboratories (VL) to produce accurate and timely testing. Others have studied cost savings related to reducing unnecessary venous duplex testing and after hour studies; however, little has been written regarding Upper Extremity Arterial Duplex (UEAD) and reduction of unnecessary testing. As transradial interventions increase in frequency, so too will UEAD. By evaluating the indications for the studies and the results, we hope to identify a subset of patients for whom UEAD testing is specifically indicated.

**Methods:** We queried our prospectively maintained database for all UEAD performed between January, 2006 and December, 2013. We excluded tests for which the Testing Indications (TI) was not clearly noted or unrelated. UEAD were then separated broadly based on TI into objective or subjective findings, and then further subcategorized based on the specifics of the TI. The results of the UEAD were categorized as positive (abnormal) or negative (normal). Statistical analysis was performed with Chi Squared for nominal categorical data.

**Results:** Overall 130 (35%) of 368 UEAD had positive (abnormal) findings. There was no difference in the number of abnormal UEAD when categorized broadly into objective or subjective indications (36% vs. 34%,  $p=0.4$ ). When subdivided by their more specific indications, UEAD whose TI were findings such as a pulse deficit or bruit had the highest rate of abnormal tests. When the TI was for a presumed complication without objective findings, the UEAD displayed had the lowest rates of abnormal findings.

**Conclusion:** Abnormal UEAD is found more often in patients who have objective findings on physical examination than, pre-existing diagnosis of vascular disease, or presumed complications without objective findings. However, not all objective findings were found to

be highly correlated with abnormal UEAD. With further studies of patient characteristics we can develop guidelines for eliminating unnecessary UEAD.

### Introduction

Since the Deficit Reduction Act (DRA) of 2005 was passed, there has been significant financial pressure on Vascular Laboratories (VL) through reduced reimbursement. While the main focus was on high cost imaging services such as CT and MRI, technical fees to the VL were significantly reduced. More recently the Patient Protection and Affordable Care Act were passed. With this, further pressure has been placed on the VL through a 50% reduction in technical fees for same day services on imaging. In the future, it will be difficult for VL to continue to operate without evaluating potential areas of cost reduction within the VL. In addition, since 2005, the use of transradial approach to coronary angiography has increased [1,2]. As a consequence, there has been an increase in requests for Upper Extremity Arterial Duplex (UEAD). Several studies have been performed in the VL domain related to improving efficiency, cost reduction and improved financial performance [1,3]. These have included reducing unnecessary venous duplex testing, and reducing after hour studies that were often normal. Recommended strategies to reduce utilization and cost have included implementation of algorithms used to screen patients, education of physicians and other personnel and initiation of empiric treatment based on risk stratification [1]. In addition to potential cost savings, reducing unnecessary testing can increase efficiency of a vascular lab. While much has been written about venous duplex testing, little has been written regarding the increase in upper extremity arterial duplex.

The objective of this study was to analyze the documented indication for and the results of UEAD, and to then use that data to create ordering guidelines and educate physicians as to the role of UEAD.

### Methods

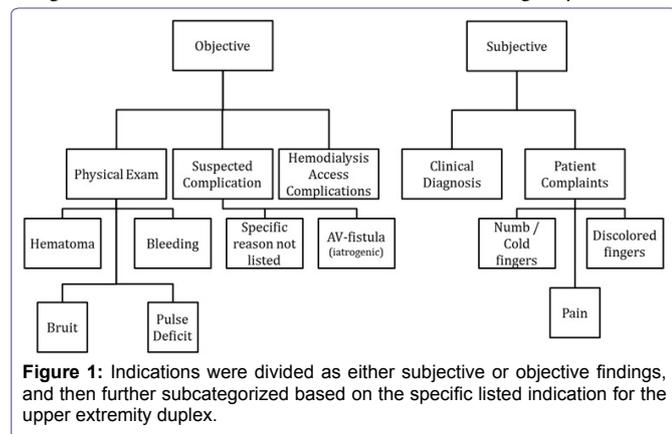
We retrospectively queried our prospectively maintained database for Upper Extremity Arterial Duplex scans (UEAD) performed from January, 2006 through December, 2013 (Vascupro, Consensus Medical, and Richmond, BC). The Test Indication (TI) and the results of each study were recorded. These indications were typically entered by the ordering physician and are from a drop down list in the electronic ordering system with a comments section available to clarify when needed. We excluded tests for which the indication was not clearly noted, were performed for preoperative imaging for radial artery harvest, or for preoperative assessment of arterial adequacy for arteriovenous access. If the findings were noted to be equivocal they were excluded as well. Equivocal results were those in which there was inadequate visualization or objective criteria to label the study as abnormal. All tests were performed by ultrasonographers who are certified as Registered Vascular Technologists (RVT) by the American Registry of Diagnostic Medical Sonographers (ARDMS). All tests were interpreted by Registered Physician Vascular Interpretation (RPVI) certified physicians (ARDMS). UEAD tests were then separated based on the TI into broad categories of objective

\*Corresponding author: Mounir J Haurani, Division of Vascular Diseases and Surgery, The Ohio State University, 376 W., 10th Ave., Prior Hall 701, Columbus, OH 43210, USA, Tel: +1 614 293 8536; E-mail: Mounir.Haurani@osumc.edu

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or subjective findings (Figure 1). We then further subcategorized these indications within the broad TI based on the more specific indication listed. Those patients who had objective findings were divided into those with physical exam findings, suspected complication, or complications of hemodialysis. Those who had more subjective findings were divided into testing ordered for a suspected diagnosis, or patient complaints (Figure 1). The indication and the results were categorized as positive (abnormal) or negative (normal). Other variables analyzed included the inpatient or outpatient status of the patient, and patients with physical exam findings compared to those with a suspected complication without physical findings. Statistical analysis was performed with Chi Squared for nominal categorical data. Fisher's exact test was used for contingency table data.



## Results

From 2006 and 2013 563 UEAD were identified in our database. 177 studies were eliminated because the indication was for preoperative examination of the arterial system (see Methods). An additional 18 studies were excluded because the findings were equivocal or the vessels were inadequately visualized to allow for interpretations. 368 studies were found to be appropriate for analysis. Overall, 130 (35%) of these studies were found to have abnormal findings. There were 229 inpatient or Emergency Department (ED) studies, and 181 outpatient studies (21 studies did not have the location recorded and were excluded from this portion of the analysis). There was no difference in the rates of abnormal studies between the inpatient/ED and outpatient studies (40% vs. 36%, P=0.4).

Overall there were an equal number of studies done for each broad TI (N=182 objective, 186 subjective). In the objective group, 66 (36%) had an abnormal finding vs. 64(35%) in the subjective group but this was not significantly different (P=0.71). In patients with hard signs of vascular injury (Physical Exam findings), the incidence of abnormal studies was 78%. This was significantly higher than in those who had objective findings without hard signs (the suspected complications and complications of hemodialysis groups, 34%, P<0.001). Despite there not being any difference in the rate of abnormal studies when broadly categorized into objective and subjective findings, when grouped according to the subgroups in figure 1, those with hard signs were significantly more likely to have positive (abnormal) findings (Table 1).

## Discussion

Venous duplex studies are the most frequently performed study in the hospital based vascular lab. With the increasing use of transradial

Indication	Negative	Positive	Total	Ib Positive
Objective	116	66	182	36%
Subjective	122	64	186	34%+
<b>Subsets</b>				
Physical Exam (Bruit / Pulse Deficit**)	5	18	23	78%*
Complications or Hematoma **	56	17	73	23%
Hem dialysis Access Complications**	55	31	86	36%
Complaints of blue fingers, cold hands etc. **	69	32	101	32%
Diagnosis of Vascular Disease **	53	32	85	38%
<b>Total</b>	<b>238</b>	<b>130</b>	<b>368</b>	<b>35%</b>

**Table 1:** There was no difference in the number of abnormal (positive) studies in the Objective, vs Subjective groups, + P=0.7.

Patients with hard signs of vascular injury such as a pulse deficit or bruit were much more likely to have an abnormal UEAD (\*78%, P<0.001 compared to any other group). There was no significant differences noted in any of the Subsets in objective (\*\*) or subjective (\*\*) groups.

catheterizations, we have noted more UEAD being requested. Much like in venous duplex studies, there is potential for over use of UEAD. We undertook this study to investigate the most appropriate indications for UEAD and the study ensuing results. Based on these findings we hope to establish the framework of recommendations for ordering of UEAD. With approximately two-thirds of our studies being negative (normal), we questioned the appropriateness of indication for the studies. Interestingly, when we excluded hemodialysis studies and studies ordered for pre-operative assessment of upper extremity vessels, equal numbers of studies were ordered for subjective and objective findings. Not unexpectedly, patients with hard signs were much more likely to have abnormal findings. In fact, unlike the overall rate of only 35% abnormal studies, patient with hard findings were twice as likely to have an abnormal study (78%). If there are hard signs, then the utility of an UEAD is limited and the patient could be treated based on clinical examination alone.

Based on this, one could argue that many of the UEAD are unnecessary. By using clinical criteria such as the objective findings of hard signs, we can increase the pre-test probability of an abnormal exam. This study was not designed to test that hypothesis, as it was a retrospective review of our UEAD. However, it may help frame future algorithms and strategies for ordering UEAD. We have already employed this strategy to reduce unnecessary after hour lower extremity duplex scanning for Deep Venous Thrombosis (DVT) in our lab. Patients with a high probability of DVT based on clinical signs are started on anticoagulation and their DVT scan was delayed until regular hours, while patients with low pre-test probability are not scanned at all [4]. This elimination of afterhours testing and institution of low-molecular weight heparin for high probability patients was estimated to save over \$11,000 annually in one lab alone [5]. This cost savings even included the cost of the low-molecular weight heparin. As UEAD becomes increasingly ordered, we could establish a similar strategy to increase the pre-test probability of an abnormal study based on clinical findings and reduce unnecessary tests.

Reduction in unnecessary testing is necessary in all VL because of the potential cost savings, reduction in sonographer burnout and turnover, and overall improvement in patient and physician satisfaction. For example, in our institution patients remained

highly satisfied with their care despite testing being delayed until normal hours for DVT. However, physicians were dissatisfied with having to wait [6]. The implementation of our afterhours DVT scan policy has the potential of providing physicians with an objective way of assessing patients and then being able to provide the patient with a logical treatment plan.

During the time period of our study, the national incidence of transradial catheterizations increased dramatically. In 2006, less than 1% of cardiac catheterizations were transradial access whereas by 2012 16.1% were transradial [4,5]. From the time period between 2007 and 2012 over 178,000 transradial catheterizations were performed nationally. The reported rate of vascular complication or major hemorrhage nationally is 2.83% for transradial PCI [4,5]. Considering there has been a 6 fold increase in the frequency of radial catheterization in the time period of this study, the expectation is that an increasing number of patients will need screened for complications post catheterization surgeons may be reluctant to operate on a patient based on physical examination alone without imaging to help demonstrate the extent and location of the injury and appropriate, high quality imaging can help guide intervention. Our objective was to determine which patients might have a low enough pretest probability that they can be safely followed clinically rather than ordering UEAD to determine that. Patient's with subjective findings should perhaps undergo a more thorough evaluation or be seen by a vascular specialist before ordering unnecessary testing. Often, a physiologic test may have been a better choice in these patients than arterial duplex.

Another potential reason for increased UEAD utilization is to assess the adequacy of the radial artery prior to transradial catheterization, especially when it has been previously accessed. While physical exam alone may not always be adequate to screen for radial artery adequacy, we excluded those studies from this review for several reasons. To begin with, 15% to 23% of patients being considered for coronary artery bypass graft had an abnormal Allen's test [7]. Of those patients with an abnormal modified Allen's test, only 11.6% will have an abnormal duplex ultrasound examination [7]. So the use of precatheterization screening of radial arteries would not necessarily prevent complications because of the low rate of abnormal studies. Furthermore, no guidelines have been established for differentiating radial artery adequacy. So routine screening of the

radial artery we propose would not prevent any more complications than a good physical examination.

## Conclusion

The use of radial arteries for cardiac catheterization and intervention is rapidly increasing. In conjunction with this, even though the complication rate is low, we expect an increasing number of radial artery injuries and request for imaging to assist in diagnosing and treating these injuries. In order to prevent overuse of UEAD, we need to establish guidelines as to when to order these tests. Since there are no established guidelines for this, further investigation is needed. We found that with the presence of hard signs of vascular injury there was a high abnormal UEAD rate. Given the low rates of abnormal UEAD in our study, especially among patients with subjective findings only, we would recommend reserving UEAD to confirm the extent or location of injury in patients with hard signs of vascular injury among patients with objective findings on physical exam.

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