Clinical Imaging 42 (2017) 240–248

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: http://www.clinicalimaging.org

Original Article

Emergency color Doppler sonography of the extremity artery: A pictorial essay☆,☆☆

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ARTICLE INFO

Article history:
Received 16 September 2016
Accepted 13 January 2017

Keywords:
Arterial embolism
Arteriovenous fistula
Color Doppler sonography
Emergency ultrasound
Pseudoaneurysm

ABSTRACT

Arterial color duplex sonography (CDUS) of the extremities is routinely analyzed in the field of emergency radiology. A retrospective review of 500 consecutive arterial CDUS extremity studies was performed in our emergency department. Abnormal CDUS examinations were classified into two groups according to their primary etiology: 1) traumatic arterial injuries (accidents or post-operative complications) and 2) acute arterial ischemia (thrombosis or embolism outside of the setting of acute trauma). This article reviews common CDUS imaging findings in a busy emergency radiology division including traumatic pseudoaneurysm, secondary pseudoaneurysm, arteriovenous fistula, acute ischemic arterial disease and chronic peripheral arterial disease. This essay highlights the crucial role of CDUS in the diagnosis of vascular abnormalities in the emergency setting. CDUS provides several advantages over other imaging modalities including high accuracy, rapid results, portability, lack of radiation, and low cost.

1. Introduction

By combining gray scale with color flow and spectral Doppler imaging, vascular color duplex sonography (CDUS) can provide valuable arterial morphological and hemodynamic information of the extremities. Arterial CDUS is often utilized in the initial assessment of suspected arterial injury (traumatic or iatrogenic) or acute ischemia (e.g. thrombosis or embolism) of the extremities [1,2]. This imaging modality can facilitate diagnosis of various disorders including pseudoaneurysms (PSA), arteriovenous fistulas (AVF) [3,4], and acute occlusive ischemia [4,5] that may require immediate intervention.

Current literature supports the use of CDUS by citing decreased turnaround time, expedited diagnosis and treatment, and improvement in patient outcomes [1–2,6]. As a noninvasive, radiation-free study, CDUS also poses relatively low risk compared to other imaging modalities. Given its various advantages, CDUS is now considered an essential imaging study for vascular emergencies and training on the use of this technology has increasingly been included in residency programs for radiology and emergency physicians [7–8].

In this pictorial review, we present imaging findings of common acute arterial pathologies, along with potential incidental findings, in emergency CDUS of the extremities. We additionally discuss the importance of proper technique in improving diagnostic accuracy for various pathologies of the extremities.

2. Material and methods

2.1. Patients

The Institutional Review Board at Weill Cornell Medicine approved the study (IRB0905010436). Written informed consent was waived for medical imaging and chart reviews.

We retrospectively reviewed 500 consecutive arterial CDUS studies performed on patients presenting to the adult emergency department in a large academic hospital between January 2010 and December 2012. All patients were referred for suspected arterial injury or ischemic limb. All CDUS studies were performed by an ultrasound technologist in conjunction with an emergency radiologist.

2.2. Color duplex sonography

Acuson Sequoia 512, Acuson S2000 (Siemens Medical Solutions, Mountain View, CA) and Loq 9 (GE Medical, Milwaukee, USA) ultrasound units equipped with L6–9 linear array, and C4–6 curved linear array transducers were used for arterial CDUS of the extremities.

There was no specific patient preparation prior to ultrasound. Patients were positioned supine and the extremities were minimally rotated, both internally and externally, during the exam to optimize visualization. Patient comfort was prioritized to improve compliance

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

☆☆ All Authors have no conflict of interest to disclose.

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http://dx.doi.org/10.1016/j.clinimag.2017.01.005
0899-7071/

with necessary maneuvers and to encourage assistance with extremity stabilization and muscle relaxation, all of which are essential to obtain high quality vascular images and Doppler spectra [9].

Gray scale, color Doppler, and spectral Doppler imaging were performed on each patient. For upper extremity visualization, efforts were made to initiate imaging near the aortic arch with evaluation of the brachiocephalic (right) or subclavian (left) arteries and to continue imaging more distally to the wrist. For evaluation of the lower extremities, imaging was initiated near the inguinal ligament and extended through the ankle. In certain cases, evaluation of the proximal contralateral extremity was performed in the event that endovascular access would be necessary and/or for comparison [10–12].

Gray scale imaging was used to evaluate the shape and size of the arterial lumen and to detect plaques. Color flow imaging was utilized to locate areas of abnormal blood flow as indicated by increased velocity, flow turbulence, and decreased flow. Spectral analysis, consisting of velocity measurements and Doppler waveform patterns, was used to evaluate the patency of the artery and vein, the severity of arterial stenosis (peak systolic velocity), and the direction of flow in both arteries and veins. Color and spectral Doppler settings were changed depending on the flow velocity in the artery. Pulse repetition frequency was adjusted based on the flow rate. In addition, a Doppler angle correction <60° was used for spectral analysis based on standard protocol for the arterial CDUS imaging [2,7]. The Doppler angle is considered ideal when the sound wave is parallel to the direction of flow. Power color Doppler was added for slow flow in severe, near occlusive arterial stenosis. A curvilinear transducer with wider view and increased penetration was used for trauma assessment to evaluate a region with overlying edema or to measure the size of a large hematoma.

3. Results

In our hospital, approximately 2% of vascular ultrasound exams (total 500 exams from January 2011 to December 2012) requested by emergency physicians were arterial CDUS of the extremities. Clinical indications for arterial CDUS included extremity pain, swelling, trauma, peripheral vascular abnormality following cardiac catheterization, cold limb, and weakness or absence of pulse. Atherosclerotic disease was the most frequent finding on CDUS imaging. Other commonly diagnosed abnormalities included pseudoaneurysm, arteriovenous fistula, acute embolic arterial occlusion, and non-iatragenic traumatic injury such as transection or dissection.

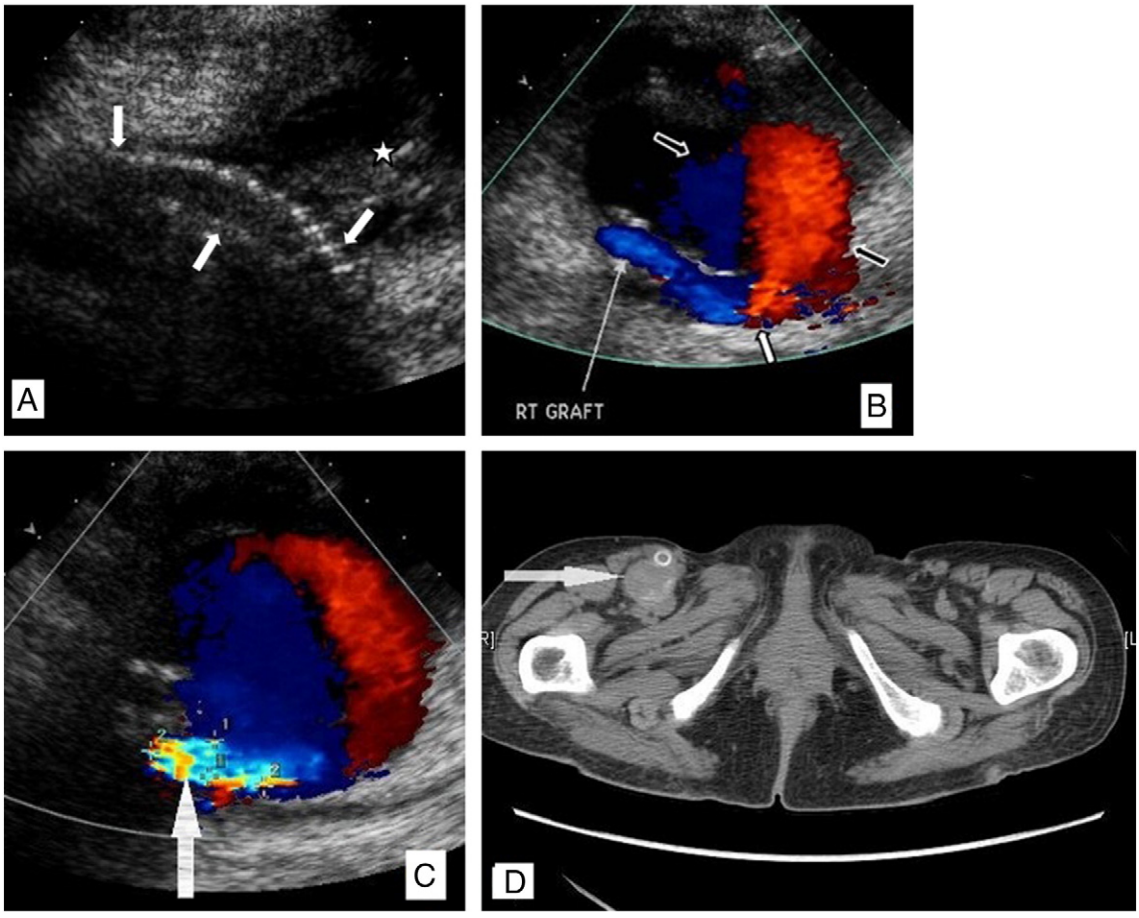

Fig. 1. A 66-year-old woman presented to the emergency department complaining of "vibrations" and a "dull ache" in her right groin one year following a right lower extremity synthetic arterial bypass graft between the common femoral artery (CFA) and popliteal artery. A. Right groin ultrasound demonstrated a tubular structure (between white arrows), consistent with a synthetic arterial bypass graft, that demonstrated good flow on additional images (not shown). B. An ill-defined heterogeneous area (star, A) was noted at the origin of the graft (RT GRAFT) near the CFA. Color Doppler imaging showed blood entering a pseudoaneurysm (PSA) at the anastomosis of the graft (solid white arrow) and CFA. The long white arrow indicates the graft and two open white arrows indicate the PSA sac. C. The classic swirling pattern ("yin-yang") indicates turbulent flow as blood enters the PSA sac, coming towards the transducer (red) and then turning away from the transducer (blue) to exit into the graft. This image provides a sagittal cut through the neck of the PSA (white arrow) and an axial cut through the PSA sac. D. CT in the axial plane corroborated CDUS findings (white arrow).