

however, flow rate fell significantly following band application ( $p < 0.05$ ,  $p < 0.01$ ). Venous diameters increased on changing from the supine to erect posture ( $p < 0.01$ ). The application of above knee bands did not significantly alter venous diameters with respect to the erect posture. In view of this, we recommend that routine scanning of the calf veins be performed in both a supine and erect position as this will aid vein visualization without flow reduction.

#### 1400 Complications of Hemodialysis Access Fistulas: A Comparative Study of Duplex Ultrasound Versus Angiography

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This prospective study was performed to define the diagnostic value of duplex and color Doppler sonography in evaluating dysfunctions of hemodialysis vascular access, with respect to angiography as a gold standard. The study group consisted of 27 patients referred for suspected complication of hemodialysis vascular access. The different segments of 32 arteriovenous fistulas, included 13 synthetic grafts, were studied independently by two investigators using DSA an duplex ultrasound scanning. The two examinations were then reviewed jointly to determine the diagnostic accuracy of both methods according to the type and the site of vascular lesions. Duplex ultrasound scanning was superior to DSA in four cases of thrombosis, in one hematoma and in four out of six venous aneurysms. In 15 stenoses out of 19, it provided a good analysis of the stenosis at the level of the arteriovenous anastomosis and of the proximal segment of the fistula. At the present time, color Doppler sonography should be used as the first imaging examination in patients presenting with complication of hemodialysis access to select the regions of interest for DSA and to decrease the amount of contrast medium injected.

### Instrumentation Scientific Papers

#### 0508 Two Dimensional Array Ultrasound Transducers

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Two-dimensional array transducers have been developed for medical ultrasound applications. A  $4 \times 32 = 128$  element array operating at 2.8 MHz has been designed and fabricated for improved B-scan image quality enabling dynamic focusing as well as phase correction in both the azimuth and elevation dimensions. Element dimensions are  $0.4 \text{ mm} \times 3.4 \text{ mm}$  maintaining a width to thickness ratio = 0.6 and a length to thickness ratio = 5.6 to reduce parasitic lateral modes in the desired pass band. Element sensitivity is approximately that of conventional linear arrays with a -6 dB fractional bandwidth of 43%. In addition, several  $16 \times 16 = 256$  two-dimensional arrays have been developed for high speed volumetric phased array imaging at center frequencies of 1.0 MHz to 2.4 MHz. The arrays use 96 elements for transmit and 32 elements for receive and employ various geometries to reduce side lobes. In a recent example, a 2.4 MHz array was fabricated with element spacing = 0.5 mm, kerf width = 0.1 mm, using a light epoxy backing, a diced conductive epoxy matching layer and a silver foil as a front ground plane. Pulse-echo sensitivity of a single element is approximately 1 in 10 that of conventional linear arrays with a -6 dB bandwidth of 67%.

#### 0511 Experiment of Imaging Contrast of $J_0$ Bessel Nondiffracting Transducer

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$J_0$  Bessel nondiffracting beams were discovered by J. Durnin in 1987. These beams are pencil-like and have a large depth of field as compared to conventional focused beams. However, the  $J_0$  Bessel beam has high sidelobes. To study the trade-off between large depth of field and high sidelobes, we performed an experimental study of the effects of the sidelobes of the  $J_0$  Bessel beam on the imaging contrast of B-scan images using a commercial tissue-mimicking contrast-detail phantom. A broadband, 2.5-MHz, 50-mm diameters, ten-element composite annular array transducer was used for the study. The resulting images show that: (1) transmitting with the  $J_0$  Bessel beam and receiving with the Fresnel focused Gaussian shading (FFGS) focused at a distance  $z = 120 \text{ mm}$  produces a lower contrast but higher resolution than transmitting and receiving with the FFGS focused at the same distance and (2) transmitting with the  $J_0$  Bessel beam and receiving with FFGS focused at distance  $z = 216 \text{ mm}$  presents a similar contrast but much higher resolution than when transmitting and receiving with the FFGS focused at the same distance. These results imply that the  $J_0$  Bessel nondiffracting transmitting system, produces higher imaging resolution and good contrast at deeper depth than the conventional dynamically focused Gaussian transmitting system. Because the Bessel beam has deep depth of field, its use for transmitting can eliminate the need for multiple focused transmits, thus increasing the frame rate for the same resolution in abdominal imaging and may produce uniform high-resolution in heart imaging. This work was supported in part by NIH grant CA-43920.

#### 0512 Intracavitary Ultrasound Arrays to Treat Prostate Tumors

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In this study, 14 patients with stage C adenocarcinoma of the prostate were treated (with concurrent external beam radiation to 68 Gy in 34 fractions) using an array of half-cylindrical ultrasound transducers (frequency 1.5 to 1.6 MHz) inserted into the rectum. Each array element had individual power control. The whole array was surrounded by a constant (controllable) temperature water bolus that provided coupling between the applicator and the rectal wall. In addition, the water bolus temperature offered control over the rectal wall temperature. Prior to each treatment, three thermocouple probes each containing seven sensors were inserted into the prostate under diagnostic transrectal ultrasound guidance. The imaging also gave information of the size and location of the treatment volume that was then used when the therapy applicator was placed into the rectal cavity. The treatments were well tolerated (with minor sedation) with no complications except that minor bleeding occurred during the probe placement in two of the patients. This did not prevent the treatment delivery. In the best treatments of all of the patients, an average of 87% of the sensors in the target volume reached temperatures above  $42^\circ\text{C}$  some time during the treatment. When the time average temperatures over the 30 min treatment were analyzed the mean maximum and minimum temperatures were found to be  $43.2 \pm 0.6^\circ\text{C}$  and  $40.2 \pm 1.4^\circ\text{C}$ , respectively. On the average, about 55% of the sensors maintained temperatures above  $42^\circ\text{C}$  over the whole treatment period. This trial indicates that intracavitary ultrasound arrays have the ability to induce hyperthermia in prostate tumors. While we are continuing this phase I feasibility study we are also developing phased ultrasound arrays to increase penetration depth and to obtain better control over the temperatures in the treatment volume.

#### 0519 Axial Resolution Estimation with an Aluminum Wedge: A Proposed Quality Control Procedure



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