**Distal Arterial Flow in Patients Undergoing Upper Extremity Dialysis Shunting: A Prospective Study Using Doppler Sonography**

**OBJECTIVE.** The objective of this study was to document changes in the distal circulation after creation of a proximal upper extremity dialysis shunt and to correlate these findings with the patient’s clinical condition.

**SUBJECTS AND METHODS.** We prospectively examined 18 patients scheduled for upper extremity shunt creation. We used color and spectral Doppler sonography to examine flow in the radial and ulnar arteries, noting flow direction and peak systolic velocity. After the shunt procedure, we repeated the measurements and correlated them statistically with hand symptomatology.

**RESULTS.** Six (33%) of 18 patients were symptomatic. The mean peak systolic velocities in the radial and ulnar arteries were 52 and 61 cm/sec, respectively, before surgery, and decreased to 12 cm/sec after surgery in the radial artery and 44 cm/sec in the ulnar artery. The mean percentage of decrease in peak systolic velocity was 77% in the radial artery and 28% in the ulnar artery. Eight patients showed reversed flow. No statistical correlation was found between change in peak systolic velocity values before and after surgery and the presence of hand symptoms. Similarly, no correlation was found between flow reversal and symptoms. The most consistent factor associated with symptoms was diabetes; all symptomatic patients were diabetic, but only 54% of the diabetic patients were symptomatic.

**CONCLUSION.** The difference in the peak systolic velocities in the radial and ulnar arteries after shunt construction does not correlate with symptoms. The hand can tolerate a significant decrease in the peak systolic velocity and even flow reversal without symptomatology.

**Hemodialysis Shunt Placement**

and pain and sensorimotor disability after the creation of a vascular access for hemodialysis may be caused by vascular insufficiency; venous hypertension; diabetic, uremic, or ischemic neuropathy; carpal tunnel syndrome; secondary hyperthyroidism; and embolic complications [1, 2]. The differential diagnosis may be challenging. Doppler sonography is a noninvasive method for hemodynamic studies. We were interested in determining whether sonography could permit a confident diagnosis in these patients.

**Subjects and Methods**

Eighteen patients who were scheduled for upper extremity hemodialysis shunt surgery underwent baseline real-time gray-scale Doppler, color Doppler, and spectral Doppler sonography 1 month before surgery. All patients were reexamined 3–4 weeks after surgery. Half the patients were examined once again 6 months after the surgery, and the results of the two examinations were averaged.

Examinations were performed using a 7-MHz linear transducer (128XP; Acuson, Mountain View, CA) and a 5-MHz linear transducer (VST Master Series; Diasonics, Santa Clara, CA). Examinations were performed with the patient sitting and the hands on a pillow in supination. In addition, blood pressure measurements were recorded before each sonographic examination.

We examined 10 men and eight women who were 24–69 years old. The mean and median ages were both 58 years.

In addition to chronic renal failure, the patients also suffered from hypertension ($n = 16$), diabetes mellitus ($n = 11$), polycystic kidney ($n = 1$), and nephrolithiasis ($n = 1$). All hypertensive patients were treated with α- or β-blockers.

Only patients with proximal arteriovenous fistulas were included in the study. Sixteen patients underwent shunt placement in the left arm; two patients underwent placement of a right-sided shunt. The types of shunts placed are listed in Table 1.
Duplex Doppler studies were performed in the longitudinal orientation with an insonation angle always smaller than 60°. The angle was kept relatively constant for each vessel throughout the study. From each tracing, the peak systolic velocity, Doppler waveform, and direction of the flow were recorded. The radial and ulnar arteries of both hands were studied. The contralateral arm served as control, and the peak systolic velocity obtained in the arm with the shunt was normalized according to the values obtained in the control side.

Statistical analysis included bivariate correlation (Kendall’s tau). Values of p equal to or less than 0.05 were considered statistically significant.

### Results

Six (33%) of 18 patients had hand symptoms: pain, coldness, numbness, color change, or hand weakness (Table 2). All complaints started within 6 weeks of surgery, continued during the 6 months of follow-up, and were treated conservatively. One patient, who had presented with weakness of the hand, complained of severe hand pain immediately after surgery; because of this, his shunt was closed surgically.

The mean peak systolic velocities in the radial and ulnar arteries were 52 cm/sec and 61 cm/sec, respectively, before the shunt construction. After surgery, the mean velocity decreased to 12 cm/sec in the radial artery and 44 cm/sec in the ulnar artery (normalized values) (Figs. 1 and 2). The mean percentage of decrease was 77% in the radial artery and 28% in the ulnar artery (Fig. 3).

The greater decrease in the peak systolic velocity in the radial artery is influenced by the higher prevalence of reversed flow in this artery. If we exclude the cases of reversed flow, the mean velocities in the radial and ulnar arteries after shunt construction were 47 cm/sec and 43 cm/sec, respectively (normalized values). Two symptomatic patients had a peak systolic velocity of less than 22 cm/sec in both the radial and ulnar arteries; in one of these patients ulnar artery flow was 7 cm/sec and radial artery flow was –23 cm/sec (reversed flow), and this patient required surgical closure of the shunt because of hand weakness.

We did not find a statistical correlation between either the absolute peak systolic velocity after the surgery or the magnitude of the decrease in peak systolic velocity after surgery and the occurrence of hand symptoms. We also calculated the numeric average of the peak velocity of the radial and ulnar arteries in each examination and found no correlation between this average and the development of hand symptoms.

In eight patients (44%) we observed reversed flow, in six during the entire cardiac phase and in two only during diastole (Figs. 4–6). In six patients the reversed flow was seen through the radial artery and in two through the ulnar artery. Only one symptomatic patient had reversed flow. This patient had hand weakness, and his shunt was surgically closed. The occurrence of reversed flow in our study did not correlate statistically with peripheral hand symptoms. We observed changes in the spectral Doppler waveform, including increased length of systolic phase and continuous high diastolic flow in nine patients (eight with reversed flow as already noted). No correlation was seen between changes in the waveform of the spectral Doppler signal and hand symptomatology.

All six patients with hand symptoms were diabetic, but just 54% of the diabetic patients were symptomatic. Of the eight patients with reversed flow, three were diabetic.
Fig. 3.—Graph shows percentage of change that occurs in peak systolic velocity in ulnar (dotted line) and radial (dashed line) arteries after shunt construction. Note that most values are less than zero, indicating a decrease in velocity.

Fig. 4.—Development of reversed flow in 48-year-old asymptomatic man with diabetes mellitus and hypertension who was taking α-blockers.
A, Doppler sonogram of left radial artery obtained before shunt creation shows flow in distal direction.
B, Doppler sonogram obtained after shunt creation shows reversed flow through radial artery. Note that waveform is above baseline because it was inverted technically. Note also high systolic flow and continuous diastolic flow.

Fig. 5.—Doppler sonogram of left radial artery obtained after shunt creation in 57-year-old asymptomatic woman with hypertension who was undergoing α-blocker treatment shows antegrade flow during systole and reversed flow during diastole.
Blood pressure measurements did not change significantly after shunt placement. The average change was 2.5 mm Hg systolic (median, 2.2 ± 5.0 mm Hg) and 0 mm Hg diastolic (median, –1.3 ± 5.5 mm Hg).

**Discussion**

Pain and sensorimotor complaints in the extremities are not uncommon after dialysis shunt construction, and may be due to arterial insufficiency, neuropathy (ischemic, diabetic, or uremic), carpal tunnel syndrome, secondary hyperparathyroidism, or embolism [1, 2]. We wanted to determine whether the vascular complications might be predicted using Doppler sonography in the pre- and postoperative periods.

Construction of hemodialysis fistulas diminishes the peripheral blood flow. This iatrogenic decrease in the peripheral blood supply may be superimposed on preexisting vascular disease, which is common in diabetic and hypertensive patients and which may impair tissue perfusion. Haimov et al. [3] and Zerbino et al. [4] reported 1.6% and 2.5% incidence, respectively, of symptomatic vascular insufficiency after shunt creation.

The occurrence of reversed flow is a well-known phenomenon. Duncan et al. [5] found 88% of reversed flow in their study on patients with radiocephalic fistulas and concluded that this phenomenon is not important as a cause of vascular insufficiency. In a series of 14 patients, Valji et al. [1] found six cases of reversed flow. They found that digital ischemia was caused by underlying obstructive arterial disease alone or in combination with a steal phenomenon.

In our study, the timing of the appearance of symptoms indicates that vascular disturbance is the most probable cause of hand symptoms among the possible diseases that occur in these patients. However, neither baseline peak systolic velocity nor postoperative reduction in peak systolic velocity could be statistically correlated with symptoms, and thus were not of predictive value. This indicates the great tolerance of the hand for changes in perfusion.

Reversed flow was a frequent phenomenon (44%) and was not statistically correlated with peripheral symptoms.

All symptomatic patients were diabetic. No statistically significant correlation exists between diabetes and hand symptoms; however, the conditional probability of a diabetic patient to suffer from short-term hand complications of a hemodialysis shunt is much greater than for a nondiabetic patient. This finding is in accordance with the results published by Schanzer et al. [6]. This greater risk may be explained by preexisting peripheral vascular disease or by superimposed diabetic neuropathy.

Our study included only two patients with a postoperative peak systolic velocity of less than 22 cm/sec in both the radial and ulnar arteries, and both patients were symptomatic. One of them also exhibited hand weakness and reversed flow and required surgical closure of his shunt. We suggest that 22 cm/sec might be a limit below which ischemic symptoms are likely to occur. A study of a larger population would be necessary to test this hypothesis.

**References**