Segmental Acute Tubular Necrosis in Kidneys with Multiple Renal Arteries Transplanted from Living Related Donors

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Ten patients received kidneys from living, related donors, the transplants having multiple renal arteries; a retrospective analysis of the postoperative Hippuran renograms is presented. All seven kidneys that had the large artery reopened before anastomosis of the smaller, developed scintigram findings suggestive of acute tubular necrosis (ATN) in the region with the more prolonged ischemia. Three similar kidneys with simultaneous recanalization of both renal arteries had normal Hippuran scintiphotos. Electron photomicrographs from upper- and lower-pole biopsies—in one case undergoing sequential revascularization—confirm the development of ischemic changes consistent with ATN in the half of the kidney developing scan findings of ATN.

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The occurrence of acute tubular necrosis (ATN) after renal transplantation, and its clinical significance regarding the survival of the transplanted kidney and of the transplant recipient, have been well documented (*1–3*). Dynamic renal scans with [^{131}I] ortho hippuran have been valuable in suggesting the cause of acute renal failure after transplantation; this has been done by differentiating ATN from other causes of acute failure and indicating the patient's prognosis (*4–6*). The method is especially helpful when sequential renograms are followed (*7,8*). This paper reports the previously undescribed finding of ATN involving only a portion of the transplant in the setting of a kidney donated by living relatives but having multiple renal arteries.

All renograms on patients receiving kidneys from living related donors between January 1973 and December 1976 were reviewed retrospectively, and surgical reports were examined to determine the number of renal arteries in the donor kidneys. All patients receiving kidneys with two or more arteries were included in the study. No operations involving living donors with multiple arteries were performed before January 1973.

MATERIALS AND METHODS

Renograms were performed 24 hr after transplantation using a scintillation camera with a 1000-hole medium-energy collimator, and the energy set at 360 keV with a 20% window. The transplanted kidney was located using approximately 500 μCi of Tc-99m gluconate or DTPA intravenously, with the kidney and bladder regions included in the field of view. Approximately 100 μCi of [^{131}I] Hippuran were then administered intravenously and six sequential images were obtained over 4-minute intervals, with a final image obtained either postvoid or, in those patients with a bladder catheter, after drainage of the urine container. Renogram counting rates were obtained by computer analysis of counts obtained over 30-sec intervals from areas of interest drawn around the kidney and bladder regions.

Surgical technique. Two methods of anastomosis of the double renal arteries were used in this series. If both renal arteries were of approximately equal size, vascular clamps were used to occlude the iliac artery, and anastomosis of both renal arteries and veins was accomplished before releasing the clamps to revascularize the kidney. If one renal artery was very small compared to the other, and difficulty was

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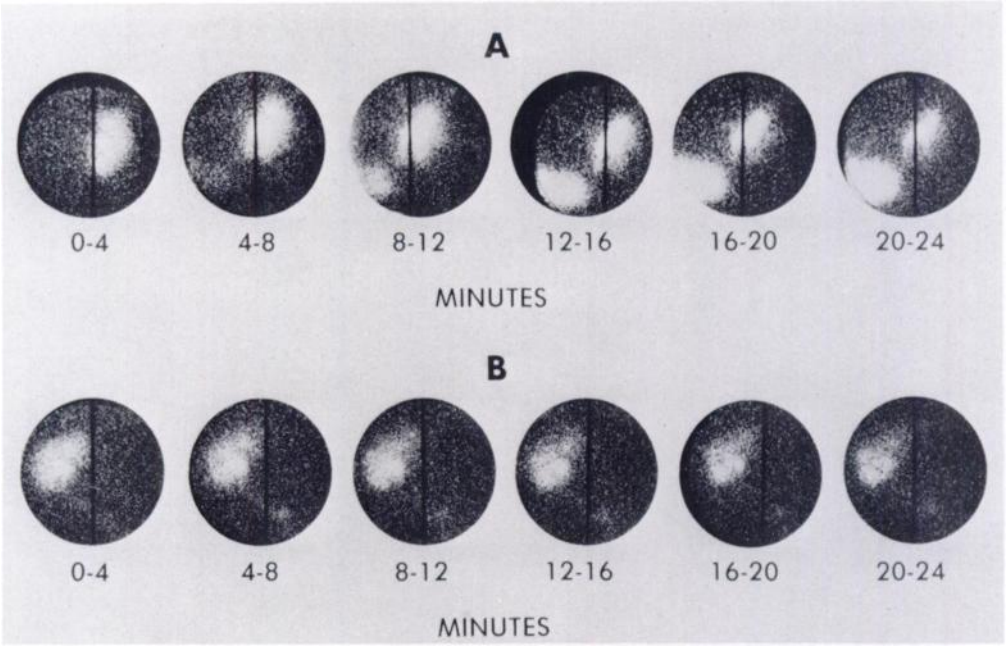

FIG. 1. (A) Scintigrams of kidney transplanted from living, related donor, two renal arteries being unclamped at same time. There is excellent uptake and excretion of tracer throughout transplant. (B) Scintigrams following sequential anastomosis of two renal arteries in transplant from living, related donor; this causes increased ischemia time in lower pole. There is prompt uptake throughout transplant; upper pole then excretes well, but there is cortical retention in lower pole, suggesting segmental ATN.

anticipated with its surgical anastomosis, iliac vascular clamps were placed and then only the larger artery and vein were anastomosed before revascularization by removal of the clamps. The iliac artery was then reoccluded below the principal renal-artery anastomosis and the smaller artery, and sometimes the accompanying vein, were then anastomosed and the clamp removed.

Pathology. A single patient who underwent sequential reopening of the two renal arteries during transplantation had needle biopsies of both renal poles before the conclusion of surgery. At the time of the biopsy the lower pole had been without arterial supply for 45 min. The upper pole was for 20 min without arterial supply before anastomosis, which occurred 25 min before the biopsy. Electron microphotographs ($\times$ 4000) of these specimens were obtained, but there was insufficient tissue for light microscopy.

RESULTS

Over the 3-year period, 47 patients had transplants from living, related donors. Of these, ten donor kidneys had two renal arteries. Three of these ten had an anastomosis involving the reopening of both arteries at the same time. In these three cases there was excellent renal function, as demonstrated by Hippuran renogram without evidence of ATN. The sequential images from one of these patients are shown in Figure 1A. Seven of the ten patients had one renal artery that was significantly smaller than the other, the smaller artery supplying the lower pole. Here the smaller artery was anastomosed and reopened only after the reopening of the major artery. These kidneys all initially demonstrated excellent cortical uptake throughout, with subsequent excellent excretion by the upper pole, supplied by the renal artery reopened first. The lower poles of these kidneys, on the other hand, all demonstrated the late

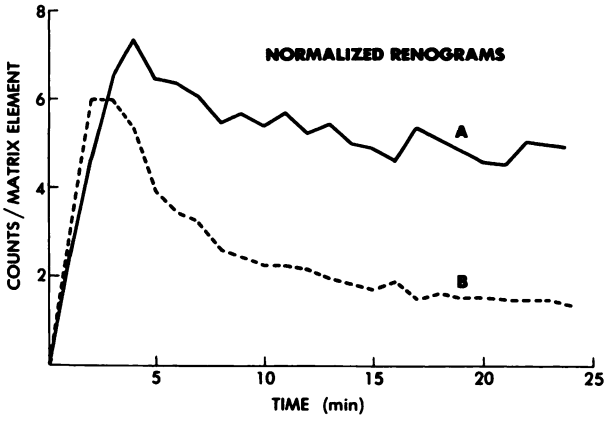

FIG. 2. Area-of-interest renograms from kidney transplanted 24 hr earlier from living related donor, the two renal arteries being anastomosed and reopened consecutively. Solid line is from lower pole (A, late reopening), whereas dashed line represents upper pole (B, early reopening). Uptakes are comparable initially, but delayed excretion from lower pole (A) is consistent with segmental ATN.

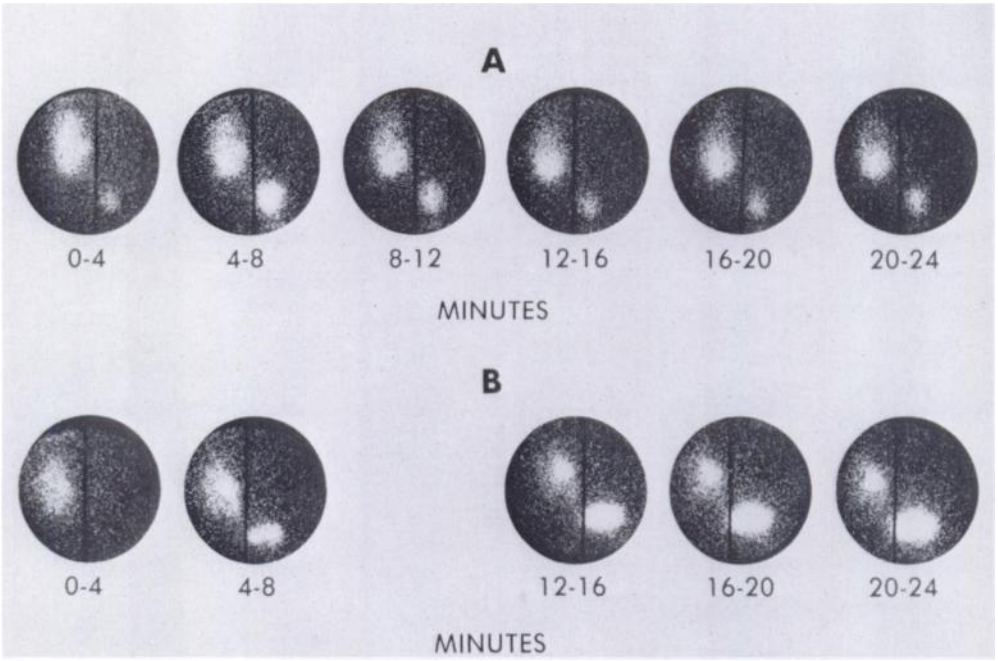

FIG. 3. (A) Scintigrams of kidney with two renal arteries, transplanted from living, related donor; arteries anastomosed sequentially, causing more prolonged lower-pole ischemia. Initially uptake is good throughout, but segmental ATN is suggested by prolonged retention of tracer in lower pole. (B) Same patient as in (A), 2 wk later. Rejection has set in; uptake is present in both poles but is weaker than before. Excretion, however, is also comparable throughout, suggesting resolution of earlier ATN in lower pole.

cortical retention of the tracer characteristic of ATN (*8*). Figure 1B presents a typical example of this situation. A study on a different patient in this group was analyzed by computer, with separate areas of interest drawn over the cortex of the upper and lower poles of the kidney, carefully excluding renal pelvic activity. The junction between the two regions was determined by identifying the area of late cortical retention on late images and overlaying it on the entire early outline of the kidney. The separate renogram curves—with counts corrected for the number of picture elements included in the irregular regions of interest—are shown in Fig. 2; the corresponding images are shown in Fig. 3A. The segmental renograms demonstrated excellent, and approximately equal, uptake (per sq cm) for the two poles of the transplanted kidney. The prolonged retention of activity in the lower pole, as compared with the normal excretion in the upper pole, suggests the presence of ATN. Followup scintigrams made on this patient 2 wk later (Fig. 3B) and similarly analyzed (Fig. 4) showed resolution of the former prolonged cortical retention of tracer in the lower pole, thus suggesting resolving segmental ATN. Owing to superimposed rejection, both poles show decreased initial uptake when compared with the earlier examination.

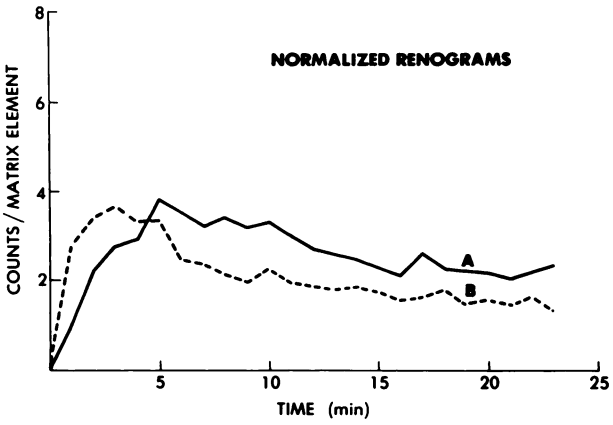

FIG. 4. Same patient as in Fig. 2, 2 wk later. A and B represent lower and upper poles respectively. Decreased initial uptake in both regions of kidney are due to interval rejection episode. Retention of tracer in lower pole, seen earlier, is now less marked, which would be consistent with resolving acute tubular necrosis in that segment.

Electron photomicrographs of the single kidney biopsied at surgery demonstrate an essentially normal upper pole (Fig. 5A). The lower-pole biopsy (Fig. 5B) had marked abnormalities consistent with severe ischemia, including partial collapse of capillary walls, gross swelling and vascularization of endothelial cells, inspissation of the plasma filling the capillary lumen, as well as cytoplasmic vascularization and mitochondrial swelling in tubular cells, which was not present in the upper pole. On the basis of these findings, the pathologist predicted that the lower pole of this kidney would develop ATN.

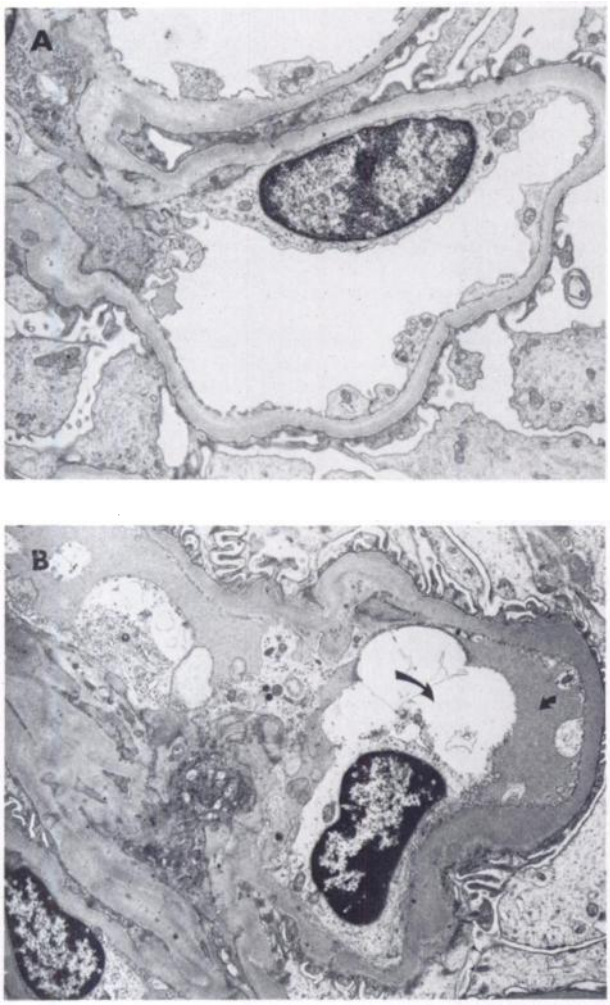

FIG. 5. (A) Electron photo micrograph (X4000 before photographic reduction) of biopsy of *upper* pole of transplanted kidney with two renal arteries, the upper-pole artery being reopened first. Detail of capillary shows normal endothelial cell and patent capillary lumen. (B) Same patient as in (A), electron photo micrograph (X4000) of capillary from *lower*-pole biopsy demonstrates swelling and vascularization of endothelial cell (large arrow), with inspissation of plasma in lumen of collapsed capillary (small arrow). This findings are felt to be consistent with severe ischemia.

DISCUSSION

Transplantation of kidneys with multiple arteries has posed no problem when the donor has been a cadaver. In this situation, a cuff of aorta (a Carrel patch) encompassing the multiple vessels can easily be used for the anastomosis. With a living, related donor, on the other hand, deprivation of the cuff of aorta would produce an unacceptable hazard. In the past, the tendency has been not to accept potential living, related donors with bilateral multiple renal arteries. Current practice however, is to use a well-matched living, related donor with bilateral multiple arteries whenever possible, performing separate anastomoses of the multiple renal vessels.

The surgical procedure has involved either anastomosis of all of the multiple vessels before release of occluding vascular clamps, or anastomosis of the major renal artery and renal vein followed by prompt revascularization of the portion of the transplant supplied by this artery. The smaller accessory vessels can then be anastomosed with less hurry. Compared with simultaneous revascularization, this prevents a prolonged ischemia time for the entire kidney, but does create a significant difference in ischemia time between the major portion of the kidney and the second portion revascularized later. The advantage of the two-staged anastomosis is that the small accessory artery can be meticulously anastomosed—particularly important when dealing with children or atherosclerotic iliac vessels. The two-staged arterial anastomosis therefore minimizes ischemia time to the major portion of the kidney in potentially time-consuming technical situations.

In this series, this two-step procedure always resulted in findings consistent with segmental lower-pole ATN, although with good upper-pole function without ATN; ATN was absent in those cases in which the sizes of the two renal arteries allowed rapid simultaneous revascularization.

Clinically, the segmental ATN had no apparent effect on a patient's postoperative course, compared with those without ATN. However, the recognition of this finding in this setting will help rule out other pathologic processes, such as extravasation from ureteral necrosis. Furthermore, the electron-microscope analysis of the biopsies of these separate areas with different ischemia times may give some insight into the pathogenesis of early ATN in man.

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