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Stanley G. Dienst

Mohammed R. Ansari

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Use of a Cooling Jacket During Kidney Transplantation*

Stanley G. Dienst, M.D. and Mohammed R. Ansari, M.D.****

The model of renal autotransplantation, with immediate contralateral nephrectomy in the dog, is used to demonstrate that continuous cooling by means of a cooling jacket during vascular anastomoses is effective in preserving renal function acutely and over a two-month follow-up period.

It has been demonstrated in animal studies by Oliver et al[1] and by Friedman[2] that periods of warm ischemia will produce a definite pattern of histologic change and transient functional loss in the kidney. It has also been shown by Bogardus and Schlosser[3] that lowering the renal temperature during ischemic intervals minimizes these changes.

In clinical transplantation, the kidney is surface cooled by immersion in ice-saline slush and simultaneously perfused with cold electrolyte solution. Using this procedure, the core temperature of the kidney may be lowered to less than 2° C in five minutes. When using surface cooling without perfusion, the rate of cooling is rapid down to 10° C and then becomes appreciably slower. The rate of cooling may be measured by placing a telethermometer probe in the medulla of the kidney (Fig 1). The rate of rewarming during the vessel anastomosis is approximately 1° C per minute. The anastomoses are generally completed in 20-25 minutes in the dog and 25-45 minutes in the human kidney transplant.

After observing the wide variation in the immediate functional capacity of transplanted kidneys, we initiated an investigation of this interval of warming. This study was undertaken to evaluate the functional and morphological changes which occur in the autotransplanted canine kidney as the result of 45 minutes of warming during revascularization.

Methods

A double-walled silastic kidney cooling jacket was devised through which ice cold saline is circulated to maintain the temperature of the enclosed kidney at 0° C during the vascular anastomosis. To demonstrate acute differences, the canine kidney autotransplanted with the jacket was compared to a kidney subjected to 45 minutes of warming. For this, the dog was systemically heparinized and both kidneys resected. The kidneys were initially surface-cooled to 0° C by immersion in ice-saline slush. One kidney was transplanted using a kidney cooling jacket, but no cooling jacket

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**Division of Vascular Surgery, Department of Surgery

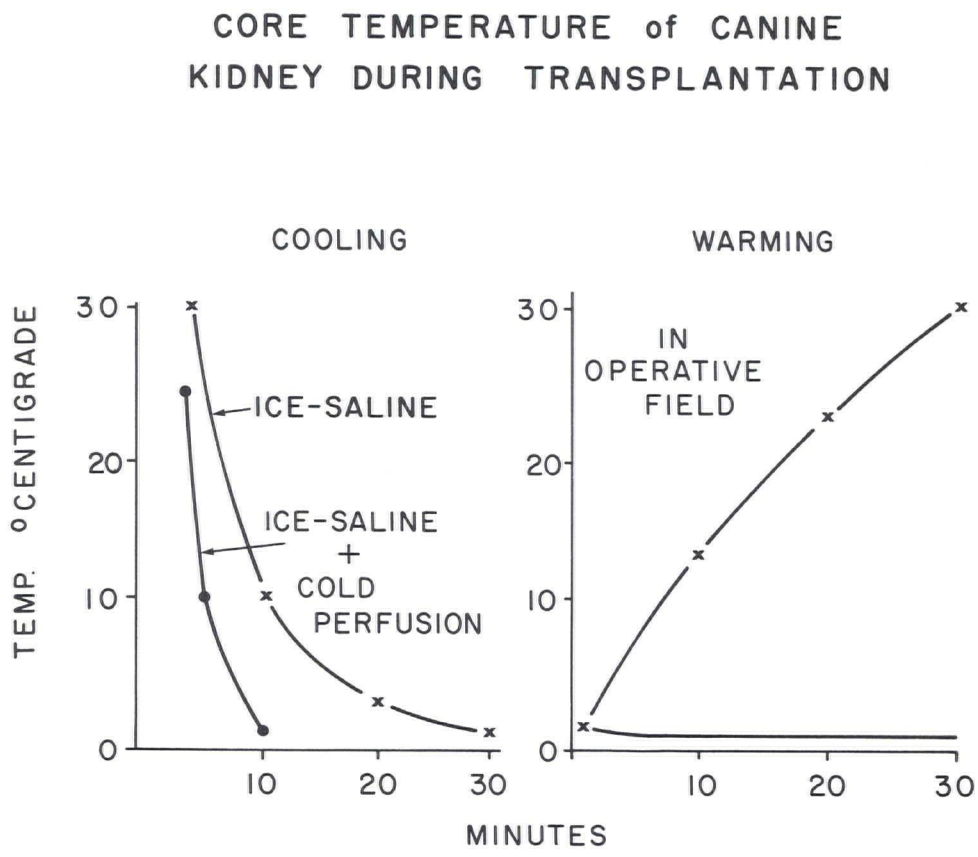


Figure 1

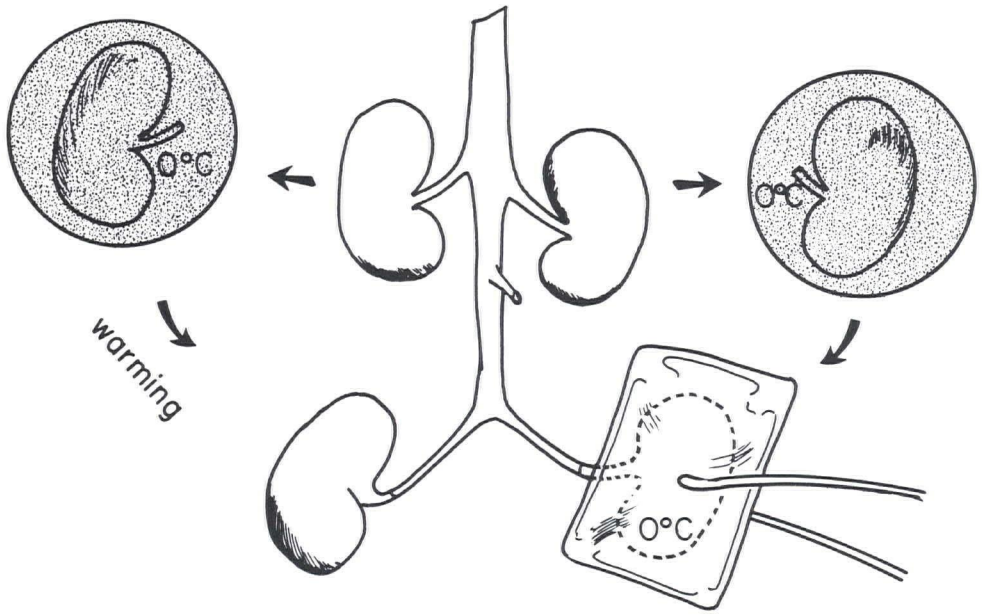
These curves show the rate of cooling and rewarming of the canine kidney during various procedures of transplantation. From the left: surface cooling by immersion in ice-saline, surface cooling and perfusion with cold electrolyte solution, rewarming in the operative field, and near zero temperature maintained by a kidney cooling jacket.

was used for the other (Fig 2). The anastomosis time was kept at 45 minutes for each kidney.

To evaluate persistance difference in these kidneys, the following protocol was devised: Sixteen dogs underwent autotransplant and simultaneous contralateral nephrectomy, eight using the cooling jacket and eight without. All animals were followed for two months or until death, at which time the kidneys were resected and subjected to histological examination. Serum creatinines and endogenous creatinine clearances were measured at two, four, and eight weeks. Three animals were excluded from each group because of surgical technical failures or infections.

Results

In the acute study, the kidney transplanted without the cooling jacket was very firm in consistency, glistening and edematous in appearance with a definite bluish cyanotic discoloration. The kidney transplanted with the jacket was



Acute Effect of Warm Ischemia on Canine Kidney Autotransplant

Figure 2

Diagrammatic presentation of a protocol to show the acute effect of rewarming on the gross appearance and function of canine autotransplanted kidneys.

pink and relatively soft. Urine production did not start for three to four minutes in the nonjacketed kidney and was very slow thereafter in spite of pretreatment with Mannitol. Even after the kidney was secreting, the volume was only one-third that of the kidney protected with the jacket. The immediate endogenous creatinine clearance for the nonjacket kidney was 0.2 ml/min/Kg compared to 1.2 for the jacketed kidney.

In the dogs followed until they succumbed from renal failure or for two months, the renal function was evaluated by serum creatinine levels (Fig 3) and endogenous creatinine clearances (Fig 4). One dog in the nonjacket group survived the two-month period and never had a serum creatinine over 2.0 mg%. The remainder developed oliguria over the first 10 days, with rising serum creatinine levels, and died of uremia. Over the two months, the creatinine clearances reached 1.0 ml/min/Kg in the single surviving nonjacket dog and over 1.2 in the five cooling jacket animals. Two of the latter achieved a normal clearance for a single kidney of 2.0 ml/min/Kg.

Histologic studies of the kidneys from the noncooling jacket group showed there was considerable linear

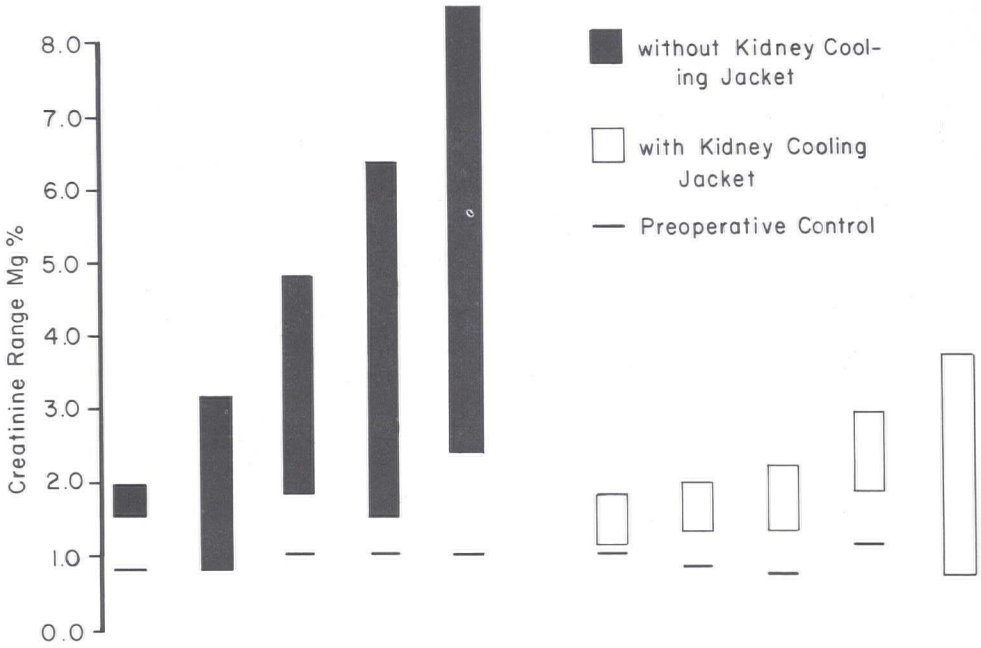


Figure 3
The postoperative range of serum creatinine of each dog following autotransplant.

focal scarring, mainly in the cortical area, and a crowded appearance of glomeruli, indicating tubular atrophy or degeneration. The scarred areas contained large numbers of lymphocytes and plasma cells. There was some early periglomerular fibrosis and the tubules contained granular deposits and some casts (Fig 5A and 5B). In each case, sections from the jacketed kidneys (Fig 6) showed normal glomeruli and tubules.

Discussion

The period of rewarming during the vascular anastomosis has generally been accepted as a necessity, if not a desirable occurrence. Most clinicians would agree, however, that brief intervals are certainly less damaging than the 45 minutes selected in this study. Collins[4] has indicated that surface-cooled heparinized canine kidneys, with 20 minutes or less of rewarming, have virtually normal function after four to five days as measured by serum creatinine levels. Major differences in survival only become striking after 30 minutes. This may be related to the temperature achieved. After 20 minutes of rewarming, the kidney's temperature is approximately 20° C. Its metabolic rate and requirements are less than a third of those at 37° C. Each succeeding minute exposes it to the rapidly increasing catabolic effects of hypoxia. The point at which irreversible damage evidenced by morphologic changes will occur has generally been considered somewhat longer than the warm ischemia period of this study. However, most prior studies have con-

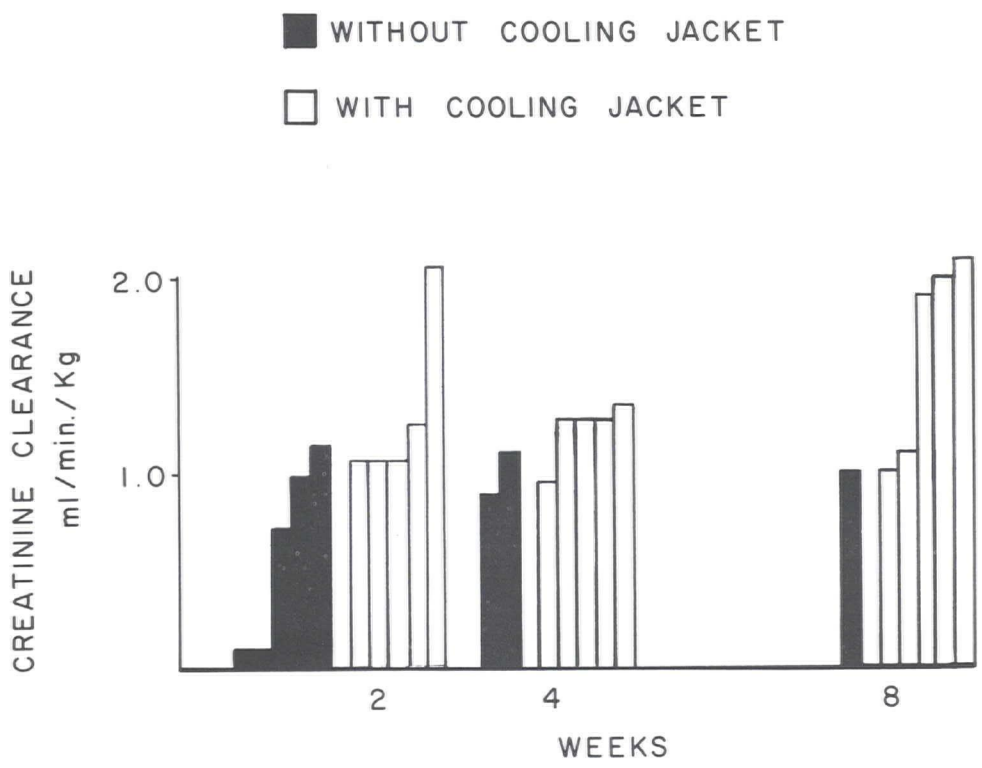


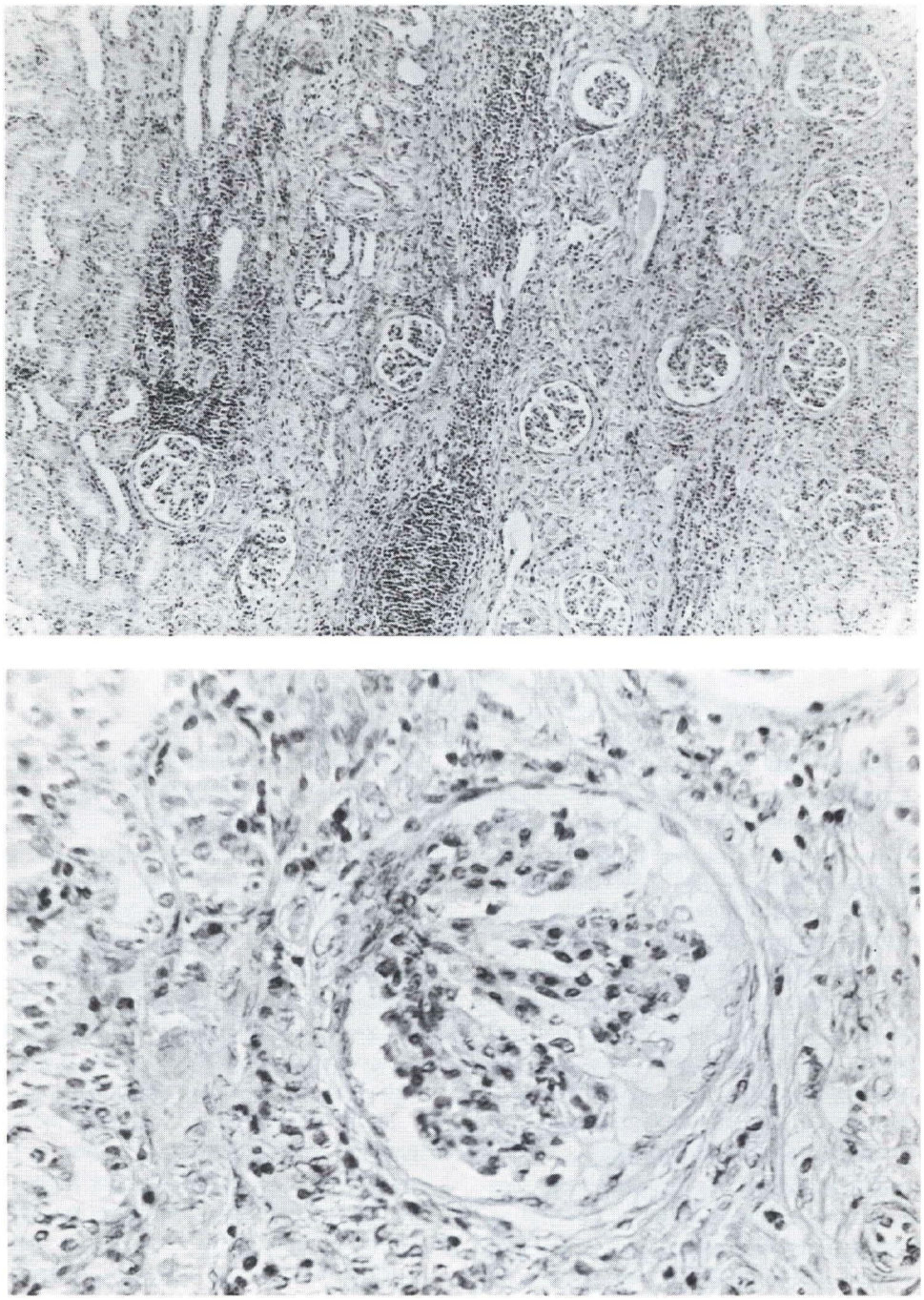
Figure 4
Creatinine clearance for each dog in the study over the two-month period of the study.

sidered partial perfusion states, such as clinical shock or clamping of the renal artery of the undissected canine kidney. Studies using electron microscopy of the totally devascularized kidney could better define the interval at which actual disorganization of the intercellular organelles and disruption of tubular basement membrane will occur in transplanted kidneys.

The cooling jacket has evolved from a simple double-walled circulating cooling envelope, which was wrapped around the dog kidney as a sling to improve results in the experimental laboratory, to a molded silastic jacket which has now been used in human transplantation over the last year.* The additional inch or two of space required in the recipient wound to accommodate the jacket is readily provided with a longer incision. This effort is well compensated by the prompt diuresis and a relatively soft kidney when the clamps are released.

It is also our clinical impression that the jacketed kidney is less antigenic to the recipient. Preliminary studies indicate that transplanting with the jacket markedly reduces the production of humoral antibody (lymphocytotoxic) in the dog exposed for three

*Extracorporeal



Figures 5A and 5B

Photomicrographs showing an autotransplanted canine kidney subjected to 45 minutes of rewarming during vascular anastomosis. (Figure 5A, x 70; Figure 5B, x 300)

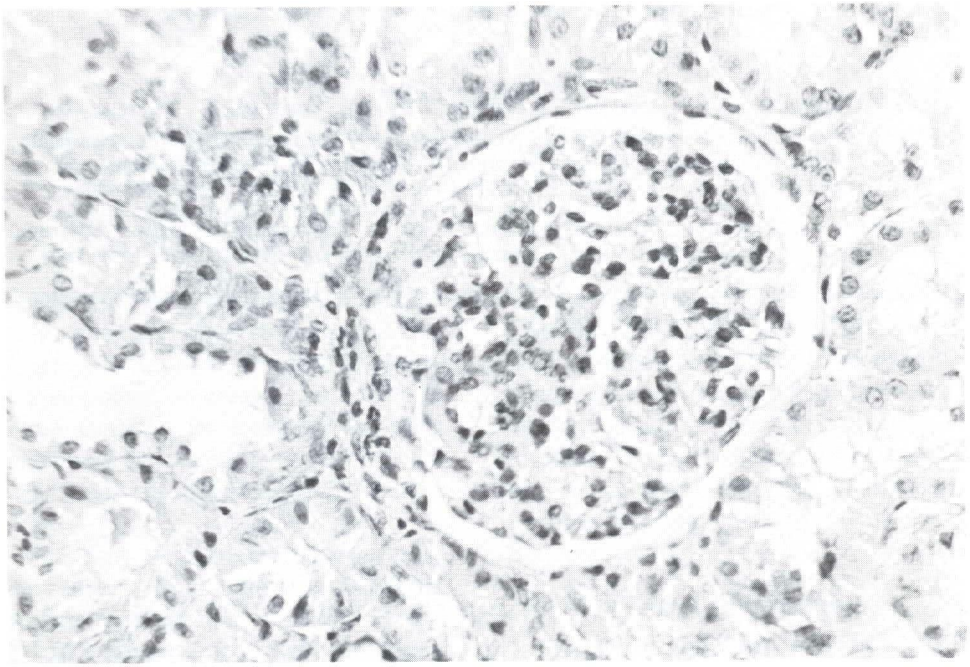


Figure 6

Photomicrograph showing an autotransplanted canine kidney for which a cooling jacket was used during the vascular anastomosis. (x 300)

days to an allograft kidney. An extension of this work is in progress.

Addendum

Since the article was submitted, the series of canine transplants has been extended to 20. In 10 of them, the cooling jacket has been used, and in 10, it was not. Differences in preservation of function between the two groups was not altered. The final mortality from uremia was five out of ten in the non-cooling jacket group and no deaths over three months in the cooling jacket group.

REFERENCES

1. Oliver, J.; MacDowell, M., and Tracy, A.: The pathogenesis of acute renal failure associated with traumatic and toxic injury: Renal ischemia, nephrotoxic damage and the ischemuric episode, *J Clin Invest* 30:1305-1440, Dec (pt 1) 1951.

2. Friedman, S. M.; Johnson, R. L., and Friedman, C. L.: The pattern of recovery of renal function following renal artery occlusion in the dog, *Circ Res* 2:231-5, May 1954.

3. Bogardus, G. M., and Schlosser, R. J.: The influence of temperature upon ischemic renal damage, *Surgery* 39:970-4, Jun 1956.

4. Collins, G. M.: Unpublished work.