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SHORT COMMUNICATION

# The Elimination of Warm Ischemic Time in Kidney Transplantation Using the Ice Bag Technique: A Feasibility Study

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Warm ischemic time is an established risk factor for delayed graft function (DGF) after kidney transplantation. DGF is a negative prognostic indicator for long-term allograft survival. We propose a technique that eliminates warm ischemic time during the arterial and venous anastomoses. This is a retrospective review of the first 20 cases performed between January and May 2010 at Albert Einstein Medical Center, Philadelphia, Pennsylvania, a nonuniversity tertiary care center. Approximately one-half of the patients who underwent kidney transplantation were selected for this method of implantation while the feasibility of this technique was evaluated. Fifteen patients were male. DGF was seen in 6 of 20 patients (30%). There were no graft losses. Operative time was not lengthened. There were no complications related to the use of this technique. Renal parenchyma frostbite was never encountered. We propose a technique that eliminates warm ischemic time. This may lead to less DGF. In the case of a difficult anastomosis or if an anastomosis needs to be performed again, damage to the kidney is minimized. Right and left donor kidneys and kidneys with multiple vessels can safely be transplanted with this technique. It also allows for improved resident and fellow teaching.



## 1. Introduction

Warm ischemic time, the time necessary to perform the vascular anastomosis during kidney transplantation, may be associated with delayed graft function (DGF) or even nonfunction. DGF is a well-established negative prognostic indicator for long-term allograft survival. Attempts to minimize warm ischemic time include wrapping the kidney in an ice-soaked laparotomy pad. Some surgeons eschew this technique, preferring to sew as quickly as possible (Figure 1). This may lead to technical errors, excessive bleeding, worse long-term outcomes, and a poor learning experience for the resident staff. Other techniques, such as a raytech sponge (Figure 2), stockinet,[1] a cooling jacket,[2] and a clear sterilized bag,[3] have not been addressed in the literature since the turn of the century. We sought to review our preliminary experience with the "ice bag technique." We wished to determine its feasibility and lay the groundwork for future studies evaluating its possible effect on DGF and allograft survival.

## 2. Materials and Methods

An institutional review board approved retrospective chart review of 20 kidney transplant patients from January 29 to May 5, 2010 was conducted to evaluate the "ice bag technique" in a community teaching hospital. Parameters recorded included recipient demographics, primary diagnosis of kidney disease, donor demographics, and presence of DGF. Patients were followed until discharge from hospital. Results were complied into a series of Excel databases to be reviewed at the end of the specified time period. A right or left lower quadrant Gibson incision was used to gain access into the retroperitoneum. A Bookwalter was used for retraction. The external iliac artery and vein were freed from their adventitial attachments in the usual fashion. On the back table, the kidneys were prepared for implantation with standard techniques. The craniad side of both the artery and vein were marked to maintain orientation. At this point, the transport bag in which the kidney was shipped was filled with a small amount of ice and preservation fluid. The kidney was introduced into the bag. A small hole was made near the hilum and the renal artery and vein were passed through the hole. A Kelly clamp was used to maintain the fluid and ice in place and as a handle (Figure 3). The kidney was introduced into the field. A penetrating towel clamp affixed the kidney to one side of the wound while the anastomoses were performed

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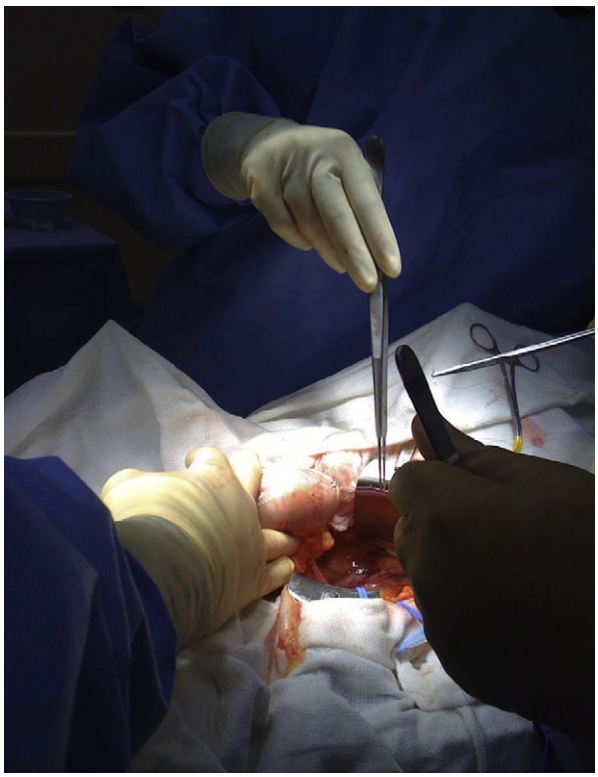

**Figure 1** Traditional method of holding donor kidney: one of the assistants is holding the kidney while the surgeon is performing the arterial and venous anastomoses. This technique tends to prolong the warm ischemic time.

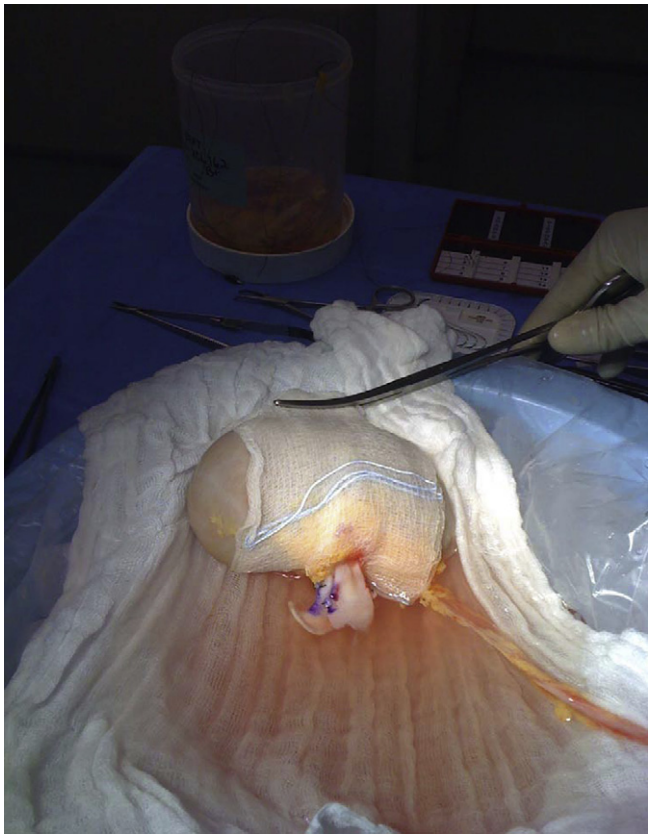

**Figure 2** Raytech sponge technique: A Raytech sponge is soaked in ice-cold preservative solution, and wrapped around the kidney and held with a clamp.

**Figure 3** Ice bag technique: The kidney is introduced into the bag with ice and a small hole was made near the hilum through which the renal artery and vein were passed. A Kelly clamp was used to maintain the fluid and ice in place and as a handle.

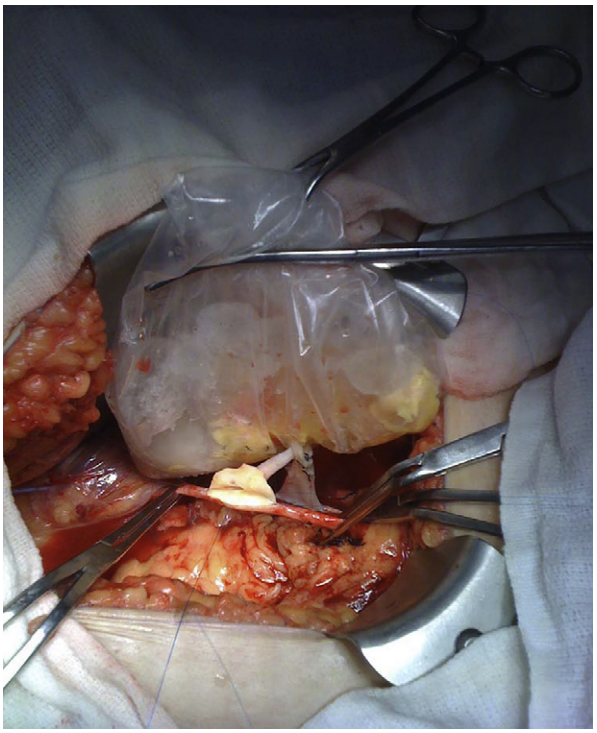

**Figure 4** Ice bag technique during anastamosis. The kidney placed in ice bag is introduced into the field with a penetrating towel clamp affixed it to one side of the wound, while the anastomoses are performed.

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**Table 1** Donor information

| Variables | Values (20 donors, 22 kidneys) |
|---|---|
| Donor type, *n* | |
| DCD | 1 |
| DND | 14 |
| ECD | 2 |
| ECD/DCD | 3 |
| Donor kidney, *n* | |
| Right | 7 |
| Left | 11 |
| Both | 2 |
| Donor gender, *n* | |
| Male | 14 |
| Female | 6 |
| Number of arteries in the donated kidney, *n* | |
| One | 19 |
| Two | 3 |
| Number of veins in the donated kidney, *n* | |
| One | 21 |
| Two | 1 |
| Donor age (y), mean (SD) | 44 (±13.91) |
| Terminal creatinine, mean (SD) | 1.01 (±0.38) |

DCD = donation after cardiac death; DND = donor after neurologic death; ECD = expanded criteria donor; SD = standard deviation.

(Figure 4). After completion, the vascular clamps were removed and the bag was cut and passed off the field.

## 3. Results

We identified 20 patients who underwent renal transplants with the use of the "ice bag technique." Recipient ages varied from 31 years to 71 years, with a mean age of $53.72 \pm 12.04$ years. Fifteen were male. The most common primary diagnosis was hypertensive nephrosclerosis ($n = 10$). The donor's mean age was $44 \pm 13.91$ years. Fourteen were male. Most donors were deceased after neurological death ($n = 14$) with a mean terminal creatinine of $1.01 \pm 0.38$ mg/dL. With the ice bag technique, warm ischemic time was an average of $34 \pm 12.31$ minutes. There were two dual, ipsilateral kidney transplants. Of the donors, 11 were left and 7 were right kidney donors. Seventeen transplants were performed in the right lower quadrant. Average recipient body mass index was $28.17 \pm 7.4$ kg/m$^2$. Three kidneys had two arteries. One kidney had two veins. We have tabulated the donor, pre-, intra-, and postoperative data in Tables 1–4. With the use of the new technique,

**Table 2** Recipient preoperative information

| Variables | Values (20 recipients) |
|---|---|
| Age at the time of transplant (y), mean (SD) | 53.72 (±12.04) |
| BMI (kg/m$^2$), mean (SD) | 28.17 (±7.4) |
| Primary diagnosis, *n* | |
| IgA nephropathy | 2 |
| Focal glomerularscherosis | 1 |
| Diabetes-Type II | 3 |
| Hypertensive nephrosclerosis | 10 |
| Focal segmental glomerulosclerosis | 2 |
| Focal glomerulonephritis | 1 |
| Unknown focal glomerulonephritis | 1 |
| Recipient gender, *n* | |
| Male | 15 |
| Female | 5 |

BMI = body mass index; IgA = immunoglobulin A; SD = standard deviation.

**Table 3** Operative information

| Variables | Values (20 recipients, 22 kidneys) |
|---|---|
| Site of incision | |
| Right | 17 |
| Left | 3 |
| EBL (mL), median (range) | 200 (75–600) |
| WIT (min), mean (SD) | 34 (±12.31) |
| CIT (min), mean (SD) | 802 (±321.04) |

CIT = cold ischemic time; EBL = estimated blood loss; SD = standard deviation; WIT = warm ischemia time.

**Table 4** Postoperative information

| Variables | Values (20 recipients) |
|---|---|
| Creatinine at POD 10, mean (SD) | 4 (±3.06) |
| DGF | 6 |
| Rejection within 30 d | 1 |

DGF = delayed graft function; POD = postoperative day; SD = standard deviation.

14 transplants showed immediate graft function. Of the six patients with DGF, two were expanded criteria donors and donors after cardiac death, one suffered an antibody-mediated rejection, one was reoperated on for compartment syndrome, and one was re-explored secondary to postoperative bleeding after heparin administration for atrial fibrillation. There were no complications related to the use of this technique. Allograft frostbite was not encountered.

## 4. Discussion

Prolonged warm ischemic time is associated with DGF and diminished outcomes. If the thermal threshold of glomerular and tubular activation (18°C) is never reached, the damage from warm ischemia may be eliminated. We believe that maintaining the kidney inside a bag with ice-cold preservation fluid keeps the temperature as low as possible (approximately 6°C). This is also the temperature at which kidneys are machine perfused. Although placement of the kidney in a chilled laparotomy pad may be helpful, it is doubtful that the temperature remains under 18°C during the usual 35–45 minutes of warm ischemic time. Surely the temperature is much higher if a difficult anastomosis is encountered and excessive surgical manipulation is necessary. Szostek et al[4] observed an increased incidence of DGF when kidney temperature was greater than 15°C. Although many cooling devices have been reported in the past, [1–3] there have been no new studies in the English literature since the turn of the century. One recent report from Poland described a very complex polyethylene receptacle that requires 6 hours to sterilize and contains three separate containers.[5] Our technique allows for excellent orientation of the kidney and visualization of the anastomoses. The ice bag is secured to the surgical drapes, freeing both hands of the assistant. The bag is clear; therefore, the clamps may be removed while it is still in place. This allows for a quick evaluation of the color of the kidney. If there is bleeding, the clamps may be reapplied and warm ischemia is still obviated. The bag is also free. Because warm ischemic time is eliminated, physicians in training can perform more of the procedure without jeopardizing the long-term outcome of the allograft. We were able to use this technique with right and left kidneys in the right and left lower quadrants, with multiple vessels and in obese patients. Because of our excellent early results, we have embarked on a randomized trial with a control arm. We will

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analyze whether the elimination of warm ischemic time decreases the incidence of DGF and improves long-term allograft survival.

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