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Machine Perfusion as a Temporal and Resuscitative Bridge in Emergent Renal Autotransplantation: A Novel Case Report

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Statistical Analysis C
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Manuscript Preparation E
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Patient: Female, 57-year-old
Final Diagnosis: Adrenal insufficiency • delayed graft function • renal cell carcinoma
Symptoms: Abdominal pain • shock
Clinical Procedure: —
Specialty: Nephrology • Transplantology • Urology

Objective: Unusual clinical course

Background: Renal autotransplantation is a well-described but infrequently used alternative to nephrectomy, complex renal or ureteral reconstruction, and allograft transplantation. While commonly performed and reported in the elective setting, it can be limited by ischemia, hemodynamic stability, and operative timing. Its use in the emergent setting can be limited by the patient's clinical stability and by the inability to safely perform immediate reimplantation. Hypothermic machine perfusion has been well described as a tool to improve outcomes following deceased donor transplantation. However, the role of hypothermic machine perfusion in autologous transplantation has not been clearly defined.

Case Report: We describe a novel case of emergent renal explantation in a 56-year-old woman followed by delayed autotransplantation after a period of hypothermic machine perfusion. Reimplantation was performed following resuscitation and stabilization of the patient. After a period of postoperative delayed graft function, the patient experienced recovery of her native renal function and was ultimately able to discontinue hemodialysis.

Conclusions: This case demonstrates the safety and viability of renal autotransplantation following preservation with hypothermic machine perfusion. Machine perfusion can function as a temporal bridge in emergent situations when immediate reimplantation is unsafe, expanding the indications for organ preservation beyond deceased donation. This approach enables staged reconstruction in patients who may otherwise not be appropriate transplant candidates.

Keywords: Delayed Graft Function • Dialysis • Kidney • Perfusion • Renal Autotransplantation • Transplantation, Autologous

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Introduction

Renal autotransplantation is a well-described but infrequently performed alternative to nephrectomy, complex renal or ureteral reconstruction, and allograft transplantation [1-3]. It is most commonly performed in the elective setting for indications such as urothelial malignancies or renal vessel pathology, including nutcracker syndrome [4]. Non-electively, it is used to address trauma or catastrophic ureteral injury [5].

In recent years, organ preservation technology has advanced significantly, revolutionizing the landscape of transplantation. In particular, the adoption of hypothermic machine perfusion has had a profound effect on deceased donor kidney transplantation. Multiple studies have demonstrated improved outcomes with hypothermic machine perfusion compared with outcomes of static cold storage, including lower rates of delayed graft function and improved graft survival [6]. Despite these advances, the application of machine perfusion in emergent autologous renal transplantation has not been previously described.

Case Report

A 56-year-old woman with a medical history significant for coronary artery disease, stable angina, hypertension, hyperlipidemia, stage III chronic kidney disease, and gastroesophageal reflux disease presented to her primary care physician in May 2024 for routine follow-up. Of note, she was a former smoker with a 12-pack year history, quitting 25 years prior to presentation. Her only surgical history was significant for an open appendectomy as a child. The patient reported worsening reflux symptoms, including epigastric discomfort and nausea. An abdominal ultrasound incidentally revealed a left renal mass with extension into the left renal vein and tumor thrombus involving the inferior vena cava (IVC). Subsequent computed tomography (CT) confirmed a 12.6×8.6×9.9 cm left renal mass occupying the majority of the upper and lower poles, with an area of central hypodensity suggestive of necrosis (**Figure 1A**). The left renal vein was retroaortic and dilated, with tumor thrombus extending into the infrahepatic IVC (**Figure 1B**). A staging chest CT was negative for metastatic disease.

The patient was scheduled for an open radical left nephrectomy with caval thrombectomy and possible IVC reconstruction. Intraoperatively, the thrombus was found to extend into the retrohepatic IVC and abut the orifices of the right renal and adrenal veins. Suprahepatic and infrarenal control of the IVC was obtained, and thrombectomy was attempted. The thrombus was densely adherent to the caval wall, and significant hemorrhage was encountered, including bleeding from the right renal and adrenal veins. To achieve hemostasis, the right renal vessels were clamped, and the left renal vein was transected. Given the extent of caval involvement, resection and reconstruction of the affected IVC segment was required.

Following completion of the left nephrectomy and IVC reconstruction using a polytetrafluoroethylene graft, the right kidney appeared ischemic, having been without arterial inflow for approximately 1 hour. Further, the right renal vein had been

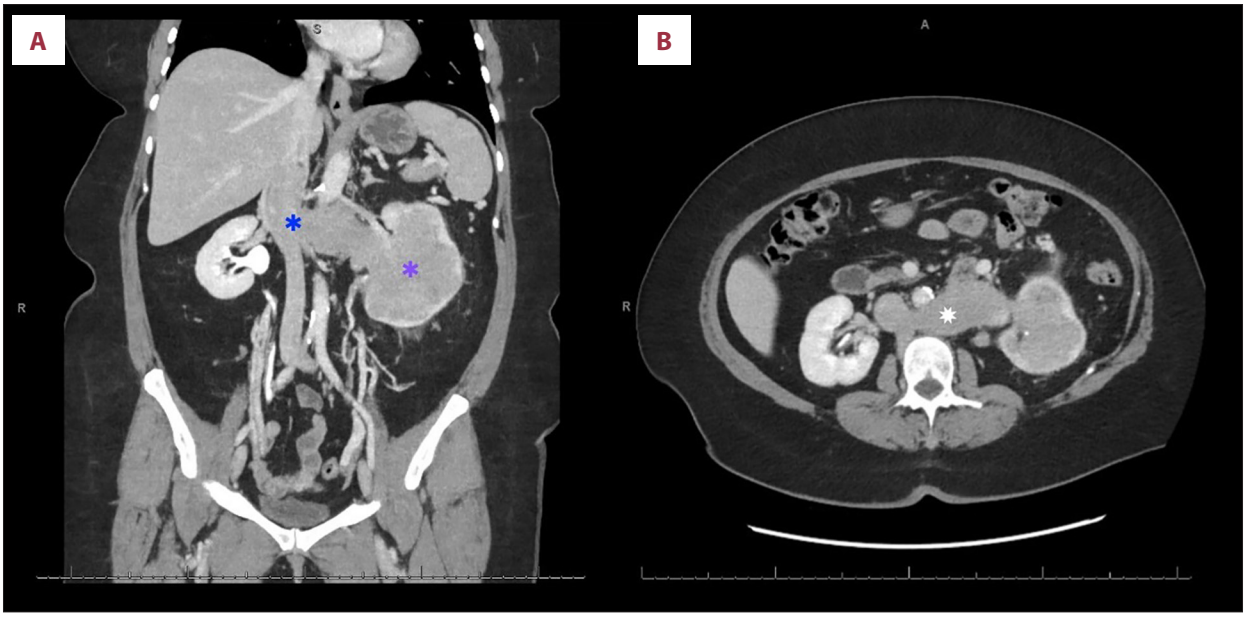

Figure 1. (**A**) Preoperative imaging of 12.6×8.6×9.9 cm left renal mass (purple asterisk) extending into the inferior vena cava (blue asterisk). (**B**) Preoperative imaging of retroaortic left renal vein with tumor thrombus extending into the infrahepatic inferior vena cava (white star).

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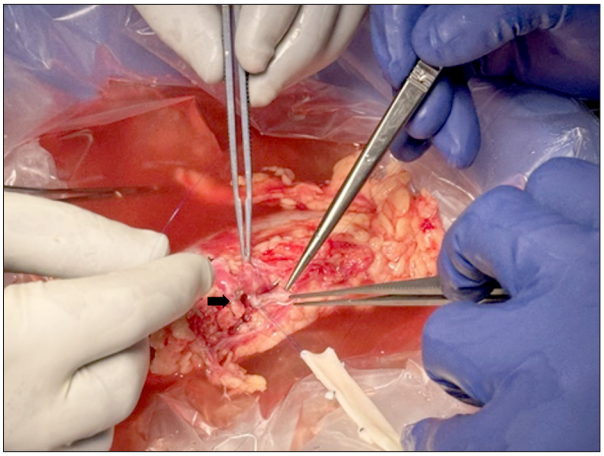

Figure 2. Backbench renal vein reconstruction using cryopreserved femoral vein graft (black arrow).

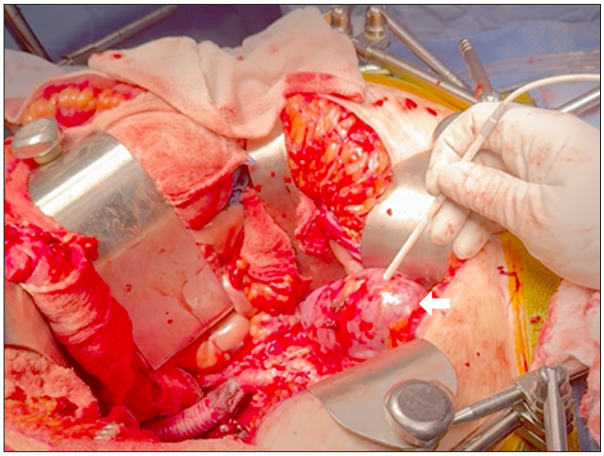

Figure 3. Autologous renal graft in right lower quadrant after implantation (white arrow).

transected distal to its orifice, leaving insufficient length for in situ reconstruction. A right nephrectomy with adrenalectomy was therefore performed, and the kidney was transferred to the backbench for planned venous reconstruction.

During backbench preparation, the patient developed profound hemodynamic instability requiring multiple vasopressors in the setting of massive hemorrhage. Given the patient's instability, an interdisciplinary discussion was held regarding immediate vs delayed autotransplantation. The decision was made to preserve the kidney using hypothermic machine perfusion and defer reimplantation until the patient was adequately resuscitated. The abdomen was packed and temporarily closed, and the kidney was placed on a renal perfusion pump using standard cold preservation techniques.

The estimated blood loss was approximately 42 L. Intraoperative resuscitation included 9 L of crystalloid, 450 mL albumin, 61 units of fresh frozen plasma, 74 units of packed red blood cells, 8 units of platelets, and 5 units of cryoprecipitate. The patient, now anephric, was transferred to the surgical intensive care unit for ongoing resuscitation and renal replacement therapy.

Overnight, the patient required hemodialysis for hyperkalemia and received additional blood products. With improvement in hemodynamics, she returned to the operating room on postoperative day 1 for autotransplantation. After renal vein reconstruction using a cryopreserved femoral vein graft (**Figure 2**), the kidney was reimplanted into the right lower quadrant with end-to-side anastomoses to the external iliac vessels. Mild arterial spasm was observed after reperfusion; however, intraoperative Doppler confirmed good flow, and the kidney began to produce urine (**Figure 3**). Ureteral reimplantation was performed over a 6-Fr stent using a Lich ureteroneocystostomy technique. The abdomen was temporarily closed, with definitive closure occurring on postoperative day 2 using a Wittmann patch.

Postoperatively, the patient experienced delayed graft function and required intermittent hemodialysis for several weeks. Immunosuppression was not required, as the graft was autologous. Renal function gradually recovered, and the patient discontinued hemodialysis approximately 12 weeks after her index operation.

Discussion

Although hypothermic machine perfusion has been shown to reduce delayed graft function and improve outcomes in deceased donor kidney transplantation, and is now widely accepted as a standard preservation method, its role in autologous transplantation has not been explored [7,8]. This case illustrates a novel, new conceptual use of perfusion; applying hypothermic machine perfusion as a temporizing strategy in emergent renal autotransplantation.

Renal autotransplantation has historically been reserved for select emergent and elective indications, including trauma, ureteral injury or disease, renal artery stenosis, nutcracker syndrome, tumor resection, and fibromuscular dysplasia [1,2,4,5,9]. The feasibility of autotransplantation is often limited by ischemic injury and the inability to safely perform immediate reimplantation in patients in unstable condition. Given such constraints, it has been underutilized. This case reconsiders the role of autotransplantation in the era of perfusion. Machine perfusion allowed preservation of renal viability while prioritizing patient safety, survival, and physiologic stabilization. Although the patient experienced postoperative complications including delayed graft function, this was expected and acceptable, as the patient ultimately avoided both a permanent anephric state and the need for immunosuppression, preserving long-term native renal recovery.

Current data on machine perfusion in autotransplantation is limited. In vivo porcine data supports its use, demonstrating lower

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creatinine levels and improved histologic outcomes in machine-perfused autografts compared with that of static cold storage [10]. While cold ischemia time remains an independent risk factor for delayed graft function, hypothermic machine perfusion consistently reduces its incidence relative to static cold storage, particularly when ischemic times are shorter than 10 hours [7,8,10,11]. Further, when compared up to 20 hours, while statistically insignificant, every additional hour increases the odds of developing delayed graft function, and the incidence of delayed graft function in the hypothermic machine perfusion was 6.0%, compared with 28.1% in the cold storage group. Therefore, machine perfusion can act as a bridge, not a storage method, by buying time for hemodynamic stabilization, coagulopathy correction, and team reassessment, enabling staged surgery.

Another potential benefit of this case report can be extrapolated to renal allograft transplantation. After deceased- or living-donor implantation, allograft vein or arterial thrombosis can have devastating results, most often leading to graft loss and nephrectomy [12]. When a patient presents with thrombosis, beyond the immediate return to the operating room, the technical steps to thrombectomy and revascularization are varied. Often, the graft is explanted or kept in situ and flushed with preservation solution and thrombolytic therapy [13]. Following mechanical thrombectomy, the graft is either reimplanted or revascularized to assess for salvage. In situations in which graft patency is questionable, it may be warranted to place the graft on hypothermic machine perfusion, allowing the team to monitor function, potentially flush out any micro-clots, and resuscitate the organ. This could allow for improved decision-making and possible salvage of organs that otherwise may have been discarded.

In the present case, despite exposure to prolonged ischemia, intraoperative trauma, hemodynamic instability, and multiple postoperative complications, the stressed autograft ultimately recovered function. The kidney was not only ischemic but was also subjected to manipulation and explantation under catastrophic physiology, followed by multiple additional insults. This highlights the resilience of the preserved kidney and supports the concepts of machine perfusion as a bridge to delayed reimplantation rather than solely a preservation modality that may be the reason the kidney survived. Perfusion serves not only to preserve the organ but also as a salvage strategy, with physiologic instability as an indication.

Conclusions

Hypothermic machine perfusion can be safely used to preserve autologous kidneys in emergent settings when immediate reimplantation is unsafe. Although delayed primary graft function can occur and temporary renal replacement therapy may be required, this strategy can prevent permanent anephric status and eliminate the need for immunosuppression associated with allograft transplantation. Machine perfusion should be considered a valuable adjunct in catastrophic intraoperative scenarios requiring staged renal autotransplantation.

Patient Permission/Consent Declaration

Appropriate consent was obtained.

Declaration of Figures' Authenticity

All figures submitted have been created by the authors who confirm that the images are original with no duplication and have not been previously published in whole or in part.

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