Perspective

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Advancements in Nephron-Sparing Surgery Techniques Enhancing Kidney Preservation

Maria Emmanuel*

Department of Nephrology, Erciyes University, Kayseri, Turkey

Corresponding author: Maria Emmanuel, Department of Nephrology, Erciyes University, Kayseri, Turkey, E-mail: sisman@sohu.com

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Description

Nephron-Sparing Surgery (NSS), also known as partial nephrectomy or kidney-sparing surgery, has emerged as a vital treatment option for patients with renal tumors. Unlike radical nephrectomy, which involves the complete removal of the affected kidney, NSS aims to preserve renal function by removing only the tumor and a portion of healthy kidney tissue surrounding it. This approach is particularly important for patients with small renal masses or tumors in a solitary kidney, where preserving kidney function is paramount for maintaining overall health and quality of life.

Nephron-sparing surgery

The primary goal of NSS is the complete removal of the renal tumor while preserving maximum healthy kidney tissue. Preservation of renal parenchyma NSS aims to minimize the loss of functional kidney tissue to maintain adequate renal function postoperatively. Despite preserving kidney function, NSS must ensure oncologic efficacy by achieving negative surgical margins and minimizing the risk of tumor recurrence. Ischemia time, the duration during which blood flow to the kidney is interrupted, should be minimized to prevent ischemic injury to the remaining renal tissue. Preservation of urinary continuity NSS should preserve the integrity of the urinary collecting system to maintain urinary function and minimize the risk of complications such as urinary leakage or obstruction. Small renal masses is a tumors smaller than 4 cm in diameter are ideal candidates for NSS, as they are associated with favorable outcomes and a low risk of metastasis. Solitary kidney patients with a solitary functioning kidney, either due to previous nephrectomy or congenital anomalies, require nephron-sparing surgery to preserve renal function. Bilateral renal tumors may necessitate NSS to preserve renal function while removing the tumors from both kidneys. Hereditary renal cancer syndromes patients with hereditary renal cancer syndromes, such as Von Hippel-Lindau (VHL) disease or hereditary leiomyomatosis and renal cell cancer, often present with multiple renal tumors, making NSS the preferred treatment option to preserve renal function.

Techniques of nephron-sparing surgery

Open partial nephrectomy traditional open surgery involves making an incision in the abdomen or flank to access the kidney and remove the tumor while preserving healthy surrounding tissue. Minimally invasive laparoscopic surgery utilizes small incisions and specialized instruments to perform partial nephrectomy under direct visualization using a camera. Robot-assisted surgery offers enhanced precision and dexterity compared to traditional laparoscopy, enabling meticulous tumor excision and renal reconstruction with minimal tissue trauma. In select cases, percutaneous techniques such as Radiofrequency Ablation (RFA) or cryoablation may be employed to destroy small renal tumors without the need for surgical resection. Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) scans are essential for assessing the size, location, and characteristics of the renal tumor. Preoperative renal function tests, including serum creatinine level and estimated Glomerular Filtration Rate (eGFR), help determine the baseline kidney function and predict postoperative renal outcomes. Patients undergo a comprehensive preoperative assessment by an anesthesiologist to evaluate their fitness for surgery and optimize perioperative care. Optimal anesthesia management aims to maintain hemodynamic stability, preserve renal perfusion, and minimize perioperative complications. Surgical techniques such as selective clamping of renal arteries and minimizing warm ischemia time are crucial for preserving renal function during partial nephrectomy. Various methods of renal reconstruction, including suturing, tissue glue, or renal parenchymal compression, may be employed to achieve hemostasis and restore urinary continuity. Close postoperative monitoring of renal function, fluid balance, and complications such as hemorrhage or urinary leakage is essential for early detection and intervention. Intraoperative or postoperative bleeding may occur and require intervention, including transfusion or reoperation. Urinoma or urinary fistula may develop due to disruption of the urinary collecting system, necessitating drainage and possible repair. Despite preserving renal function, some patients may experience transient or permanent renal insufficiency, particularly in the presence of

preexisting renal dysfunction. Ureteral injury, urinary tract infection, or urinary retention are potential urological complications that may occur following nephron-sparing surgery. Enhanced imaging novel imaging techniques such as contrast-enhanced ultrasound and intraoperative MRI facilitate real-time tumor localization and surgical planning, improving the precision of NSS. Continued refinement of robotic-assisted surgery has led to improved surgical outcomes, shorter hospital stays, and faster recovery for patients undergoing partial nephrectomy. Renal hypothermia techniques, including selective renal artery cooling or cold perfusion, minimize ischemic injury during partial nephrectomy, enhancing renal functional preservation. Advances in laparoscopic and robotic techniques have expanded the applicability of nephron-sparing surgery, allowing for the safe and effective treatment of complex renal tumors previously deemed unresectable.