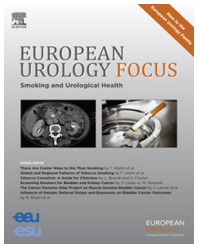
available at www.sciencedirect.com
journal homepage: www.europeanurology.com/eufocus



Review – Kidney Cancer

Robotic Surgery for Renal Cell Carcinoma with Vena Caval Tumor Thrombus

Ronney Abaza [a,*], *Daniel D. Eun* [b], *Michele Gallucci* [c], *Inderbir S. Gill* [d], *Mani Menon* [e], *Alexandre Mottrie* [f], *Ahmad Shabsigh* [g]

[a] *Department of Robotic Surgery, OhioHealth Dublin Methodist Hospital, Dublin, OH, USA;* [b] *Department of Urology, Temple University School of Medicine, Philadelphia, Pennsylvania, USA;* [c] *Department of Urology, "Regina Elena" National Cancer Institute, Rome, Italy;* [d] *USC Institute of Urology, Catherine and Joseph Aresty Department of Urology, Keck School of Medicine, University of Southern California, Los Angeles, CA, USA;* [e] *Vatikutti Urology Institute, Henry Ford Health System, Detroit, Michigan;* [f] *Department of Urology, Onze-Lieve-Vrouw Hospital, Aalst, Belgium; OLV Vattikuti Robotic Surgery Institute, Melle, Belgium;* [g] *Department of Urology, The Ohio State University Wexner Medical Center and James Cancer Hospital, Columbus, OH, USA*

Article info

Article history:
Accepted January 4, 2017

Associate Editor:
James Catto

Keywords:
Robotics
Nephrectomy
Renal cancer
Inferior vena cava
Thrombus

Abstract

Context: Robotic surgery has significantly advanced the minimally-invasive management of kidney tumors with extension into the inferior vena cava requiring caval cross-clamping and tumor thrombectomy. Additional techniques have recently been developed to continue the evolution of this complex procedure and extend its indications.
Objective: To review the current state of the art as regards robotic nephrectomy with inferior vena cava thrombectomy (RNIT).
Evidence acquisition: A systematic review of the Medline database was performed. All literature available through October 2016 was included.
Evidence synthesis: RNIT has been successfully adopted at select centers, but the number of patients reported to date remains limited. Modifications in clamping and tumor thrombus management have been described allowing for multiple options in surgical technique. Early perioperative outcomes appear favorable in comparison with traditional, open surgery, but further experience is needed.
Conclusions: Feasibility and reproducibility of RNIT has been demonstrated, but longer-term outcomes and larger patient numbers are necessary before the role of this procedure is established.
Patient summary: Kidney cancers invading the largest vein in the body, the vena cava, require complex surgery for removal. Traditionally this has required a large incision, but newer techniques with robotic surgery that continue to evolve have allowed for a minimally-invasive approach.

* Corresponding author. Department of Robotic Surgery, OhioHealth Dublin Methodist Hospital, 7450 Hospital Drive, Suite 300, Dublin, OH 43016, USA. Tel. +1 614 544 8104; Fax: +1 614 533 0128.
E-mail address: ronney.abaza@ohiohealth.com (R. Abaza).

1. Introduction

Since the first laparoscopic nephrectomy (LN) was described in 1991 [1], LN has been adopted as a preferred treatment for renal cell carcinoma amenable to minimally-invasive extirpation. Renal cell carcinoma can extend from the kidney along its route of venous drainage in 4–36% of cases, with some extending beyond the renal vein and into the inferior vena cava (IVC) [2]. Although once thought of as a contraindication [2–4], tumors invading the IVC can now be expertly managed by robotic and laparoscopic techniques in well-selected cases.

http://dx.doi.org/10.1016/j.euf.2017.01.001

Please cite this article in press as: Abaza R, et al. Robotic Surgery for Renal Cell Carcinoma with Vena Caval Tumor Thrombus. Eur Urol Focus (2017), http://dx.doi.org/10.1016/j.euf.2017.01.001

Robotic technology in surgery provides advantages that include three-dimensional vision controlled by the surgeon, wristed instruments, scaled movements, elimination of tremor, and a stable and ergonomic platform, all of which have facilitated minimally-invasive management of increasingly complex conditions. Despite more than a decade of widespread adoption of LN, the challenging surgical maneuvers needed to isolate the IVC for tumor thrombectomy had not been achieved laparoscopically until the initial report of five patients in 2011 using robotic surgery [5].

In the last 5 yr, the procedure has continued to develop and has been advanced by expert robotic surgeons at several institutions. Larger and multi-institutional patient series have now been published, in addition to novel technical modifications. The evolution of current techniques and foundation leading to the current state of robotic nephrectomy with IVC thrombectomy (RNIT) is reviewed herein.

2. Evidence acquisition

A systematic review of the Medline database was performed. All literature available through October 2016 was included. Medical subject headings included robotic surgery, nephrectomy, inferior vena cava, and thrombus, and returned 43 citations of which 26 were relevant to either laparoscopic or RNIT or animal/cadaver research in the same subject. One publication was excluded due to unavailability in English.

3. Evidence synthesis

3.1. Background

3.1.1. Thrombectomy

Minimally-invasive, completely intracorporeal IVC tumor thrombectomy was first reported robotically but evolved from previous incremental advancements in laparoscopic and hybrid techniques. Within less than a decade after the first LN, laparoscopic management of renal tumors with preoperatively identified renal vein thrombus was reported [6].

Laparoscopic excision of Level II thrombus was not reported until 2002. Sundaram et al [7] reported using hand-assistance in one patient where a Satinsky side-clamp was used to exclude the thrombus from the cava. Subsequently in 2006, pure LN was reported in a patient with a short thrombus not requiring IVC dissection and cross-clamping [8].

A hybrid approach using laparoscopy for the initial portion of the procedure followed by an open incision for the IVC tumor thrombectomy was developed to reduce the length of the open incision while allowing the most challenging portion of the operation to be performed by hand [9–12]. Completely intracorporeal laparoscopic techniques for IVC mobilization and cross-clamping were developed in a porcine model in 2002 but not applied to tumor thrombectomy until the advent of robotic surgery [13].

3.1.2. Robotic nephrectomy

Robotic nephrectomy was first reported in 2001 for benign disease [14]. Robotic nephrectomy did not find widespread adoption as with other urologic procedures that require complex tasks such as suturing. A decade after the first reported procedure, the largest series of robotic nephrectomies in the literature was only 38 patients [15]. Routine use of robotics for nephrectomy, including for tumors invading the IVC or contiguous organs, was more recently reported in 101 patients and remains the largest patient series reported to date [16].

3.2. Technical highlights of the procedure

3.2.1. Tangential clamping

Short tumor thrombi with limited extension into the IVC can typically be milked back into the renal vein without need for IVC violation, particularly after the renal artery is clipped, resulting in some contraction of the thrombus. When this is not possible, the IVC can be side-clamped tangentially, thereby maintaining flow through a portion of the IVC while it is opened to extract the thrombus (Fig. 1). This was described robotically in the first report by Abaza [5] and has been reproduced by other surgeons, including in eight patients reported in the first multi-institutional series of RNIT [17].

All initial procedures were right-sided and all were performed transperitoneally, without preoperative angioembolization. Briefly, the renal artery is divided early either at the renal hilum or in the interaortocaval space depending on the bulk of the thrombus in the renal vein and the degree of peri-hilar venous collaterals, adhesions, and/or adenopathy obstructing the artery on the right side of the IVC. The extent of retraction of the tumor thrombus after arterial interruption is assessed using laparoscopic ultrasound to determine whether cross-clamping of the IVC can be avoided with tangential clamping. The kidney can be completely mobilized except for the lateral attachments and retracted laterally with the robotic fourth arm to facilitate this.

Tangential clamping of the IVC is accomplished with a curved laparoscopic Satinsky clamp. The portion of IVC with tumor thrombus is thereby excluded while preserving flow through the remaining lumen. After tumor thrombus extraction, the IVC is sutured with the aim to maintain at least 50% of its original width (Fig. 1).

3.2.2. Cross clamping

Larger IVC tumor thrombi require cross-clamping of the cava for tumor extraction [18,19]. This requires that the IVC be dissected circumferentially above and below the level of the thrombus. Laparoscopic ultrasound facilitates delineation of the uppermost extent of the thrombus to allow safe clamping without fracture and embolization. However, it should be noted that for higher Level III thrombi, there may be no space available cephalad to the thrombus for advancement of the laparoscopic ultrasound, given the intrahepatic extent of the thrombus. All blood flow to the IVC must be interrupted prior to incision for thrombectomy,

Please cite this article in press as: Abaza R, et al. Robotic Surgery for Renal Cell Carcinoma with Vena Caval Tumor Thrombus. Eur Urol Focus (2017), http://dx.doi.org/10.1016/j.euf.2017.01.001