Current Advances in the Ureteroscopic Management of Upper Tract Urothelial Carcinoma

Iordache Valentin [1], Georgescu Dragos[12], Cozma Cosmin[1,2], Multescu Razvan[1,2], Geavlete Petrisor[1,2], Geavlete Bogdan[1,2]

[1] "Saint John" Emergency Clinical Hospital, Urology Department, Bucharest, Romania
[2] "Carol Davila" University of Medicine and Pharmacy, Faculty of Medicine, Bucharest, Romania

ABSTRACT

Upper tract urothelial carcinoma (UTUC) is a rare and biologically heterogeneous malignancy. Although radical nephroureterectomy (RNU) has traditionally been the standard treatment for high-risk disease, the potential functional consequences of nephrectomy—particularly the development of chronic kidney disease (CKD)—have fueled growing interest in nephron-sparing alternatives. Recent advances in endoscopic instruments, laser technologies, and optical imaging have broadened the feasibility of conservative approaches for appropriately selected patients. This review provides an updated overview of endoscopic management and recent technical innovations, with emphasis on oncologic outcomes, renal functional preservation, criteria for patient selection, and recommended surveillance strategies.

Key-words: narrow band imaging, upper tract, urothelial carcinoma, digital flexible ureteroscopy:bipolar en bloc resection of bladder tumors (ERBT), non-muscle-invasive bladder cancer (NMIBC), TURBT

Correspondence to: Iordache Valentin, MD
Hospital, Clinic: "St. John" Clinical Hospital of Emergency – Department of Urology
Address of the hospital: Sos. Vitan-Birzesti no 13, Bucharest Romania
Tel / Fax: 0748393261
e-mail: pc_valii@yahoo.com

Introduction

UTUC accounts for approximately 5–10% of urothelial tumors [1]. For decades, radical nephroureterectomy (RNU) accompanied by bladder cuff excision has represented the definitive management for high-risk localized UTUC, offering reliable oncologic control.[2] However, removal of an entire renal unit frequently results in chronic kidney disease (CKD) and reduced eligibility for systemic platinum-based therapies [3].

Recent advances in endourology - including flexible ureteroscopy (URS), high-powered holmium and thulium lasers, and enhanced visualization - have enabled nephron-sparing surgery (NSS) as a feasible option, particularly in low-risk UTUC or in patients with imperative indications (solitary kidney, bilateral disease, or baseline renal impairment)[4].

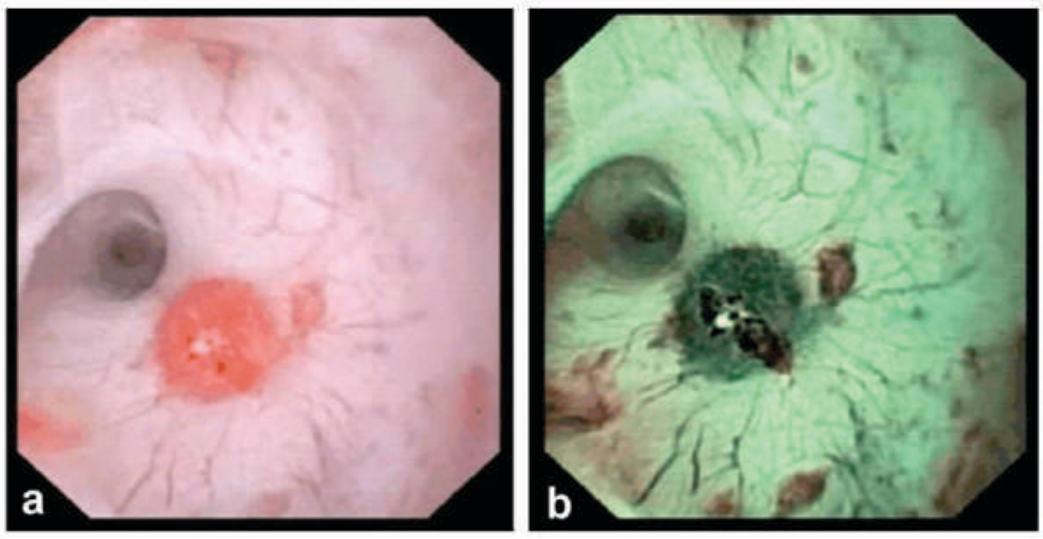


Figure 1 : Suspect lesion visible in white light and NBI

Ureteroscopy in the diagnosis of UTUC

Recent technological and methodological improvements have substantially enhanced the diagnostic performance of endoscopic evaluation in UTUC. The shift from fiber-optic to digital flexible ureteroscopes (fURS) has markedly improved image resolution, light transmission, and overall maneuverability, facilitating reliable detection of subtle mucosal abnormalities and flat lesions that might be missed with older scopes.[5]These innovations have strengthened the role of diagnostic ureteroscopy, particularly as nephron-sparing strategies gain traction.

A major advance in endoscopic diagnosis and therapy of UTUC has been the introduction of NBI in flexible ureteroscopy[6]. NBI filters white light into two narrow bandwidths (≈415 nm — blue, and ≈540 nm — green), which are strongly absorbed by hemoglobin and penetrate only the superficial mucosa; this enhances vascular contrast and more clearly highlights urothelial lesions.

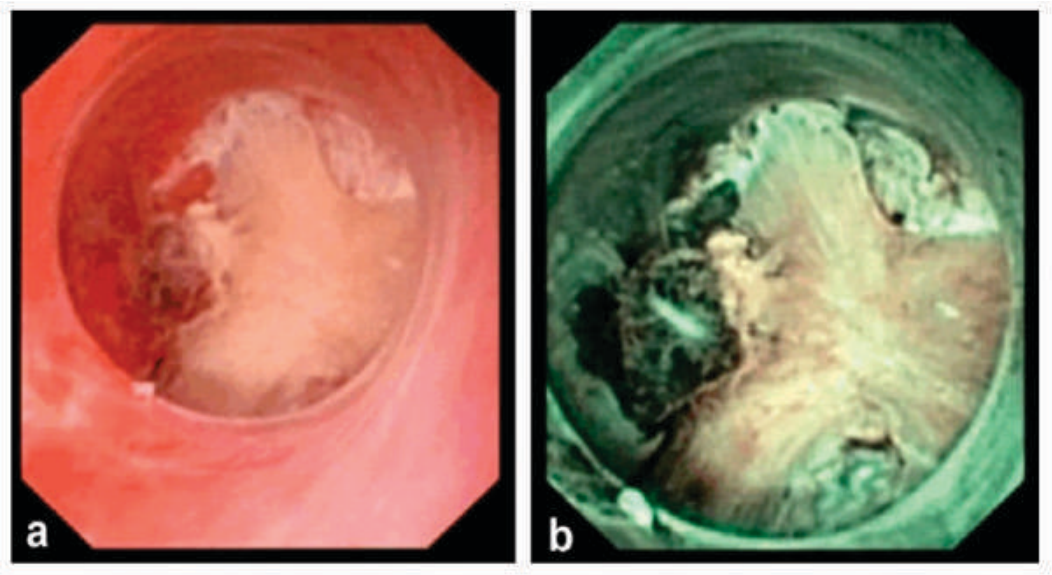


Figure 2 : Suspect lesion visible in NBI

Hao et al. (2018) reported a clinical series evaluating the use of Narrow Band Imaging (NBI) during ureteroscopy. In a series of 54 procedures (16 initial diagnostic procedures and 38 surveillance procedures), NBI revealed 4 additional tumors (11.5%) and extended the visible margins of 3 other tumors (8.5%), increasing the detection rate by ~20% compared with white light.[7] During a follow-up period ranging from 1 to 25 months, five local recurrences were observed. The authors concluded that NBI enhances visualization and improves the detection of small lesions and tumor margins.

A recent study (2024) performed in our clinical department comparing endoscopic laser treatment with NBI versus without NBI showed that the NBI group had lower recurrence rates at 1 and 3 years, as well as better cancer-specific survival (CSS).[8] At 3 years, recurrence was 11.5% vs 18% ($p<0.05$), and CSS 93.4% vs 86.9% ($p<0.05$).

These improvements suggest that NBI not only optimizes initial diagnosis and lesion characterization but also contributes to better post-treatment outcomes, likely by enabling a more complete ablation.

Indications for ureteroscopic treatment of UTUC
Nephron-sparing strategies preserve renal function, reducing CKD risk and maintaining eligibility for systemic therapy [9]
Current risk stratification frameworks emphasize tumor grade, stage, size, focality, imaging features and renal functional reserve in therapeutic decision-making[10].
According to EAU guidelines, ideal candidates for ureteroscopic nephron-sparing treatment are:

- ·Unifocal tumors
- ·Tumor size <2 cm
- ·Low-grade cytology/biopsy
- ·No radiologic evidence of invasion
- ·Ability to adhere to rigorous follow-up[11] [12]

Ureteroscopic laser ablation of UTUC

Flexible ureteroscopy allows retrograde access to the entire upper urinary tract. Laser systems (Holmium:YAG, Thulium:YAG, TFL) permit tumor ablation with minimal thermal damage, preserving urothelial integrity [13]

Ureteroscopic kidney-sparing surgery (typically involves tumor biopsy, laser fulguration or resection, and, when necessary, staged procedures. Some centers apply adjunctive intraluminal therapy (e.g., mitomycin gel) postoperatively.[14]

Several laser modalities are currently employed for tumor ablation in upper tract urothelial carcinoma (UTUC), each characterized by distinct physical properties and clinical applications.

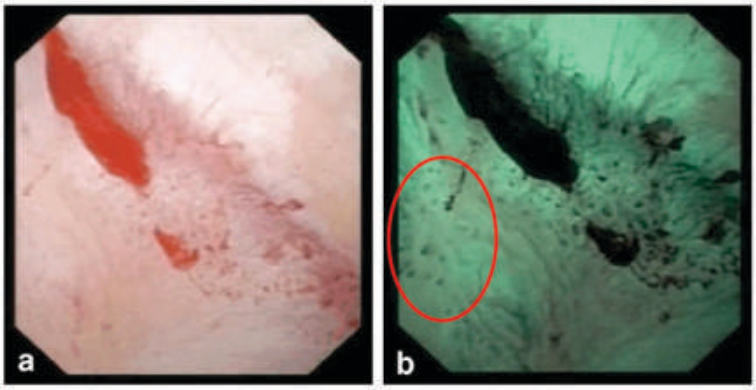


Figure 3 :Suspect lesion visible in NBI

Holmium:YAG (Ho:YAG) laser has been widely used for UTUC ablation due to its predictable tissue penetration (approximately 0.4 mm), and strong hemostatic properties,. Ho:YAG is particularly effective for treating small papillary tumors and for endoscopic lithotripsy when concomitant stones are present. Its pulsed emission enables controlled ablation, reducing the risk of deep tissue injury[15][16].

In contrast, Thulium:YAG (Tm:YAG) provides continuous-wave emission, enabling smooth cutting and vaporization of lesions with minimal collateral damage. Its superficial penetration (~0.2–0.3mm) and excellent hemostasis make it ideal for sessile or flat tumors, including carcinoma in situ [17][18]. A limitation is that it requires larger fibers (200–365µm) [19]

The Thulium Fiber Laser (TFL) represents a recent advancement in endoscopic management of upper tract urothelial carcinoma (UTUC). Unlike continuous-wave Thulium:YAG lasers, TFL delivers high-frequency, low-energy pulsed emission, allowing extremely precise tissue ablation with minimal collateral thermal damage. Its superficial tissue penetration (~0.15–0.2mm) enables controlled vaporization of lesions while preserving the underlying ureteral or renal parenchyma[20][21].

Key characteristics of lasers used for UTUC treatment are presented in Table 1.

	Ho:YAG	**Thulium:YAG**	Thulium Fiber Laser (TFL)
Emission mode	Pulsed	Continuous	Finely controlled pulsed
Ablation precision	Moderate	High	Very high
Hemostasis	Good	Excellent	Excellent
Thermal effect	High	Low	Very low
Visibility in the operative field	Moderate	Good	Very good

Table 1. Principal properties of lasers applied in UTUC management

Concerning the results of ureteroscopic laser ablation for UTUC, retrospective studies and meta-analyses show that for low-grade UTUC, ureteroscopic NSS provides cancer-specific survival similar to RNU, while preserving renal function[22].
A 2023 meta-analysis including 11 studies (2,284 patients; 737 E-KSS vs 1,547 RNU) found 5-year overall survival (OS) similar between E-KSS and RNU for low-grade tumors; for high-grade tumors, 5-year OS favored RNU (RR 1.84, 95% CI 1.26–2.69, p = 0.002). No significant difference was observed in 5-year cancer-specific survival (CSS) between groups. Bladder recurrence rate and 5-year metastasis-free survival (MFS) were also similar. [23]

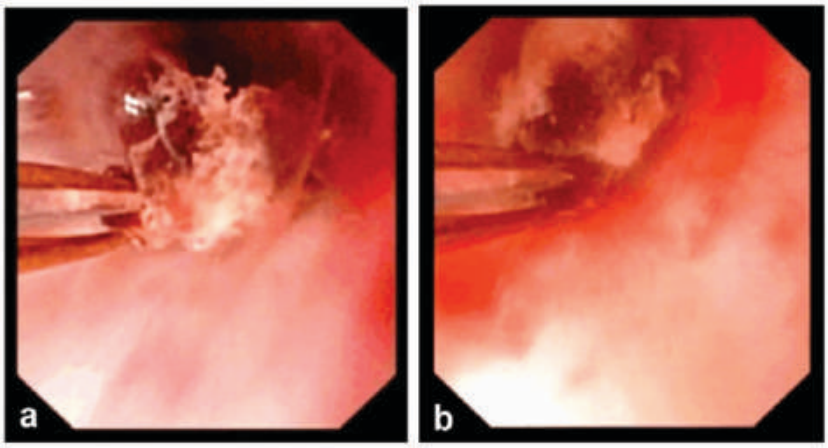


Figure 4 :Cold forceps biopsy of suspicious lesion

The same authors conducted recently a systematic search of the literature in PubMed, Web of Science, and Scopus to identify observational studies reporting outcomes of patients with upper tract urothelial carcinoma (UTUC) treated with endoscopic laser ablation .They noted that older laser modalities, such as Nd-YAG and diode lasers, have largely been abandoned due to their association with high complication rates. Most of the included studies were retrospective in nature, and follow-up durations were highly variable, which limits the strength of long-term conclusions. Importantly, favorable outcomes were predominantly observed in patients with low-grade, localized UTUC, whereas high-grade or more advanced disease continues to present challenges for conservative management.

A recent retrospective multi-institutional analysis (143 UTUC patients; 35 URS vs 108 RNU) reported comparable OS and radiographic progression-free survival (rPFS) between URS and RNU groups over median 27 months, with significantly better preservation of renal function in URS patients.[24]

A case-control study comparing nephron-sparing endoscopic treatment vs RNU in low-grade UTUC demonstrated stable renal function in the NSS group, no disease-specific mortality, but higher ureteral and bladder recurrence (44 % had bladder recurrence; 9 patients had ureteral recurrence, all successfully treated endoscopically) over a median 26-month follow-up.[25]

However, recurrence rates are higher, including ipsilateral upper tract and bladder recurrence.[26]

Surveillance

Given the high risk of recurrence after nephron-sparing treatment, a stringent and prolonged surveillance protocol is mandatory. This include:

- Ureteroscopy every 3–12 months
- CT or MR urography
- Urine cytology
- Cystoscopy for bladder surveillance.

Adjuvant intraluminal therapy remains investigational.

Limitations of Current Evidence

A major limitation of current evidence is that most studies are retrospective or single-center, which restricts the generalizability of the findings. Additionally, there is considerable heterogeneity in patient selection, tumor characteristics, follow-up protocols, and outcome reporting Recurrence rates remain high, necessitating lifelong surveillance.

A comprehensive review of nephron-sparing surgery (NSS) techniques—including ureteroscopy (URS), percutaneous approaches, and segmental ureterectomy (SU)—highlighted wide variability in upper tract recurrence rates: 19–90.5% for ureteroscopic cases, 29–98% for percutaneous approaches, and 10.2–31.4% for SU, emphasizing the importance of careful patient selection and strict postoperative follow-up.[27]

Some centers advocate for adjuvant intraluminal therapy, such as mitomycin C or BCG; however, data are limited and no consensus currently exists regarding its routine use.

Discussion and Future Directions

Current literature suggests that for carefully selected patients with low-risk disease (small, unifocal, low-grade, non-invasive UTUC), ureteroscopic laser ablation of UTUC may achieve oncologic outcomes comparable to RNU, while preserving renal function and reducing long-term morbidity. However, this equivalence comes at the cost of a higher recurrence risk and requires strict, life-long surveillance.

The shift towards personalized treatment requires a balance between oncologic safety and preservation of renal function and quality of life.

As the population ages and comorbidity burdens rise, preserving renal reserve becomes more relevant, especially when systemic therapy may be necessary.

To strengthen the evidence base and define standardized protocols, the field needs:

· Prospective multicenter studies (or registries) directly comparing NSS vs RNU, with well-defined inclusion criteria, standardized follow-up, and long-term endpoints (OS, CSS, renal function, quality of life).

· Consensus on surveillance protocols and on the role and regimen of adjuvant intraluminal therapy.

· Integration of novel imaging and optical technologies (enhanced ureteroscopy, narrow-band imaging, confocal laser endomicroscopy) to improve tumor detection and reduce under-grading or missed lesions.

· Assessment of cost-effectiveness, patient-reported outcomes, and quality-of-life measures in NSS vs RNU cohorts.

Conclusions

Nephron-sparing management of UTUC is feasible and oncologically safe in selected patients. Ureteroscopic laser ablation preserve renal function and offer comparable survival to RNU, but require meticulous patient selection and strict surveillance. Future research should focus on standardized protocols, integration of advanced imaging and optical technologies, and evaluation of quality-of-life outcomes.

References

1. Kim SH, Savul IS, Lerner SP. Nephron-sparing surgery for upper urinary tract urothelial carcinoma. J Urol Oncol. 2024;22(1):68–771
2. Lidner T, et al. Radical nephroureterectomy in high-risk UTUC: contemporary outcomes. Eur Urol. 2024
3. Raman JD, et al. Kidney-sparing surgery for upper tract urothelial cancer: a review. Nat Rev Urol. 2015;12:155–166
4. Nandurkar R, Basto M, Sengupta S. Nephron-sparing surgery: techniques and outcomes. Transl Androl Urol. 2020;9:3160–3167
5. Soria F, Laguna MP, Roupret M, Garcia-Marchinena P, Gonzalez MS, Habuchi T, Erkan E, Ng A, Gontero P, de la Rosette J. Flexible fibre optic vs digital ureteroscopy and enhanced vs unenhanced imaging for diagnosis and treatment of upper tract urothelial carcinoma (UTUC): results from the Clinical Research Office of the Endourology Society (CROES)-UTUC registry. BJU Int. 2021

Dec;128(6):734-743.
6. Traxer O, Geavlete B, de Medina SG, Sibony M, Al-Qahtani SM. Narrow-band imaging digital flexible ureteroscopy in detection of upper urinary tract transitional-cell carcinoma: initial experience. J Endourol. 2011 Jan;25(1):19-23.
7. Hao YC, Xiao CL, Liu K, Liu YQ, Ma LL. Application of narrow-band imaging flexible ureteroscopy in the diagnosis, treatment and follow-up of upper tract urothelial carcinomas. Zhonghua Wai Ke Za Zhi. 2018 Mar 1;56(3):222-226.
8. Geavlete P, Iordache V, Multescu R, Paunescu A, Ene C, Popescu R, Bulai C, Geavlete B. The Recurrence Rates at Three Years for the Conservatively Managed UTUC Cases Using NBI-Assisted Flexible Ureteroscopy and Holmium Laser Vaporization. Medicina (Kaunas). 2024 Nov 21;60(12):1911.
9. Raman JD, et al. Kidney-sparing surgery for upper tract urothelial cancer: a review. Nat Rev Urol. 2015;12:155–166.
10. [Bitaraf, M.; Ghafoori Yazdi, M.; Amini, E. Upper Tract Urothelial Carcinoma (UTUC) Diagnosis and Risk Stratification: A Comprehensive Review. Cancers 2023, 15, 4987]
11. Masson-Lecomte A, Gontero P, Birtle A, Compérat E, Dominguez-Escrig J, Liedberg F, Mariappan P, van Rhijn B, Seisen T, Shariat S, Teoh J, Xylinas E, et al. EAU Guidelines on Upper Urinary Tract Urothelial Carcinoma. Presented at the 40th EAU Annual Congress, Madrid 2025. Arnhem, The Netherlands: EAU Guidelines Office; 2025.
12. Xiong G, et al. Endoscopic intervention versus RNU for localized UTUC: meta-analysis. World J Urol. 2024.
13. Wen, J., Ji, Z.G. & Li, H.Z. Treatment of upper tract urothelial carcinoma with ureteroscopy and thulium laser: a retrospective single center study. BMC Cancer 18, 196 (2018).
14. Ko, Young Hwii. Nephron-sparing approaches in the management of upper tract urothelial carcinoma: indications and clinical outcomes" Translational Cancer Research [Online], Volume 9 Number 10 (10 April 2020) [Raman JD, et al. Kidney-sparing surgery for upper tract urothelial cancer: a review. Nat Rev Urol. 2015;12:155–166.].
15. Traxer O, et al. Endoscopic management of upper tract urothelial carcinoma: a comprehensive review. J Urol. 2010;184:2306–2311.
16. Breda A, et al. Flexible ureteroscopy and laser ablation for upper tract urothelial carcinoma: long-term outcomes. World J Urol. 2014;32:153–160.
17. Kronenberg P, Traxer O. Thulium fiber laser: an update on clinical applications in urology. Lasers Med Sci. 2020;35:1563–1572.
18. Somani BK, et al. Thulium laser for endoscopic treatment of upper tract urothelial carcinoma: current evidence. Urolithiasis. 2018;46:281–288
19. Somani BK et al., Urolithiasis. 2018;46:281–288.
20. Kronenberg P, Traxer O. Thulium fiber laser: an update on clinical applications in urology. Lasers Med Sci. 2020;35:1563–1572.
21. Taratkin M, et al. Thulium fiber laser versus holmium:YAG laser for upper urinary tract urothelial carcinoma: technical aspects and early clinical outcomes. World J Urol. 2022;40:2239–2248
22. Nandurkar R, Basto M, Sengupta S. Nephron-sparing surgery: techniques and outcomes. Transl Androl Urol. 2020;9:3160–3167.
23. Giulioni C, Brocca C, Tramanzoli P, Stramucci S, Mantovan M, Perpepaj L, Cicconofri A, Gauhar V, Merseburger AS, Galosi AB, Castellani D. Endoscopic intervention versus radical nephroureterectomy for the management of localized upper urinary tract urothelial carcinoma: a systematic review and meta-analysis of comparative studies. World J Urol. 2024 May 14;42(1):318.
24. Tsujino T, Komura K, Inamoto T, Maenosono R, Hashimoto T, Adachi T, Hirasawa Y, Tokushige S, Ohno T, Yamazaki S, Fukushima T, Nakamura K, Yano Y, Nishimura K, Kinoshita S, Nakamori K, Tsutsumi T, Matsunaga T, Yoshikawa Y, Uchimoto T, Takai T, Minami K, Uehara H, Hirano H, Nomi H, Takahara K, Ohno Y, Azuma H. Nephron-sparing ureteroscopic surgery vs. radical nephroureterectomy: comparable survival-outcomes in upper tract urothelial carcinoma. World J Urol. 2023 Dec;41(12):3585-3591.
25. Hoffman A, Yossepowitch O, Erlich Y, Holland R, Lifshitz D. Oncologic results of nephron sparing endoscopic approach for upper tract low grade transitional cell carcinoma in comparison to nephroureterectomy - a case control study. BMC Urol. 2014 Dec 2;14:97.
26. Kim SH, Savul IS, Lerner SP. Nephron-sparing surgery for upper urinary tract urothelial carcinoma. J Urol Oncol. 2024;22(1):68–77.

27. Nandurkar, R., Basto, M., & Sengupta, S. (2020). Nephron-sparing surgery for the management of upper tract urothelial carcinoma: An outline of surgical technique and review of outcomes. Translational Andrology and Urology, 9(6), 3160-3167.