ORIGINAL PAPER

In medio stat virtus: Exploring the potential of the pulsed thulium:YAG laser in the endoscopic management of upper tract urothelial carcinoma

Silvia Proietti, Federico De Leonardis, Cristian Axel Hernandez Gaytan, Rebeca Escobar Monroy, Stefano Gisone, Riccardo Scalia, Franco Gaboardi, Guido Giusti

Department of Urology, IRCCS San Raffaele Hospital, Milan, Italy

Citation: Proietti S, De Leonardis F, Hernandez Gaytan CA, et al. In medio stat virtus: Exploring the potential of the pulsed thulium:YAG laser in the endoscopic management of upper urinary tract urothelial carcinoma. Cent European J Urol. 2025. doi: 10.5173/ceju.2025.0111

Article history
Submitted: May 21, 2025
Accepted: Jun. 12, 2025
Published online: Aug. 21, 2025

Corresponding author
Silvia Proietti
Department of Urology,
IRCCS San Raffaele Hospital,
Via Olgettina 60,
20132, Milan, Italy
proiettisil@gmail.com

Introduction The pulsed thulium:YAG (p-Tm:YAG) laser has shown encouraging results in the management of stone disease and BPH; however, its application in the endoscopic management of upper tract urothelial carcinoma (UTUC) has not yet been clinically investigated. The aim of this study is to evaluate the effectiveness and safety of the p-Tm:YAG laser in the endoscopic management of UTUC.

Material and methods Retrospective data were collected from all patients who underwent endoscopic treatment for UTUC between January and April 2024. Eligible patients were those diagnosed with UTUC and deemed suitable for endoscopic management. Both low-grade and high-grade cases were included. All patients underwent a second-look procedure 2 months after the initial surgery, followed by endoscopic surveillance at 6 and 12 months postoperatively. The laser source used for tumor ablation and coagulation was the p-Tm:YAG laser.

Results A total of 20 patients were included in the study. Among them, 12 patients (60%) were included in the low-risk UTUC conservative treatment group, while 8 patients (40%) were categorized into the high-risk group. At the time of the second procedure, histopathological analysis revealed no evidence of tumor in 16 cases (80%), while a tumor was identified in 4 patients (20%). No intraoperative complications were recorded. Postoperatively, 10 out of 75 procedures (13.3%) were associated with Clavien-Dindo grade I–II complications. No major complications occurred.

Conclusions In short-term follow-up, the use of the p-Tm:YAG laser for endoscopic UTUC treatment has proven to be safe and effective.

Key Words: UTUC ‹› pulsed thulium:YAG ‹› conservative treatment ‹› laser ‹› urothelial cancer

INTRODUCTION

Upper urinary tract urothelial carcinoma (UTUC) is a rare disease, representing 5–10% of all urothelial carcinomas, with a significant incidence peak observed in individuals aged 70–90 years [1].

Radical nephroureterectomy (RNU) with bladder cuff excision has long been considered the gold standard surgical procedure for UTUC.

However, thanks to the advancements in flexible instrumentation and laser technology, endoscopic UTUC treatment, in selected cased, may be considered safe without compromising oncological outcomes [2].

As a matter of fact, in the last two decades, the European Association of Urology (EAU) Guidelines advocate for the consideration of "kidney-sparing management" for patients with low-risk UTUC, and also for selected high-risk individuals, particularly those with severe renal insufficiency or a solitary kidney or bilateral tumors [3].

There are three lasers currently used in soft tissue application in urology: the holmium-YAG (Ho:YAG)

laser, the thulium-YAG (Tm:YAG) laser and the thulium fiber laser (TFL) [4].
Several clinical studies have shown the outcomes in terms of efficacy and safety of the Ho:YAG, the continuous wave-Tm:YAG, and the TFL lasers for the treatment of UTUC [5–7].
A new player has recently emerged in the endourological field: the pulsed-thulium:YAG (p-Tm:YAG) laser. Currently, only a limited number of studies have been published regarding its application in stone disease and BPH, suggesting its potential as an effective alternative to traditional lasers in endourology [8–11]. However, no data are currently available on its use in the endoscopic treatment of UTUC.
The aim of this study is to evaluate the effectiveness and safety of the p-Tm:YAG laser in the endoscopic management of UTUC, with particular focus on tumor ablation outcomes and complication rates.

MATERIAL AND METHODS

Retrospective data were collected from all patients who underwent endoscopic treatment for UTUC between January and April 2024. Before the procedure, all patients received detailed counseling regarding the benefits and risks of conservative UTUC management, including in cases of high-risk disease, as well as the critical importance of strict, lifelong follow-up. Eligible patients included those diagnosed with UTUC deemed suitable for endoscopic treatment and without evidence of metastatic disease. Both low-grade and high-grade UTUC cases were included, with high-grade tumors considered for endoscopic management only in patients with imperative indication, such as solitary kidney, bilateral disease, or significant renal insufficiency or any other comorbidity compromising the use of RNU. Patients were excluded if they declined endoscopic management or refused to adhere to the proposed surveillance protocol.
All patients underwent a second-look procedure two months after the initial surgery, followed by endoscopic surveillance at 6 and 12 months postoperatively.
Routine preoperative workup at baseline included history, physical examination, urine analysis, urine culture, blood test, urinary cytology, abdominal computed tomography (CT) scan, or magnetic resonance imaging (MRI). Peri/postoperative complications were reported according to the Clavien-Dindo classification system.

Surgical technique

All procedures were performed by two experienced surgeons at a single tertiary care referral center. The surgical technique was the same as described previously [7].
The laser source used for UTUC ablation and coagulation was the p-Tm:YAG (Dornier Thulio, Dornier MedTech Systems, Germany).
The UTUC ablation was achieved using the laser settings of 1 J, 10 Hz, Long Pulse Duration; the diameter of the laser fiber used was 200 mm in the core (Thulio Performance Fiber, single-use).

Bioethical standards

The study was approved by the Ethics Committee of the San Raffaele Hospital, Milan, Italy (N° Endourologia_2016). All patients provided written informed consent before study enrollment.

RESULTS

A total of 20 patients, comprising 13 men and 7 women, were included in the study after meeting the inclusion criteria. The mean age of the patients was 74.5 ±8.5 years at the UTUC diagnosis. Among them, 12 patients (60%) were included in the low-risk UTUC conservative treatment group, while 8 patients (40%) were categorized into the high-risk group.
The mean size of the tumors was measured at 18.4 ±9.5 mm. Biopsy results indicated low-grade UTUC in 12 patients and high-grade UTUC in 8 patients. Three patients did not complete the scheduled 6- and 12-month follow-up procedures. One patient died from a cerebrovascular event four months after the initial treatment. Another patient, with Lynch syndrome, started systemic therapy due to disease progression. The third patient, initially managed conservatively, ultimately underwent nephroureterectomy – despite having initially refused surgery – because of high-grade UTUC.
In total, 75 procedures were performed during the study period, including two biopsies that yielded inconclusive results.
At the time of the second procedure, histopathological analysis revealed no evidence of tumor in 16 cases (80%), while tumor was identified in 4 patients (20%), all of whom belonged to the high-risk conservative treatment group.
No intraoperative complications were recorded. Postoperatively, 10 out of 75 procedures (13.3%) were associated with Clavien-Dindo grade I–II complications. These included acute urinary retention requiring temporary bladder catheterization in one patient, self-limiting hematuria in two cases, fever requiring antibiotic therapy in six cases, and a single episode of transient renal colic with anuria

managed conservatively. No major complications occurred, and no cases of ureteral stricture were identified during follow-up (Tables 1, 2).

DISCUSSION

Kidney-sparing management, aimed at preserving renal function while ensuring effective oncological control, is playing an increasingly significant role in the treatment of patients with UTUC. According to the EAU guidelines, endoscopic management is recommended for low-risk UTUC and, on a case-by-case basis, for selected high-risk patients with imperative indications [3].

Until the release of the 2025 edition of the EAU guidelines, no specific recommendations had been provided regarding the optimal laser technology for achieving these objectives. Notably, the latest guidelines now suggest that UTUC tumor ablation should be performed using holmium and/or thulium lasers [3]. These technologies allow for effective tumor resection while minimizing tissue damage, thereby underscoring the critical role of laser energy in the endoscopic treatment of UTUC.

Currently, despite the availability of various laser technologies, the Ho:YAG laser remains the most commonly used energy source for the endoscopic treatment of UTUC [12]. Its widespread adoption is largely attributed to its availability in most urology departments for stone management, rather than to proven superiority in soft tissue ablation.

More recently, the TFL has gained attention for UTUC endoscopic management, demonstrating in ex vivo studies a more favorable safety profile and superior ablation and coagulation properties compared to the Ho:YAG laser [13], with encouraging clinical outcomes reported in early experience [7].

To the best of our knowledge, this represents the first clinical study assessing both the effectiveness and safety of the p-Tm:YAG laser in the endoscopic management of UTUC.

Previous ex vivo studies have explored the laser-tissue interaction properties of the p-Tm:YAG laser on soft tissues.

Kutchukian et al. evaluated the performance of three pulsed laser systems – Ho:YAG, TFL, and p-Tm:YAG – using a porcine kidney model. Histological analysis demonstrated that the p-Tm:YAG laser achieved greater tissue penetration compared to TFL, while remaining less penetrative than the Ho:YAG laser. Its coagulation performance appeared promising, producing uniform coagulation without evidence of carbonization. Furthermore, tissue incisions created by the p-Tm:YAG laser were uniform, with no signs of tearing or laceration [13].

Table 1. *Patient demographics, UTUC characteristics (n = 20) and intra/postoperative outcomes*

Gender, n (%)	
Male	13/20 (65)
Female	7/20 (35)
Age (years), mean ±SD	74.5 ±8.5
Low-risk UTUC treatment group	12/20 (60)
High-risk UTUC treatment group	8/20 (40)
Tumor size (mm), mean ±SD	18.4 ±9.5
Complications by Clavien-Dindo grade, n (%)	
Grade 0	65/75 (86.7)
Grade I	3/75 (4)
Grade II	7/75 (9.3)
Grade III/IV/V	0/75 (0)

SD – standard deviation

Table 2. *UTUC patients follow-up*

Patient	UTUC indication	FURS	2-month FURS	6-month FURS	12-month FURS
1	Imperative	LG	NEG	NEG	NEG
2	Elective	LG	NEG	NEG	NEG
3	Imperative	HG	HG	–*	–*
4	Imperative	HG	HG	–**	–**
5	Imperative	LG	NEG	NEG	LG
6	Elective	HG***	NEG	HG	–***
7	Elective	LG	NEG	NEG	NEG
8	Imperative	LG	NEG	NEG	NEG
9	Elective	LG	NEG	NEG	?
10	Imperative	HG	HG	HG	HG
11	Elective	LG	NEG	NEG	NEG
12	Imperative	HG	NEG	HG	HG
13	Imperative	LG	NEG	NEG	NEG
14	Imperative	LG	LG	NEG	NEG
15	Imperative	HG	NEG	HG	NEG
16	Elective	LG	NEG	NEG	NEG
17	Imperative	HG	NEG	NEG	NEG
18	Imperative	HG	NEG	NEG	NEG
19	Elective	LG	NEG	?	NEG
20	Elective	LG	NEG	NEG	NEG

* Patient died for cerubrovascular attack
** Patient with Lynch syndrome started systemic therapy for disease progression
*** Patient refused nefrou at the diagnosis and then accepted at 6-month FU
? Biopsy was inconclusive for a diagnosis
FURS – flexible ureteroscopy; UTUC – upper tract urothelial carcinoma

Similarly, Yilmaz et al. investigated soft tissue dissection using four different laser systems – high-power Ho:YAG, low-power Ho:YAG, TFL, and p-Tm:YAG – in an ex vivo porcine model. Their results showed that the high-power Ho:YAG laser achieved the most effective separation of fascial layers, followed by the p-Tm:YAG laser. Notably, the

p-Tm:YAG laser received the highest average score for coagulation performance, with TFL ranking second. These observations provide valuable insights into the practical application of laser systems in endourological procedures [14].

As a matter of fact, historically, the Tm:YAG laser has been used in a continuous wave mode in soft tissue, especially in BPH and UTUC, distinguishing itself by virtue of smooth incision and optimal hemostatic properties [6, 15]. In contrast, the drawback of CW emission and the consequent absence of thermal relaxation is the high degree of carbonization, which may impair intraoperative navigation or affect cutting precision [16, 17]. Moreover, the release of their energy in a continuous mode has made it unsuitable for lithotripsy, also due to the emission of unnecessary and potentially detrimental heat.

Recently, the novel p-Tm:YAG laser has become available on the market.

The p-Tm:YAG laser was designed to combine known advantages of Tm:YAG lasers, like good coagulation and the proven pulsed properties of Ho:YAG lasers.

This provides a substantial benefit, enabling its use across various domains, such as lithotripsy due to the higher peak power (up to 3.7 kW) and soft tissue applications because of good coagulation with very limited carbonization.

Indeed, several preclinical and clinical studies have already demonstrated the effectiveness and safety of p-Tm:YAG laser in lithotripsy [10]. Thus far, no clinical data are available on UTUC endoscopic treatment.

The present study reports the outcomes of 20 patients who underwent endoscopic treatment of UTUC using the p-Tm:YAG laser, showing its effectiveness and safety.

The laser ablation yielded satisfactory results with 16 out of 20 patients (80%) at the second look procedure showing absence of tumor; in the remaining four patients (20%) the biopsy showed tumor recurrence/persistence of urothelial carcinoma.

Importantly, all patients were classified as high-risk UTUC, suggesting that residual tumors are more likely due to the aggressiveness of the disease rather than any shortcomings of the laser treatment.

The present findings are consistent with those reported in a previous study on UTUC patients treated with the TFL laser [7], which showed a tumor ablation rate of 70.4% at the 2-month follow-up. This rate is slightly lower than the effectiveness observed with the p-Tm:YAG laser in the current study, which achieved an ablation rate of 80%.

Both the TFL and p-Tm:YAG lasers demonstrated superior tumor ablation rates compared to the series by Villa et al., in which endoscopic treatment of UTUC using the Ho:YAG laser was associated with a tumor recurrence rate of 51.2% [5]. These findings suggest that the physical properties of the TFL and p-Tm:YAG lasers may offer improved laser-induced tumor extirpation. However, it is important to emphasize that all the aforementioned studies are retrospective in nature. Therefore, well-designed comparative studies are of utmost importance before definitive conclusions can be drawn regarding the most effective laser modality for endoscopic management of UTUC.

A total of 75 procedures were performed, yielding a recurrence rate of 23.5 % at 6-month follow-up and 18.7% at 12-month follow-up. These findings are consistent with those reported in the TFL laser series [7], which documented recurrence rates of 21.7% and 17.7% at 6 and 12 months, respectively. Such comparable outcomes support the idea that both laser modalities are effective options for the endoscopic management of UTUC.

Regarding the safety profile of the p-Tm:YAG, we encountered only a low-grade complication rate in 10 out 75 procedures (13.3%), none of them related to the use of the laser.

No major complications were observed, and no ureteral stenosis was noted during the follow-up procedures. Moreover, no intraoperative complications were experienced and in particular no intraoperative bleeding limiting the visibility.

Indeed, especially compared with Ho:YAG laser, the hemostatic properties of the pulsed Tm:YAG laser provide a bloodless and clear operative field, which is of paramount importance during endoscopic management of highly vascularized tissues, such as those encountered in UTUC.

In light of these findings, the p-Tm:YAG laser appears to be an effective and safe option for the endoscopic treatment of UTUC, showing comparable performance to the TFL. However, comparative clinical studies are still required to confirm these preliminary results and to establish its definitive role in the endourological management of UTUC.

From an ergonomic perspective, the p-Tm:YAG laser is more compact and lighter than high-power Ho:YAG systems, and quite similar to the size of the TFL devices.

Similarly to TFL, its reduced footprint makes it a practical solution for endourological operating rooms, where space is often limited due to the presence of multiple medical and radiological devices. In addition, its power supply through a standard 240 VAC plug, increases its ergonomics so that it can be used in all operating theater, including in outpatient setting.

While its performance appears comparable to that of the TFL in the management of UTUC, the higher peak power of the p-Tm:YAG laser provides superior versatility, extending its potential use across a broader spectrum of endourological procedures. Specifically, it is suitable not only for soft tissue applications, such as UTUC treatment, but also for the management of all types of urinary stones [8, 18]. This positions the p-Tm:YAG laser as a potentially comprehensive energy source for the full range of endourological interventions.

Although preliminary, these outcomes suggest promising potential for expanded clinical application of the pulsed Tm:YAG laser in UTUC endoscopic treatment.

However, the present study is limited by its small sample size, retrospective single-center design, and the absence of comparative groups, which restricts the generalizability of the findings.

Nevertheless, this is the first study that explores the use of p-Tm:YAG laser in clinical settings in 20 patients with UTUC, showing its effectiveness and safety.

The p-Tm:YAG laser appears to represent an optimal compromise between the Ho:YAG and TFL lasers, because it is well-suited for both lithotripsy and soft tissue applications, effectively combining the advantageous properties of both technologies.

Prospective randomized studies in larger populations using different laser sources are required to confirm the clinical laser performance and the safety profile of the new p-Tm:YAG laser in treating UTUC patients.

CONCLUSIONS

In the endoscopic management of UTUC, the p-Tm:YAG laser has proven to be safe and effective, providing optimal tumor ablation and precise hemostasis, with no major complications observed in the short-term follow-up.

CONFLICT OF INTEREST

Guido Giusti: consultant for Dornier MedTech Systems
Silvia Proietti: consultant for Dornier MedTech Systems
The other authors declare no conflicts of interest.

FUNDING

This research received no external funding.

ETHICS APPROVAL STATEMENT

The study was approved by the Ethics Committee of the San Raffaele Hospital, Milan, Italy (N° Endourologia_2016).

References

1. Munoz JJ, Ellison LM. Upper tract urothelial neoplasms: incidence and survival during the last 2 decades. J Urol 2000; 2000: 1523-1525.
2. Territo A, Foerster B, Shariat S et al. Diagnosis and kidney-sparing treatments for upper tract urothelial carcinoma: state of the art. Minerva Urol Nefrol 2018; 70: 242-251.
3. Masson-Lecomte A, Birtle A, Pradere B, et al. European Association of Urology Guidelines on Upper Urinary Tract Urothelial Carcinoma: Summary of the 2025 Update. Eur Urol. 2025; 87: 697-716.
4. Giulioni C, Pirola GM, Maggi M, et al. Current Evidence on Utility, Outcomes, and Limitations of Endoscopic Laser Ablation for Localized Upper Urinary Tract Urothelial Carcinoma: Results from a Scoping Review. Eur Urol Open Sci. 2024; 59: 7-17.
5. Villa L, Haddad M, Capitanio U, et al. Which Patients with Upper Tract Urothelial Carcinoma Can be Safely Treated with Flexible Ureteroscopy with Holmium:YAG Laser Photoablation? Long-Term Results from a High Volume Institution. J Urol. 2018; 199: 66-73.
6. Musi G, Mistretta FA, Marenghi C, et al. Thulium laser treatment of upper urinary tract carcinoma: A multi-institutional analysis of surgical and oncological outcomes. J Endourol. 2018; 32: 257-263.
7. Proietti S, Johnston T, Pupulin M, et al. Effectiveness and Safety of Thulium Fiber Laser in the Conservative Management of Patients with Upper Tract Urothelial Carcinoma. Eur Urol Open Sci. 2022; 46: 99-104.
8. Proietti S, Marchioni M, Oo MM, et al. Flexible Ureteroscopic Lithotripsy with the Pulsed Thulium:Yttrium Aluminum Garnet Laser Thulio: Preliminary Results from a Prospective Study. Eur Urol Open Sci. 2024; 67: 77-83.
9. Ventimiglia E, Robesti D, Bevilacqua L, et al. What to expect from the novel pulsed thulium:YAG laser? A systematic review of endourological applications. World J Urol 2023; 41: 3301-3308.
10. Kallidonis P, Spinos T, Guven S et al. Pulsed Thulium: YAG laser for the management of Urolothiasis: a systematic review from the EAU section of endourology. World J Urol. 2025; 43: 118.
11. von Bargen MF, Glienke M, Tonyali S, et al. Real-world experience with the new pulsed solid-state Thulium: YAG laser (Thulio) for endoscopic enucleation of the prostate. World J Urol. 2024; 42: 467.
12. Ortner G, Somani BK, Güven S, et al. Experts' recommendations in laser use for the treatment of upper tract urothelial carcinoma: a comprehensive guide by the European Section of Uro-Technology (ESUT) and Training Research in Urological Surgery and Technology (T.R.U.S.T.) group. World J Urol. 2023; 41: 3367-3376.
13. Kutchukian S, Chicaud M, Berthe L, et al. Comparison of holmium:yttrium-aluminium-garnet (YAG), thulium fiber laser, and pulsed thulium:YAG lasers on soft tissue: an ex vivo study. BJU Int. 2024; 134: 763-772.
14. Yilmaz M, Esser J, Kraft L, et al. Experimental ex-vivo performance study

comparing a novel, pulsed thulium solid-state laser, chopped thulium fibre laser, low and high-power holmium:YAG laser for endoscopic enucleation of the prostate. World J Urol 2022; 40: 601-606.

15. Proietti S, Rodríguez-Socarrás ME, Eisner BH, et al. Thulium:Yag versus holmium:Yag laser effect on upper urinary tract soft tissue: Evidence from an ex vivo experimental study. J Endourol 2021; 35: 544-551.

16. Becker B, Enikeev D, Glybochko P, et al. Effect of optical fiber diameter and laser emission mode (cw vs pulse) on tissue damage profile using 1.94 µm Tm:fiber lasers in a porcine kidney model. World J Urol. 2020; 38: 1563-1568.

17. Taratkin M, Kovalenko A, Laukhtina E, et al. Ex vivo study of Ho:YAG and thulium fiber lasers for soft tissue surgery: which laser for which case? Lasers Med Sci. 2020; 37: 149-154.

18. Panthier F, Solano C, Chicaud M, et al. Initial clinical experience with the pulsed solid-state thulium YAG laser from Dornier during RIRS: first 25 cases. World J Urol. 2023; 41: 2119-2125.