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Impact of Thulium Laser En Bloc Resection on Catheter-Related Bladder Discomfort after Bladder Tumor Surgery

Ali Hassan[1]*, Noor Siddiqui[1], Bilal Khan[2], Sana Malik[1]

[1]Department of Clinical Cancer Medicine, Faculty of Medicine, Aga Khan University, Karachi, Pakistan.
[2]Department of Oncology and Translational Therapeutics, Faculty of Medicine, Qatar University, Doha, Qatar.

***E-mail** ✉ ali.hassan@gmail.com

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ABSTRACT

To assess how thulium laser en bloc resection of bladder tumor (ERBT) compares with conventional transurethral resection of bladder tumor (TURBT) regarding their influence on catheter-related bladder discomfort (CRBD) in individuals with bladder cancer. From January 2022 through December 2024, we retrospectively collected demographic and clinical information from patients with bladder cancer. The study included 79 patients who underwent conventional TURBT and 58 who received thulium laser ERBT. Demographic characteristics and outcome measures were documented; analysis focused on CRBD frequency and intensity at 1, 6, and 24 hours after surgery, pain scores at these same time points, and patient satisfaction 24 hours post-procedure. The groups did not differ meaningfully in terms of age, sex distribution, number of tumors, tumor dimensions or positioning, or length of the operation ($P > 0.05$). Histopathological assessment indicated that detrusor muscle was present more often in ERBT specimens than in TURBT specimens ($P = 0.04$). At both 1 and 6 hours postoperatively, the ERBT cohort exhibited reduced CRBD occurrence and severity compared with the TURBT cohort ($P < 0.001$). However, the difference was no longer statistically significant at 24 hours ($P = 0.17$). Postoperative pain, as measured by VAS scores, was notably lower in the ERBT arm at 1 hour ($P = 0.001$) and at 6 hours ($P = 0.02$); by 24 hours, this gap had closed ($P = 0.08$). Patient satisfaction at 24 hours post-surgery was significantly lower in the ERBT group than in the TURBT group ($P = 0.02$). Furthermore, the ERBT approach was associated with significantly less intraoperative hemorrhage and a shorter postoperative irrigation period ($P = 0.001$). The time an indwelling catheter remained in place did not differ significantly between the study arms ($P = 0.07$). These data suggest that thulium laser ERBT, compared with standard TURBT, substantially reduces the frequency and intensity of CRBD, diminishes postoperative discomfort, and yields superior patient satisfaction. That said, given the single-center, retrospective design, corroboration through expansive, prospective, multicenter investigations is warranted.

Keywords: Bladder cancer, Thulium laser, En bloc resection, Catheter-related bladder discomfort, Transurethral resection of bladder tumor

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Introduction

Indwelling urethral catheters are widely used across clinical settings, with reports estimating that 15%–25% of hospitalized individuals undergo catheter placement during their stay [1]. Within urology, the figure climbs to roughly 80% of patients, underscoring the device's integral role in diagnostics and therapy. Nonetheless, the very act of transurethral catheter insertion inflicts mechanical trauma upon the urothelium of the bladder and urethra. This procedure-driven irritation, commonly labeled catheter-related bladder discomfort (CRBD), represents a troublesome and unwelcome sequela capable of precipitating severe repercussions—urinary urgency, dysuria with burning, and an incessant impulse to pull at the catheter. In more extreme manifestations, intense bladder spasms can shear off hemostatic clots, giving rise to renewed bleeding, impaired wound healing, and a disrupted convalescence trajectory. Published clinical series reports a CRBD incidence of 47%–93% following transurethral operations [2].

While CRBD and overactive bladder (OAB) share symptomatic features on occasion, their origins diverge. The prevailing pathophysiological model attributes CRBD to mechanical, inflammatory [3], and chemically mediated irritation of the vesical mucosa triggered by the presence of a catheter, which in turn stimulates M3 muscarinic receptors and triggers uncontrolled detrusor contractions. Beyond eroding patient satisfaction, these symptoms increase analgesic requirements and contribute to other unfavorable outcomes. Consequently, CRBD management constitutes an especially formidable hurdle for individuals recovering from transurethral tumor resection, where catheter drainage is indispensable for ongoing irrigation and hemorrhage control. The literature describes a range of multimodal preventive measures: urethral instillation or catheter coating with local anesthetic-laden lubricants like lidocaine or tetracaine [4]; catheter adjustments, including downsizing the balloon or altering the fixation point [5]; transcutaneous electrical nerve stimulation (TENS) and acupuncture [6]; and pharmacotherapy with agents of varied mechanisms, such as histamine H1-receptor blockers [7], conventional NSAIDs [8], cyclooxygenase-2 selective NSAIDs, tolterodine, and tramadol [9]. Multiple investigations have confirmed at least partial prophylactic efficacy; however, real-world outcomes frequently fall short of expectations, and adverse effects—xerostomia, drowsiness, nausea, emesis—often intervene [10]. To date, a reliably effective intervention for CRBD devoid of untoward effects remains elusive [11].

Regarded as the benchmark treatment for non-muscle invasive bladder cancer (NMIBC), standard transurethral resection of bladder tumor (TURBT) relies on high-frequency electrical current to excise tumor tissue fragment by fragment. The intervention's core objectives encompass securing a histological diagnosis, informing therapeutic decision-making, and establishing prognostic indicators—among which diagnostic precision is paramount. Nevertheless, an array of detrimental influences—inherent drawbacks such as extensive collateral thermal damage, uneven resection planes at the bladder wall and margins, and protracted intraoperative oozing, compounded by sustained bladder wall irritation from refluxing fluid [5]—intensify postsurgical mucosal inflammation. Such an inflammatory milieu heightens CRBD by sensitizing nociceptive afferent pathways and amplifying pain signaling cascades. Although pharmacotherapy (e.g., anticholinergic agents, lidocaine preparations) can alleviate symptoms [12], it leaves the fundamental driver—operative insult—unaddressed. Adding to the concern are recognized perioperative hazards tied to TURBT, including fragmentation of tumor integrity, stimulation of the obturator nerve reflex, challenges in governing resection depth, and risk of bladder wall perforation [13]. These limitations are propelling the search for refined techniques that can mitigate such shortcomings while reducing procedural risks.

Thulium laser en bloc resection of bladder tumor (ERBT) has surfaced as a compelling substitute. Emitting light at a wavelength continuum of 1.75–2.22 μm (with a mean of 1.940 μm), the thulium laser restricts tissue penetration to 250 μm and confines thermal injury to a mere 200 μm depth. This modality accomplishes swift, precise tissue cutting and vaporization while inflicting minimal unintended thermal spread. Its superior hemostatic capacity additionally results in a clean, flat resection bed [14]. Conceptual and empirical work affirms that the en bloc approach excises the neoplasm in one intact piece, including the tumor proper and its base—a so-called "no-touch technique"—while routinely achieving the requisite depth to incorporate detrusor muscle (DM). In doing so, it aligns more closely with the oncological principle of "optimized resection with low residual tumor rates," which underpins cancer surgery [15]. Beyond safeguarding the specimen's architectural integrity for meticulous pathological staging [16], ERBT obviates repeated instrument traversals across the bladder, thereby curtailing mechanical provocation.

That said, the body of evidence has yet to characterize thulium laser ERBT's bearing on CRBD definitively. In this study, we juxtaposed the effects of thulium laser ERBT and conventional TURBT on CRBD frequency and intensity. Additionally, we evaluated postoperative discomfort and patient satisfaction to determine whether thulium laser ERBT offers a measurable advantage over standard TURBT in attenuating postoperative CRBD.

Materials and Methods

We conducted a retrospective compilation of demographic and clinical records for patients who underwent thulium laser ERBT and conventional TURBT at our institution from January 2022 through December 2024.

Eligible patients were aged 40–82 years and harbored histologically confirmed primary Ta or T1 NMIBC. Grounds for exclusion encompassed a prior diagnosis of bladder dysfunction (including neurogenic bladder,

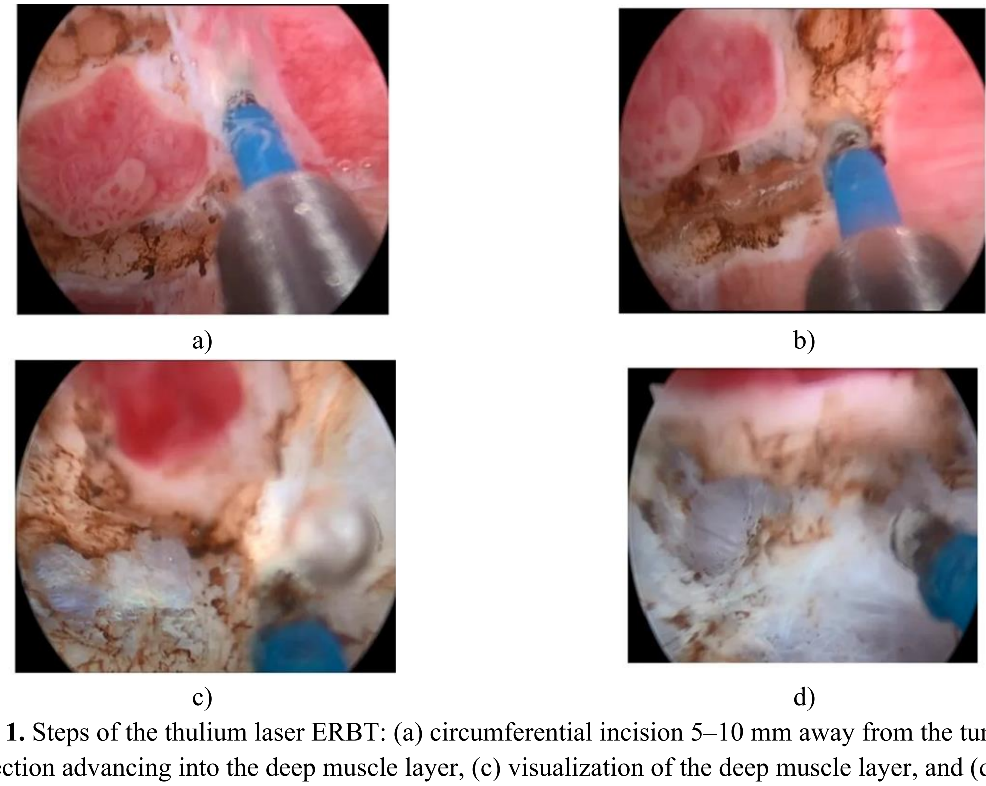
bladder outlet obstruction, or overactive bladder), the simultaneous presence of an upper tract urothelial carcinoma, pure carcinoma in situ, or imaging/pathology findings raising suspicion of muscularis propria invasion on computed tomography (CT) or magnetic resonance imaging (MRI), and recurrent NMIBC. The protocol received Institutional Review Board approval, and written informed consent was obtained from each participant. Standard TURBT was performed in a stepwise manner using bipolar electrocautery, consistent with the established technique at our center. The Thulium laser ERBT was performed using the en bloc methodology detailed below.

Operative methodology for thulium laser ERBT

The operative interventions were performed by two senior surgeons, who followed a consistent, internally harmonized procedural protocol.

During surgery, patients were positioned in lithotomy under either general or continuous epidural anesthesia, employing a 26 FR resectoscope with a continuous flow of normal saline irrigation. The thulium laser output was calibrated between 25 and 30W, with intraoperative modifications made based on tumor bulk and the site being dissected.

A detailed account of the operative steps for the thulium laser ERBT has been described in our prior publications [15, 16]. To summarize, the laser fiber was fed through the working channel of a continuous-flow resectoscope. Once the entirety of the bladder and any tumors had been closely inspected, a circular incision was traced around the lesion, preserving a safety border of approximately 5 mm. The cut was then deepened toward the underlying muscular planes, blending laser cutting with blunt separation achieved via the resectoscope's tip, progressively freeing the lesion before exposing and elevating the tumor base. Employing a "traction-and-countertraction" approach renders the surgical plane more visible and serves as a safeguard against perforating the bladder wall. At the discernible anatomical interface, muscle fibers were severed from the tumor base along multiple vectors. When minor bleeding occurred, the laser was used to coagulate the bleeding. Step by step, the entire tumor mass was liberated together with the detrusor muscle beneath its base. The complete specimen, inclusive of its base, was withdrawn whole through the sheath of the resectoscope—a concluding step of considerable importance. When the tumor's dimensions exceeded 3 cm, vertical sectioning into two or more fragments was carried out. Throughout the operation, maintaining identification of the deep muscle plane is crucial to circumvent perforation or loss of the visual field. The procedural sequence is shown in **Figure 1.**



a) b) c) d)

Figure 1. Steps of the thulium laser ERBT: (a) circumferential incision 5–10 mm away from the tumor base, (b) resection advancing into the deep muscle layer, (c) visualization of the deep muscle layer, and (d) en bloc resection nearly completed.

Once the surgery concluded, a 20 FR sterile Foley catheter was positioned, and its balloon was filled with 15 mL of distilled water. Following anesthetic recovery, the patient was transported back to the ward. Bladder irrigation was halted as soon as grossly visible hematuria resolved. The neoplastic tissue was dispatched for histopathological workup. Both study arms received intravesical Mitomycin-C instillation (40 mg dissolved in 50 mL saline) between postoperative days 4 and 6.

Outcome parameters

All study participants received thorough instruction regarding CRBD and the postoperative pain rating method from a designated research nurse who was masked to group allocation. The investigation's primary endpoint was the occurrence rate and intensity of CRBD at postoperative hours 1, 6, and 24. CRBD was defined as a urethral burning sensation accompanied by an urge to void, increased urinary frequency, and suprapubic aching discomfort. CRBD intensity was graded from mild to severe employing a classification system extensively utilized and validated in earlier post-TURBT CRBD literature [12]: ① mild—discomfort mentioned solely when prompted; ② moderate—unprompted expression of discomfort without accompanying behavioral reactions; ③ severe—spontaneously voiced discomfort combined with visible behavioral indicators, such as loud vocal expressions, thrashing limb movements, and tugging at the catheter [17].

Secondary outcome measures included the postoperative pain score—characterized as a tingling, aching sensation localized to the suprapubic region—at 1, 6, and 24 hours after surgery, along with patient-reported satisfaction at 24 hours postoperatively. Pain was quantified using the Visual Analog Scale (VAS), a well-established and reliable metric for assessing acute pain [12, 17], which consists of an unmarked line extending from 0 to 10 cm. A rating of 0 equaled absence of pain; 3 signified manageable pain permitting normal sleep; 5 denoted sleep-preventing, intolerable pain; 8 indicated involuntary posturing and autonomic instability; and 10 represented the most extreme, unbearable pain imaginable. Patients were asked to mark a point along the line that best matched their pain experience [11]. These descriptors were carefully defined to help patients distinguish suprapubic wound-related pain (a steady, dull ache) from CRBD (a urethral or suprapubic burning sensation associated with an urge to urinate). Patient satisfaction was measured using a 4-point Likert scale ranging from 1 (very satisfied) to 4 (very dissatisfied) [8].

Demographic and outcome information was systematically logged. Every procedure complied with pertinent guidelines and regulatory frameworks, including the Declaration of Helsinki. The protocol received approval from our hospital's Institutional Ethics Committee. All patients reviewed and endorsed the informed consent document. The study flow is depicted in **Figure 2.** Because the central objective of this research was to contrast CRBD following thulium laser ERBT and conventional TURBT among NMIBC patients, extended oncological follow-up data and survival outcomes were omitted from this report.

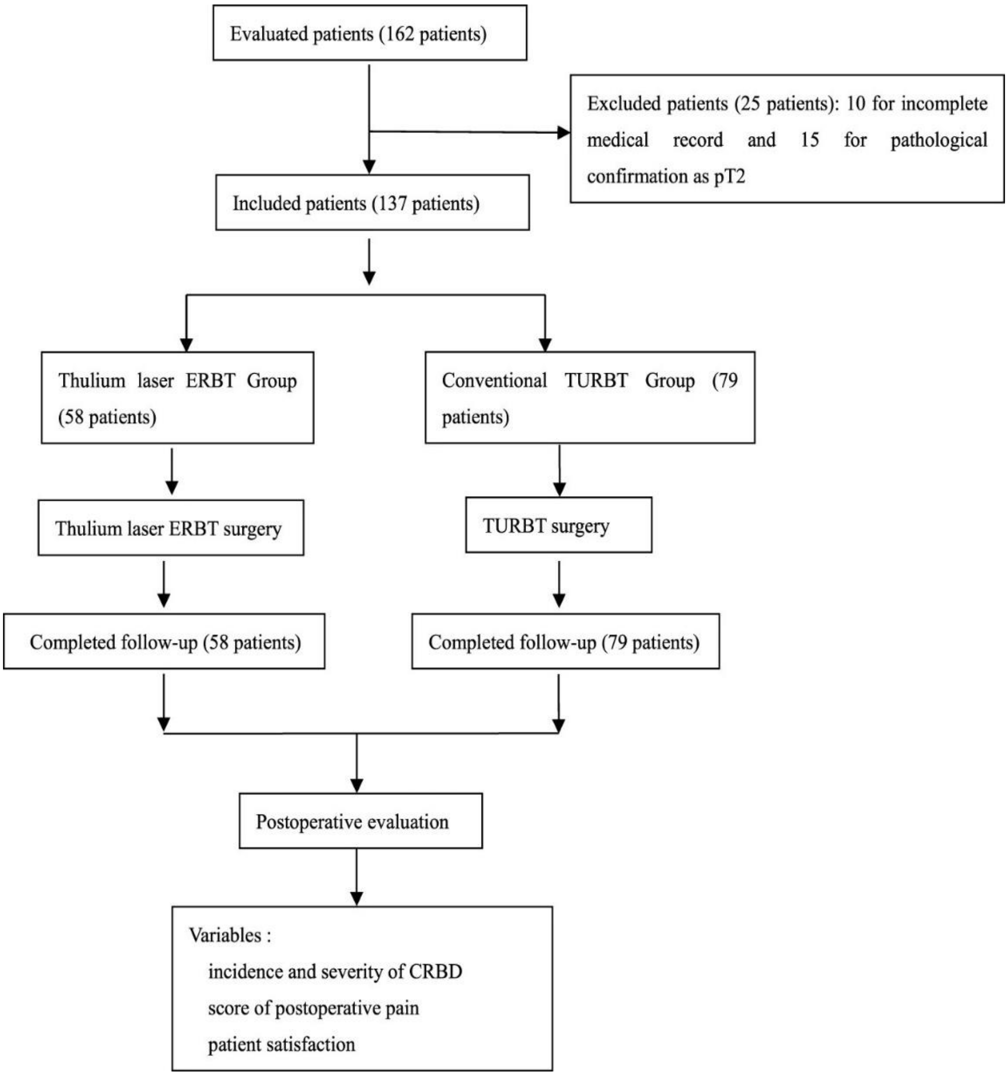


Figure 2. Study flow chart.

Statistical approach

Data analysis was carried out using SPSS version 18.0 (SPSS Inc., USA). Results are expressed as a number (%) or mean ± standard deviation. Variables conforming to a normal distribution were evaluated for between-group differences via Student's t-test. For categorical variables, between-group differences were assessed by means of Chi-square testing. A threshold of $P < 0.05$ was adopted to define statistical significance across all comparisons.

Results and Discussion

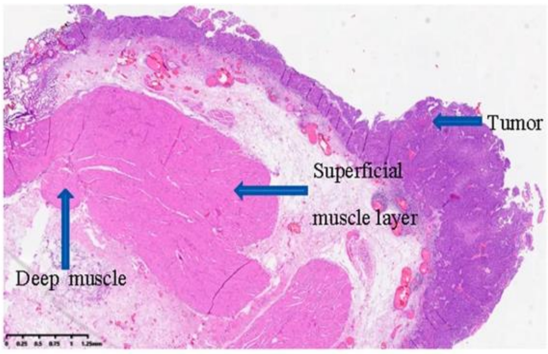
Of the initial 162 patients, 25 were excluded due to incomplete case documentation or definitive pathological upstaging to pT2 **(Figure 2).** In the final analysis, 79 patients constituted the conventional TURBT cohort, while 58 patients comprised the thulium laser ERBT cohort.

Patient baseline profiles and intraoperative parameters for both arms are summarized in **Table 1**. The table shows that age, sex ratio, tumor number, tumor size, and anatomical location were evenly distributed across groups ($P > 0.05$). The ERBT arm had a somewhat longer operative duration than the TURBT arm, though the disparity did not achieve statistical significance (30.9 ± 8.8 vs. 28.2 ± 8.0 min, P = 0.06). The Thulium laser ERBT was not complicated by any intraoperative adverse events, aside from a single bladder perforation sustained during the early phase of technique adoption. In the conventional TURBT arm, by contrast, 7 patients experienced obturator nerve reflex and 8 patients suffered bladder perforation. Intraoperative blood loss was markedly lower in the ERBT arm (25.3 ± 8.1 mL vs. 48.6 ± 12.4 mL, P = 0.001). On histopathological assessment, specimens from the ERBT group were more likely to contain detrusor muscle (91.4% vs. 78.5%, P = 0.04). A histopathology image of a thulium laser ERBT sample and a photograph of a postoperative gross specimen appear in **Figure 3.**

Postoperative irrigation duration was 9.9 ± 1.9 h in the ERBT group versus 11.1 ± 2.5 h in the TURBT group, a statistically significant difference (P = 0.001).

Table 1. Baseline characteristics and intraoperative variables of the study population.

Variable	P-value	TURBT group (n = 79)	ERBT group (n = 58)
Age (years)	0.26	65.8 ± 8.1	67.5 ± 8.5
Male/female	0.13	55/24	47/11
Duration of surgery (minutes)	0.06	28.2 ± 8.0	30.9 ± 8.8
Tumor size, number (%)			
< 3 cm	0.46	64 (81.0%)	44 (75.9%)
> 3 cm		15 (19.0%)	14 (24.1%)
Solitary/multiple mass	0.85	69/10	50/8
Tumor location, number (%)	0.56		
Lateral wall		39 (42.4%)	33 (48.5%)
Anterior wall		9 (9.8%)	6 (8.8%)
Posterior wall		15 (16.3%)	11 (16.2%)
Bladder neck		12 (13.0%)	7 (10.3%)
Trigone		10 (10.9%)	8 (11.8%)
Dome		7 (7.6%)	3 (4.4%)
Obturator nerve reflex (%)	0.02	7 (8.9%)	0
Bleeding volume during operation (mL)	0.001	48.6 ± 12.4	25.3 ± 8.1
Bladder perforation (%)	0.04	8 (10.1%)	1 (1.7%)
Detrusor presence (%)	0.04	62 (78.5%)	53 (91.4%)
Postoperative irrigation duration (hours)	0.001	11.1 ± 2.5	9.9 ± 1.9
Duration of indwelling urinary catheter (days)	0.07	2.4 ± 0.6	2.1 ± 0.5



a)

b)

Figure 3. A histopathological image of a thulium laser ERBT specimen and a photograph of a postoperative gross specimen: (a) H&E-stained section of a specimen (2 × 10), and (b) Postoperative gross specimen.

The postoperative CRBD occurrence rate and severity were lower in the ERBT group than in the TURBT group at hours 1 and 6 **(Table 2);** (P < 0.001). The intensity of CRBD was likewise milder in the ERBT arm than in the TURBT arm at these early time points (P < 0.001). At hour 24, no statistically significant difference persisted between the two groups in either the frequency or the severity of CRBD (P = 0.17).

Table 2. The incidence and severity of postoperative CRBD in the study population.

CRBD	P-value	TURBT group (n = 79)	ERBT group (n = 58)
Postoperative hours			
1 h			
Incidence (%)	< 0.001	67 (84.8%)	19 (32.8%)

Severity			
Mild		14 (17.7%)	11 (19.0%)
Moderate		38 (48.1%)	6 (10.3%)
Severe		15 (19.0%)	2 (3.4%)
6 h			
Incidence	< 0.001	60 (75.9%)	12 (20.7%)
Severity			
Mild		18 (22.8%)	8 (13.8%)
Moderate		32 (40.5%)	3 (5.2%)
Severe		10 (12.6%)	1 (1.7%)
24 h			
Incidence	0.17	20 (25.3%)	9 (15.5%)
Severity			
Mild		13 (16.4%)	7 (12.1%)
Moderate		6 (7.6%)	2 (3.4%)
Severe		1 (1.3%)	0

The VAS-measured postoperative pain scores were substantially depressed in the ERBT cohort compared to the TURBT cohort at 1 and 6 hours (1 h: 2.39 ± 1.02 vs. 3.05 ± 1.25, P = 0.001; 6 h: 2.03 ± 1.05 vs. 2.52 ± 1.26, P = 0.02), **(Figure 4).** By the 24-hour time point, no statistically significant separation was observed (1.83 ± 0.96 vs. 2.10 ± 0.83, P = 0.08).

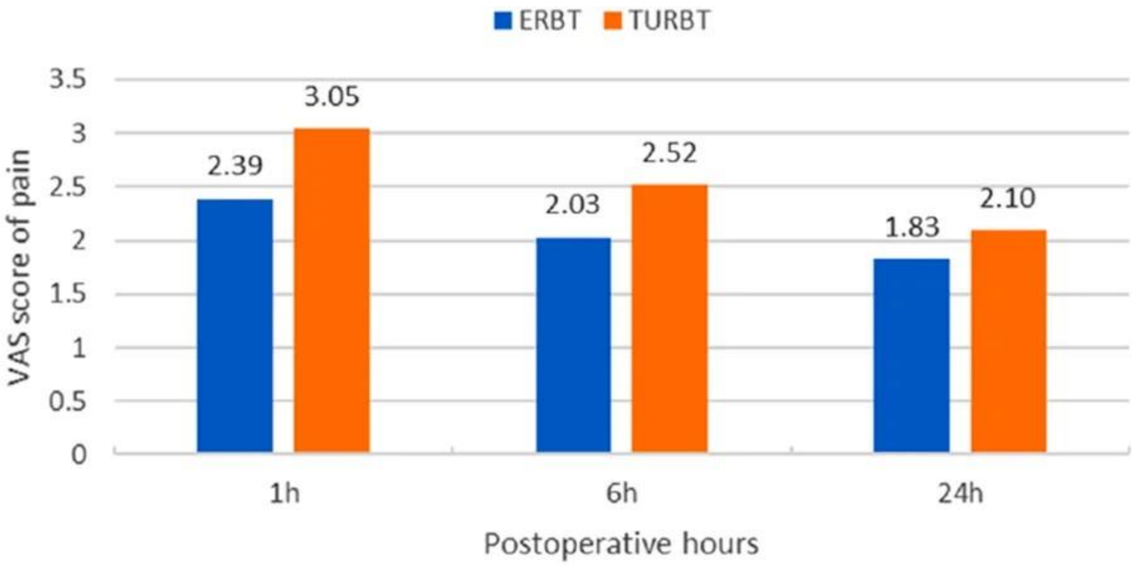


Figure 4. The VAS scores of postoperative pain in the study population.

Turning to 24-hour postoperative patient satisfaction as measured on a four-point Likert scale, the ERBT group's mean rating was significantly lower than that of the TURBT group (1.86 ± 0.73 vs. 2.19 ± 0.83, P = 0.02**); (Figure 5),** signifying that those who received thulium laser ERBT were more favorably disposed toward their surgical treatment.

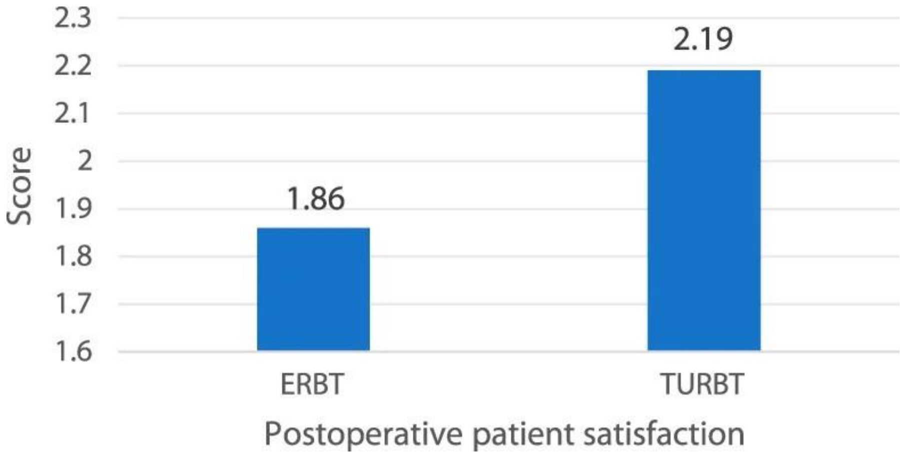


Figure 5. The postoperative patient satisfaction scores in the study population.

Catheter-related bladder discomfort in the postoperative period creates marked suffering for patients who require urinary catheterization and frequently triggers behavioral responses such as restlessness, loud verbal outbursts, thrashing limb movements, and even forceful attempts to dislodge the catheter, which can culminate in urethral damage and stricture disease. Beyond amplifying postsurgical pain and anxiety—thereby contributing to postoperative cognitive impairment and eroding patient satisfaction—CRBD also escalates demands on nursing and medical teams by potentially extending hospitalization and imposing avoidable strain on healthcare infrastructure.

The fundamental mechanisms governing CRBD development after TURBT remain only partly characterized. Current thinking implicates a confluence of factors in driving CRBD manifestations: ① Mechanical pressure applied by the Foley catheter balloon against the bladder neck and trigonal region. This activates afferent nerve terminals, producing electrical discharges that travel along lumbar nerve pathways and through the spinal cord before reaching central sensory centers, where they are perceived as pain and various forms of discomfort. ② Excessively distended catheter balloons, which intensify compression at the bladder neck and internal urethral orifice [11]. This readily sets off bladder spasms, leaving the patient with pain, distress, and a powerful sensation of needing to void. ③ A constitutionally diminished pain tolerance in some individuals, making them incapable of bearing the localized urethral irritation inflicted by the indwelling catheter. ④ Insufficient patient education concerning the purpose of the indwelling catheter and its proper handling, which magnifies both physical unease and psychological turmoil. And crucially, ⑤ inflammation driven by tissue disruption: catheter insertion, particularly following piecemeal tumor ablation, inflicts mechanical insult upon the bladder and urethral mucosa [17]. The traumatized urothelium releases pro-inflammatory cytokines and damage-associated molecular patterns (DAMPs), activating innate immune cascades (e.g., neutrophil and macrophage infiltration) and unleashing pro-inflammatory mediators such as prostaglandin E2 (PGE2). These mediators sensitize bladder sensory afferent fibers and augment detrusor muscle contractility, engendering postoperative pain, urgency, or bladder spasm [18]. Given the sudden onset and the erratic, episodic nature of bladder spasms after TURBT, no clinical strategies have yet been able to suppress or wholly avert their appearance. For now, therapeutic efforts concentrate principally on symptom palliation [2]. Nevertheless, in light of the potentially dangerous sequelae and the intrinsic risk profile of bladder cancer itself, existing treatment paradigms call for further optimization.

In the current study, our data revealed that for thulium laser ERBT, the occurrence rate of postoperative CRBD—whether categorized as mild, moderate, or severe—was appreciably diminished in comparison with standard TURBT at both 1 and 6 hours ($P < 0.001$), and CRBD severity was likewise significantly milder than that recorded in the TURBT cohort at these early assessment points ($P < 0.001$). The substantial curbing of CRBD conferred by thulium ERBT was attributed to its coupled benefits: the en bloc excision technique paired with a pronounced reduction in thermal insult.

When performing conventional TURBT, the tumor is dismantled in a fragmentary, “cut and scatter” approach, requiring multiple reinsertions of the resectoscope and piecemeal tumor removal. As a consequence, unfavorable outcomes may ensue—such as the risk of suboptimal tumor eradication—coupled with mechanical disturbance of the trigone and bladder neck, anatomical zones densely populated with M3 receptors. Beyond this, the electrocautery loop utilized in TURBT routinely causes tissue laceration and uneven wound beds, and the resultant rugged postoperative mucosal terrain amplifies frictional contact between the catheter and the bladder lumen. In sharp contrast, during thulium ERBT, the lesion is extracted intact, incorporating the base, the underlying DM, and a circumferential safety margin (a "no-touch technique"), thereby satisfying the oncological standard of "optimized resection with low residual tumor rates" for cancer surgery. The controlled cutting depth inherent to thulium ERBT eliminates repetitive trauma, and its limited tissue-penetrating reach produces smoother, more level wound contours, thereby preserving the submucosal nerve networks and microcirculatory bed. Tissue-based studies have corroborated that ERBT yields a coagulation zone of 0.3–0.8 mm (compared with 2–3 mm for TURBT), thereby reducing the release of PGE2 and interleukin-6 (IL-6), each of which acts as a principal driver of bladder hypersensitivity [19]. What is more, the smoother vesical surface attenuates physical provocation from the catheter, restraining detrusor overactivity and the accompanying CRBD symptoms [20]. These observations dovetail with our documentation of lower postoperative VAS scores in the ERBT arm (1 h: 2.39 ± 1.02 vs. 3.05 ± 1.25, P = 0.001; 6 h: 2.03 ± 1.05 vs. 2.52 ± 1.26, P = 0.02).

During TURBT, electrocautery more readily fosters widespread tissue necrosis and subsequent crust formation. With laser ERBT, conversely, a "coagulation layer" takes shape. Because the thulium wavelength falls much nearer to the water absorption peak, the absorbed energy rapidly seals small-caliber vessels (< 1 mm in diameter) and lymphatic channels in the course of tissue incision [21]. This instantly coagulated tissue plane provides superb hemostatic control, protects the adjacent normal mucosa and muscular layers, and mitigates damage to sensory nerve endings [15]. Thus, the preserved bladder wall architecture and mucosal function reduce nerve stimulation directly attributable to the catheter. Within our series, the shorter irrigation duration (ERBT vs. TURBT: 9.9 ± 1.9 h vs. 11.1 ± 2.5 h, P = 0.001) and diminished hematuria observed in the ERBT arm were understood to derive from the thulium laser's shallow tissue penetration and brisk vaporization–coagulation dynamics, thereby curtailing thermal disruption to the peritumoral vasculature.

Thermal injury remains a foremost concern in transurethral operative procedures, as excessive heat propagation may lead to unintended tissue necrosis, postoperative complications, and protracted recovery [22]. Clinical series have reported that thulium ERBT exhibits a conspicuously narrower thermal injury zone and minimizes collateral thermal effects [23]. This edge originates from the unique biophysical traits of the thulium laser. Owing to its specific wavelength, the thulium laser is avidly absorbed by water, and the synergy between the laser beam and water molecules yields efficient thermal effects for surgical cutting, vaporization, and coagulation, rendering the incision exceptionally precise. This sits in stark opposition to the deeper thermal destruction (one to three mm) wrought by monopolar or bipolar electrocautery in TURBT, which can subsequently intensify bladder hypersensitivity and hypercontractility [21]. In addition, the shallow penetration depth of the thulium laser curtails carbonization and necrosis at the resection margin while also facilitating more rapid mucosal repair. Research has established that reduced carbonization helps maintain the structural integrity of bladder mucosal strata [15], and the technique's precision ensures minimal disruption to the detrusor muscle and submucosal nerve plexuses. In aggregate, these properties subdue postoperative bladder wall irritation—a central element in CRBD pathogenesis. Furthermore, laser ERBT produces no electrical current flow, thereby sidestepping the occurrence of obturator nerve reflex, which stands as a meaningful advantage for bladder cancer patients in whom lateral wall tumors constitute a large fraction [24]. For TURBT, by contrast, elicitation of the obturator nerve reflex is a common adverse event, triggering abrupt leg jerking intraoperatively that can lead to iatrogenic bladder perforation [25], as was borne out in the present investigation.

Its superior impact on CRBD may additionally stem from the dampened inflammatory cascade associated with thulium laser ERBT. Standard TURBT relies on high-frequency electrical current, which produces extreme temperatures (300 °C–400 °C), inflicting deep coagulative necrosis and broad thermal conduction into adjacent tissue. A localized inflammatory reaction is consequently initiated, leading to bladder wall edema, heightened infection risk, and the release of pain-mediating substances that hypersensitize bladder afferent nerve fibers [8]. In contradistinction, thulium laser ERBT generates only a fine layer of tissue coagulation, and the degree of inflammatory change or tissue swelling is substantially less pronounced. This disparity has been substantiated by multiple investigations juxtaposing the inflammatory responses between laser-based ERBT and conventional TURBT [15]. In a clinical study, Jin *et al*. [26] examined how laser ERBT influenced inflammatory markers (TNF-α, IL-6) in NMIBC patients compared with TURBT. Following surgery, they documented that TNF-α and IL-6 concentrations in the ERBT cohort were lower than those in the TURBT cohort. They concluded that laser ERBT was superior to TURBT in terms of efficacy, as it attenuated patients' inflammatory responses [26]. Accordingly, the negligible edema and sparse inflammatory cell infiltration induced by laser ERBT serve to both curtail perioperative tissue necrosis and lower bladder mucosal sensitivity, thereby attenuating CRBD symptomatology.

This investigation carries several limitations that deserve acknowledgment. To begin with, its retrospective, single-institution framework is inherently susceptible to selection bias, as operative technique selection may be influenced by surgeon predilection or patient-specific variables not fully controlled for. In the second place, the cohort size, though adequate for preliminary contrasts, was comparatively limited, potentially limiting the external applicability of our observations and the statistical power to detect differences in secondary endpoints or uncommon adverse events. Third, evaluation of CRBD and pain—albeit conducted via validated instruments (VAS, CRBD severity grading)—depended upon patient self-report and clinical appraisal, which may be vulnerable to interpretive bias, particularly among older adults who might struggle to disentangle CRBD from surgical wound pain. The incorporation of additional objective biomarkers or urodynamic parameters could enhance future research. Fourth, the comparator TURBT procedure in this study was executed with bipolar electrocautery. Although this mirrors prevailing clinical practice, outcomes could differ if alternative energy platforms (e.g., holmium or green laser) were used. Finally, the technical proficiency gradient and equipment demands intrinsic to thulium laser ERBT could pose obstacles to broad adoption, particularly in environments where TURBT is the entrenched norm. As such, our data ought to be regarded as encouraging yet preliminary evidence, underscoring the imperative for rigorous, prospective, multicenter randomized controlled investigations, alongside evaluations of its extended oncological effectiveness and economic viability.

Conclusion

Our retrospective review indicates that, compared with conventional TURBT, thulium laser ERBT is associated with significant reductions in both the frequency and intensity of CRBD during the early postoperative period, lower postoperative pain ratings, and greater patient satisfaction. The en bloc approach and the thulium laser's restrained thermal damage profile likely underpin these advantages. Nonetheless, given the retrospective nature and single-center scope of this work, more definitive studies with expanded populations and prospective, randomized methodologies are necessary to corroborate these observations and determine the long-term clinical ramifications of this technique.

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Conflict of Interest: None

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Ethics Statement: The studies involving humans were approved by the Clinical Research Ethics Committee of Ningbo Urology and Nephrology Hospital. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

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