Research Article

Application of needle electrodes in *en bloc* resection of single bladder tumor

Qiang Cheng[1,2,3†], Bin Jiang[1,3,4†], Jinlu Tang[1,2,3†], Wenfeng Gao[1,3,4], Yanqi Liu[2,5], Fan Gao[1,3,4], Yin Lu[1,3,4], Yi Feng[1,2,3], Bingyang Guo[1,2,3], Xupeng Zhao[1,3,4], Qing AI[1,3*], Hongzhao Li[1,3*]

[1]Department of Urology, Chinese People's Liberation Army General Hospital, Beijing, 100039 China
[2]Department of Urology, Chinese People's Liberation Army Medical School, Beijing, 100853 China
[3]Senior Department of Urology, the Third Medical Center of People's Liberation Army General Hospital, Beijing, 100039 China
[4]Department of Urology, School of Medicine, Nankai University, Tianjin, 300071 China
[5]Department of Pathology, Chinese People's Liberation Army General Hospital, Beijing, 100853 China
[†]These authors contributed equally to this work.

Abstract

Background: Transurethral resection of bladder tumor is associated with some limitations when used in the diagnosis and treatment of non-muscle invasive bladder cancer. **Objectives:** This study explored the application of needle electrodes in the transurethral resection of single bladder tumor (SBT) and highlighted the advantages of *en bloc* resection of bladder tumors. **Methods:** A retrospective analysis was conducted on 79 patients with SBT treated at the Department of Urology, People's Liberation Army General Hospital, from January to December 2023. Among the patients, 64 (81.0%) were male, and 15 (19.0%) were female, with a mean age of 62.6 years. Among the patients, 68 (86.1%) had primary tumors, 11 (13.9%) had recurrent tumors, and 2 (2.5%) had SBTs following upper urothelial carcinoma radical resection. All patients underwent transurethral resection of bladder tumors using needle electrodes. **Results:** All procedures were successfully completed. The mean operation time lasted 51.0 min, and the mean blood loss was 7.9 mL. The median tumor size was 2 cm. The obturator nerve block was employed in 22 (33.8%) cases. The incidence of obturator nerve reflex was 40.9% (9/22) and 23.3% (10/43) without ($p = 0.139$). Post-operative complications included bladder tamponade in one patient (1.3%). The accuracy of muscle invasion reporting was 89.9%. Three patients were lost to follow-up, and two patients (2.6%) suffered from recurrence at 6 months. The median follow-up time was 13 months. **Conclusion:** Needle electrode resection for SBTs was highly safe, had low complication rates, and offered accurate tumor staging, resulting in precise treatment and low postoperative recurrence.

Keywords: Needle electrodes, Single bladder tumors, Tumor staging, Precise treatment

1. INTRODUCTION

Bladder cancer remains a common malignancy across the globe, entailing effective and minimally invasive treatments. Non-muscle-invasive bladder cancer (NMIBC) accounts for roughly 70% of organ-localized bladder cancers, with 20–25% of NMIBC patients having an unfavorable prognosis [1-4].

While transurethral resection of bladder tumors (TURBT) is a cornerstone procedure for NMIBC, it is subject to some limitations. TURBT does not always provide accurate information regarding muscle invasion, often requiring a secondary surgical intervention. If the incision is deep, complications such as bladder wall perforation or bleeding may result [5-8]. The introduction of needle electrodes for *en bloc* resection of bladder tumors (ERBT) offers a refined alternative to TURBT and is superior to traditional resection techniques in terms of efficacy, safety, and outcomes.

***Corresponding authors:**
Qing AI (aiqing301@foxmail.com)
Hongzhao Li (urolancet@126.com)

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2. PATIENTS AND METHODS

2.1. Study population

This retrospective study examined 79 patients (≤ cT2N0Mo) with SBTs treated at the Department of Urology, people's Liberation Army (PLA) General Hospital, from January to December 2023. The cohort included 64 males (81.0%) and 15 females (19.0%) with a mean age of 62.59 years (±21.92). Of these, 68 cases (86.1%) had primary tumors, 11 (13.9%) developed recurrent tumors, and two (2.5%) were SBTs following radical resection of upper urothelial carcinoma. Some patients only received intravesical instillation of pirarubicin after the initial surgery, and none received systemic chemotherapy (Table 1).

2.2. Indications

It is generally accepted that virtually all NMIBC patients, except those at very high risk, are amenable to maximum TURBT surgery [9]. There are no absolute contraindications to TURBT with needle electrodes. According to the expert consensus of the Chinese Bladder Cancer Consortium, maximum TURBT may also be performed in selected patients with muscle-invasive bladder cancer who are candidates for bladder-preserving treatment [10].

2.3. Perioperative care and surgical technique

Routine pre-operative examinations were conducted for all patients to exclude surgical contraindications, and the bladder tumor was graded as a single occurrence with stage ≤ T2N0M0. Inclusion criteria involved: (i) single bladder tumor; (ii) Eastern Cooperative Oncology Group physical status score of 0 or 1; and (iii) no distant metastasis. Exclusion criteria were: (i) patients with other tumors or serious underlying diseases; (ii) metastatic bladder cancer; and (iii) patients with incomplete clinical data. All patients provided written informed consent, and all relevant details were obtained. The study was approved by the Ethics Committee of the Third Medical Centre of Chinese PLA General Hospital (No. S2022-700-01). All surgeries were performed by two senior surgeons using needle electrodes.

Table 1. Baseline, operative, and tumor information

Parameter	*n*	%
Male	64	81
Female	15	19
Operation time (mean±SD minutes)	51.04±18.38	
Bleeding (mean±SD mL)	7.90±0.71	
Tumor		
Primary tumor	68	86.1
Recurrent tumor	11	13.9
After UTUC	2	2.5
Neck opening and anterior wall	3	3.8
Trigonum	1	1.3
Lateral wall	65	82.3
Posterior parietal wall	10	12.6
Tumor size (median [range] cm)	2 (1.5–3)	

Note: Data are presented as frequency (*n*) and percentage (%) unless specified otherwise. UTUC: Upper tract urothelial carcinoma.

In performing TURBT with needle electrodes, the resection area was initially marked with electrocoagulation. A circular incision was then made around the marked area, extending to the bladder muscle layer to separate it from the surrounding bladder mucosa. The tumor was subsequently separated from the bladder wall, using a passive separation method, between the layers of the bladder wall. During this process, if connective tissue or muscle fibers were attached, they might be electrically cut. The tumor was then separated into both the deep and superficial muscle layers (a process known as ERBT) of the bladder. Blunt separation reduces electrical stimulation and the risk of obturator nerve reflex, while providing direct visualization of the depth of tumor invasion. If the tumor had invaded deeply, significant adhesion could be observed during the blunt separation, making the process more challenging (Figure 1).

2.4. Statistical analysis

Perioperative data were collected, including operation time, amount of blood loss, tumor location, and size, use of obturator nerve block or not, presence of obturator nerve reflex, post-operative complications, post-operative hospital stay, pathological results, bladder muscle involvement, and tumor recurrence. Continuous data are presented as median and range or mean and standard deviation, while categorical data are expressed as count and percentage. Chi-square tests were conducted where appropriate. Data were analyzed using Statistical Package for the Social Sciences Statistics 25.0 (IBM, United States).

3. RESULTS

All procedures were successfully completed using needle electrodes without conversion to open surgery. The mean operation time lasted for 51.04 ± 18.38 min, and the mean intraoperative blood loss was 7.90 ± 0.71 mL. Tumor locations were as follows: bladder neck opening and anterior wall in three (3.8%) cases, the trigone in one (1.3%) case, left and right lateral walls in 65 (82.3%) cases, and the posterior parietal wall in 10 (12.6%) cases. The median tumor size under microscopy measured 2 cm (range: 1.5–3 cm). For tumors located in the left and right

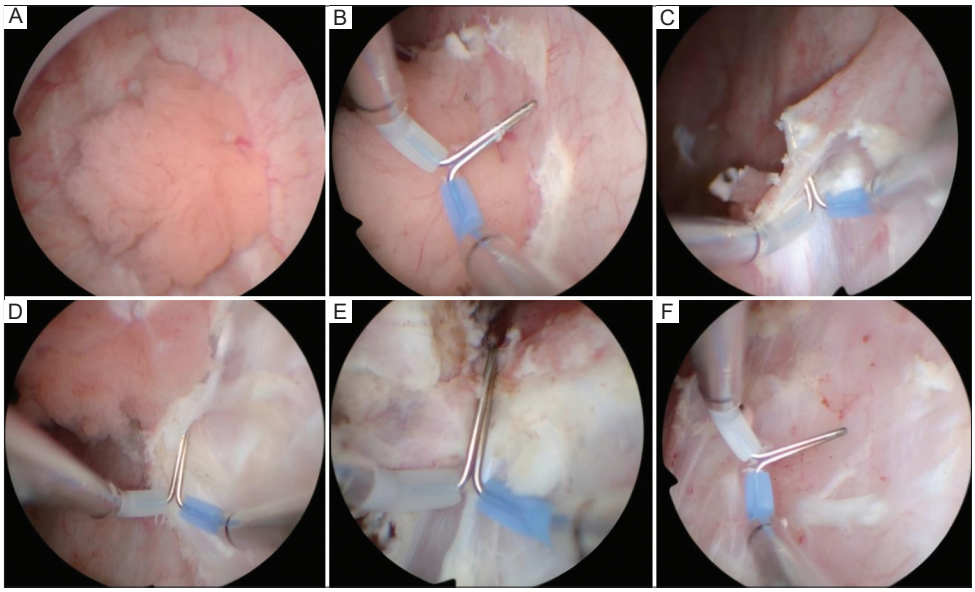

Figure 1. Needle electrode *en bloc* transurethral resection of bladder tumor (ERBT). (A) Bladder tumor in the left lateral wall, (B) Using electrocoagulation to mark the resection area 0.5 cm outside the tumor (C) Electrical incision to the bladder muscle layer, so that it was separated from the surrounding bladder mucosa, with the electrode being directed away from the bladder wall (D) The tumor was separated between the deep and shallow muscles of the bladder (ERBT), and a sharp cut was made to disentangle the dull and indivisible muscles (E) Preemptive treatment of basal blood vessels with electrocoagulation (F) Complete resection.

lateral walls, 22 (33.8%) patients received intraoperative obturator nerve block, and 19 (29.2%) patients experienced intraoperative obturator nerve reflex. One (1.5%) patient developed an intraoperative bladder perforation (Table 1). In the obturator nerve block group, the incidence of obturator nerve reflex was 40.9% (9/22), whereas in the group without obturator nerve block, the incidence was 23.3% (10/43). No significant difference was found between the two groups ($\chi^2 = 2.193$, $p = 0.139$) (Table 2). In addition, one (1.3%) patient required a second operation due to post-operative bladder tamponade. The median length of hospital stay was 1 day. Pathological findings were as follows: Five (6.3%) cases of urothelial papilloma with low malignant potential, 35 (44.3%) cases of low-grade urothelial carcinoma, 29 (36.7%) cases of high-grade urothelial carcinoma, and 10 (12.7%) cases of mixed high- and low-grade urothelial carcinoma. Regarding the pathological stage, 46 (58.2%) patients had Ta stage, 26 (32.9%) had T1, six (7.6%) had T2, and in one (1.3%) patient, the stage was unknown. Muscle layer invasion was pathologically detected in 71 (89.9%) cases, and in eight (10.1%) cases, no muscle invasion was found. The accuracy of muscle invasion detection was 89.9% (Table 3).

Post-operative treatment included bladder perfusion with appropriate drugs or surveillance as per clinical guidelines. In patients with T2-stage tumors, three underwent radical cystectomy, while the other received systemic treatment for bladder preservation (two patients were in stage T2 and one in stage T1). A follow-up (median 13 months, range 7–18 months) of 76 patients without radical cystectomy revealed that three patients were lost to follow-up. Two (2.6%) patients suffered from recurrence at 6 months after surgery and were treated accordingly. No tumor recurrence was found in the remaining patients.

Table 2. Sample size with and without obturator nerve block and with and without obturator nerve reflex

Group	With obturator nerve reflex (*n*)	Without obturator nerve reflex (*n*)	Group (*n*)	% with obturator nerve reflex
Group A	9	13	22	40.9
Group B	10	33	43	23.3
Obturator nerve reflex (*n*)	19	46	65	29.2

Notes: Group A: Obturator nerve block group. Group B: Group without obturator nerve block. χ^2=2.193, p=0.139.

Table 3. Pathological information

Type/stage of carcinoma	*n*	%
Urothelial papilloma with low malignant potential	5	6.3
Low-grade urothelial carcinoma	35	44.3
High-grade urothelial carcinoma	29	36.7
Mixed high- and low-grade urothelial carcinoma	10	12.7
Ta	46	58.2
T1	26	32.9
T2	6	7.6
Tx	1	1.3
Muscle invasion	71	89.9
Total cases	79	100

4. DISCUSSION

In 2000, Ukai *et al*. for the first time, proposed the use of a modified "J"-shaped electrode used for TURBT. Since then, there have been relatively few reports in the international literature regarding the use of needle electrode TURBT [11]. Needle electrodes have gradually been adopted in bladder tumor surgery in China, where they offer advantages such as improved detection rates of the muscle layer invasion, reduced bladder perforation rates, and lowered post-operative recurrence rates [12,13]. Our study was the first research to accurately record intraoperative obturator nerve block and obturator reflex, demonstrating that the tumor could be precisely separated in both the deep and superficial muscle layers of the bladder, a procedure known as ERBT. In addition, specialized pathologists were involved in examining each single pathological specimen to ensure accurate assessment of muscular invasion and minimize interpretation errors.

Bladder wall damage, or even perforation, due to obturator nerve reflex is a serious complication of TURBT, potentially leading to severe consequences such as massive bleeding, conversion to open surgery, and even tumor metastasis [7]. In recent years, new technologies, including various lasers, have been increasingly introduced into bladder tumor surgery. Although laser technology can eliminate the risk of obturator nerve reflex, it may vaporize tissue, resulting in inaccurate pathological staging [13]. Our findings showed that the probability of obturator nerve reflex occurring in lateral bladder tumors was 23.3% without obturator nerve block and 40.9% with obturator nerve block (with no statistically significant difference found between the two groups). This particular result suggested that needle electrodes could reduce the risk of obturator nerve reflex, thereby improving the safety of the procedure. Needle electrodes used for TURBT can better expose the tumor base and allow the energy electrode to be moved away from the bladder wall by rotating the electrode. This action reduces the likelihood of obturator reflex and improves the safety of surgery. In addition, by controlling the flow of water in and out of the bladder, the bladder wall can be thickened, keeping it away from nerves and blood vessels. Intermittent and brief use of the electrodes, along with careful control of the surgical field, minimizes the risk of serious complications such as obturator nerve reflex.

Accurate pathological diagnosis of muscle invasion is critical for determining the need for post-operative adjuvant therapy, as well as whether re-TURBT or radical cystectomy is required. Traditional ring electrodes often require repeated resections, which can lead to the scorching of the tumor's muscle layer. Moreover, tissue fragmentation may result in misjudgment of muscle tissue status during examination, hindering accurate pathological staging. In contrast, TURBT with needle electrodes provides better exposure of the tumor base and tumor depth can be more accurately assessed through sharp cutting and blunt dissection. Precise cutting and *en bloc* resection enable pathologists to obtain complete specimens, from the bladder mucosa to the muscle layer, thereby improving the detection rate of muscle invasion. In our study, muscle layer invasion was detected in 89.9% of pathological reports, compared to 36–51% in traditional TURBT, with which muscle tissue was lacking [14]. This improved detection rate reduces the need for re-TURBT and helps develop appropriate follow-up treatment plans [15]. In addition, the precise and complete resection of a tumor from its base is conducive to the manipulation of tumor blood vessels, reducing intraoperative bleeding, and improving visibility in the surgical field, thereby shortening the operation time.

In our study, the post-operative recurrence rate was 2.6%, with no tumor recurrence within 3 months, which was much lower than the reported recurrence rates of 10.9–19.5% with needle electrodes and 10.7–22.9% for ring electrodes [8,16,17]. We are led to conclude that advances in surgical techniques, adjuvant drug therapy, and clinical support have contributed to improved cure rates in general and in particular, the needle electrode's ability to completely and accurately remove the tumor lowers the risk of tumor spread and residual disease, further validating the benefits of needle electrode surgery. While general anesthesia may reduce obturator reflex to some extent, it cannot entirely eliminate the risk and may be associated with higher recurrence rates [18,19]. Therefore, the use of needle electrodes may not require highly specific anesthesia techniques and can ensure relative safety and reduce the recurrence of tumors associated with anesthesia methods.

Our study has some limitations. We only reviewed the safety and efficacy of needle electrodes in TURBT for single, small-volume bladder tumors over a short follow-up period. In future studies, we will assess the safety and efficacy of this approach in larger tumors and more complex surgeries, and conduct prospective trials comparing needle electrodes with traditional ring electrodes.

5. CONCLUSION

The use of needle electrodes for single bladder tumor resection can reduce the incidence of obturator nerve reflex, minimize intraoperative bleeding and complications, lower the post-operative recurrence rate, and provide a highly accurate assessment of muscle invasion. In addition, it allows for precise tumor staging and treatment. These

advantages render it a promising approach for clinical application.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

Conceptualization: Hongzhao Li
Data curation: Qiang Cheng, Bin Jiang, Jinlu Tang, Wenfeng Gao, Qing AI, Fan Gao, Yin Lu, Yi Feng, Bingyang Guo, Xupeng Zhao
Formal analysis: Qiang Cheng, Bin Jiang, Jinlu Tang, Wenfeng Gao, Fan Gao, Yin Lu, Yanqi Liu
Writing–original draft: Qiang Cheng, Bin Jiang, Jinlu Tang
Writing–review & editing: Qing AI, Hongzhao Li

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Ethics Committee of the Third Medical Centre of Chinese PLA General Hospital. All patients provided written informed consent, and all relevant details were discussed with the patients before obtaining their consent. The ethical approval number is S2022-700-01.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA

Data used in this work are available from the corresponding author on reasonable request.

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