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Preoperative selective arterial embolization followed by transurethral resection of bladder tumor for large bladder tumors: Early clinical experiences

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Purpose: Transurethral resection of bladder tumor for large tumors (≥5 cm) is challenging, even for experienced surgeons, due to increased risks of transfusion, bladder perforation, and incomplete resection. We developed a sequential strategy involving preoperative selective arterial embolization (SAE) followed by transurethral resection to address these challenges.

Materials and Methods: This retrospective study evaluated patients who underwent preoperative SAE followed by transurethral resection for non–muscle-invasive bladder cancer at two tertiary hospitals between 2021 and 2024. Potential candidates were patients newly diagnosed with large bladder tumors (longest diameter of the main mass ≥5 cm) and suspected non–muscle-invasive bladder cancer on preoperative studies.

Results: Eleven patients (mean age, 73.2 years) were included in this study. The mean tumor size was 5.78 cm (range, 5.0–8.0 cm). SAE was performed on the day of surgery in seven cases (63.6%) and 1–4 days before surgery in four cases (36.4%), and complete tumor resection was successfully achieved in all cases. The mean operative time was 78.8 minutes (range, 33–149 minutes). No complications related to transurethral resection or SAE, including the need for transfusion or reoperation, were observed. Pathology results revealed Ta in six cases and T1 in five cases. Disease recurrence occurred in six patients (54.5%); however, none demonstrated disease progression during a median follow-up of 24 months (range, 6–44 months).

Conclusions: Our early experiences demonstrated that preoperative SAE followed by transurethral resection for large non-muscle-invasive bladder cancers may be a feasible approach for achieving complete resection without complications.

Keywords: Embolization, therapeutic; Transurethral resection of bladder; Tumor burden; Urinary bladder neoplasms

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INTRODUCTION

Transurethral resection of bladder tumor (TURBT) is the gold standard for treating non–muscle-invasive bladder cancer (NMIBC). While a tumor size of ≥3 cm is an established risk factor for recurrence and disease progression, most NMIBC cases are potentially curable with adequate TURBT and, if necessary, subsequent intravesical therapies [1-3].

In clinical practice, performing TURBT on large bladder tumors (≥5 cm) is highly challenging, even for experienced surgeons, often leading to significant complications. A large cohort study involving nearly 18,000 patients demonstrated that larger tumors (≥5 cm) are associated with a higher likelihood of postoperative complications, including urinary tract infections, transfusions, acute renal failure, blood clots, and sepsis, compared with smaller tumors [4]. This study further highlighted that the length of hospital stay, reoperation rates, readmissions, and mortality following TURBT were significantly higher in the large bladder tumor group compared with those in the smaller tumor group.

Larger bladder tumors pose a significant challenge for complete resection. Significant bleeding during TURBT diminishes the quality of the camera view, and poor visualization, combined with the high tumor burden, increases the likelihood of complications such as prolonged operation time, bladder perforation, inadequate hemostasis, and incomplete resection. Consequently, endoscopically uncontrollable large bladder tumors may be considered candidates for radical cystectomy, even in cases of NMIBC [5]. However, when preoperative imaging strongly suggests a large but noninvasive bladder tumor, surgeons may still be inclined to pursue bladder-preserving approaches.

Selective arterial embolization (SAE) involves blocking segmental arteries that supply the targeted area. In urology, preoperative SAE is occasionally performed for large renal masses with complex vascular supplies, and to shrink prostate before benign prostatic hyperplasia surgeries [6]. This technique minimizes the risk of perioperative bleeding, thereby reducing the operation time and improving the visibility of the surgical field. The safety of renal arterial embolization is well documented in the literature. With this background, we developed a hybrid technique involving SAE prior to TURBT for bladder tumors ≥5 cm for enabling safe and complete TURBT. Furthermore, this technique has the potential to reduce tumor recurrence and disease progression. Herein, we present our early experiences with this sequential approach, involving preoperative SAE followed by TURBT for larger tumors, as performed at two tertiary hospitals.

MATERIALS AND METHODS

1. Study population

All research was performed in accordance with relevant guidelines/regulations. The requirement for written informed consent was waived by the Institutional Review Board of Gangnam Severance Hospital (approval number: 3-2024-0455) owing to the retrospective design of the study. This study was conducted in accordance with the Declaration of Helsinki (2013) and was approved by the Institutional Review Board of Gangnam Severance Hospital after a review of the study protocol (approval number: 3-2024-0455). We retrospectively reviewed clinical and pathological data from patients who underwent preoperative SAE followed by TURBT for NMIBC at two tertiary hospitals (Gangnam Severance Hospital and Seoul St. Mary's Hospital) between 2021 and 2024. Potential candidates for this sequential approach included patients newly diagnosed with large bladder tumors, with the longest diameter of the main mass measuring ≥5 cm, and suspected NMIBC based on findings from computed tomography and/or magnetic resonance imaging (MRI). Patients with equivocal findings of muscle layer invasion were included; however, those with obvious evidence of muscle invasion or extravesical extension were excluded.

2. Preoperative SAE and TURBT

Preoperative SAE was performed prior to TURBT either on the day of surgery or the preceding day. SAE using local anesthesia was avoided patients who were unable to remain still, had a contrast agent allergy, or exhibited significant renal insufficiency. SAE was performed in a standard manner. A common femoral artery puncture was performed, followed by selective angiography using a microcatheter and microguidewire to visualize the feeding vessels of the bladder tumor. SAE was performed using gel foam particles, polyvinyl alcohol particles, embosphere microspheres, and microcoils. The embolic agents were selected at the discretion of an interventional radiologist.

TURBT was performed under general anesthesia using 24 Fr or 26 Fr resectoscopes, following standard procedures, by two expert urologic surgeons (K.S.C. and S.H.H.). Bipolar cutting-loop electrodes were used for tumor resection and cauterization. Efforts were made to achieve complete and deep resections. Bipolar mushroom-like electrode was used for bleeding control if needed. Following TURBT, a 3-way Foley catheter was inserted, and continuous bladder irrigation was initiated. The timing of the Foley catheter removal

and hospital discharge was carefully determined at the physician's discretion. For patients diagnosed as pT1, high grade, re-TURBT was performed according to the American Urological Association's guidelines.

3. Data collection

Basic clinical information, such as sex, age, and smoking history, was collected. The size and number of tumors were determined based on endoscopic findings and imaging studies. Data on the timing of SAE, embolic agents used, completeness of TURBT, operation time, duration of postoperative catheterization, duration of hospital stay, pathological results, and complications related to SAE and TURBT were extracted from medical records. Preoperative and postoperative hemoglobin and serum creatinine levels were evaluated. During follow-up, the use of intravesical therapy, recurrence, and disease progression were also investigated.

4. Statistical analysis

All analyses were descriptive. Continuous variables were summarized as mean with ranges, and categorical variables (if applicable) as counts and percentages. Medians and ranges were calculated using SAS System for Windows, version 9.4 (SAS Institute). Box plots were generated using GraphPad Prism, version 10.6.0 (GraphPad Software).

RESULTS

1. Patient demographics

A total of 11 patients were included in this study. Table 1 summarizes their clinical information and demographics. Among the patients, 10 were male and one was female. The mean age was 73.2 years (range, 50–88 years). All patients had an Eastern Cooperative Oncology Group performance status score of 0. Regarding smoking status, six patients (54.5%) were non-smokers, three (27.3%) were ex-smokers, and two (18.2%) were current smokers. All patients were newly diagnosed with bladder cancer.

2. Perioperative results

Two representative cases are shown in Figs. 1 and 2. In both cases, preoperative imaging identified large bladder tumors with distinct vascular characteristics, enabling targeted SAE. Subsequent TURBT procedures achieved complete tumor resections without complications, as shown in the figures. The mean tumor size was 5.78 cm (range, 5.0–8.0 cm). SAE was performed on the day of surgery for seven cases (63.6%), 1 day prior for three cases (27.3%), and 4 days prior for one case (9.1%). Complete tumor resection was successfully achieved in all cases. The mean operative time was 78.8 minutes (range, 33–149 minutes). The mean hemoglobin change between preoperative and postoperative measurements was -0.76 g/dL, while the mean change in serum creatinine was -0.055 mg/dL. Estimated blood loss was minimal in nine cases (81.8%), while the remaining two cases (18.2%) had an estimated blood loss of 100 mL or less. No complications related to TURBT or SAE, such as the need for transfusion or reoperation, were observed. Notably, our uropathologist found that TURBT specimens obtained after preoperative SAE were histologically comparable to the typical TURBT specimens routinely examined at our institution.

Table 1. Summary of clinical and pathological features (n=11)

Variable	Value
Sex, male	10 (90.9)
Age (y)	73.2 (50–88)
Prior history of smoking	5 (45.5)
Prior history of bladder cancer	0 (0.0)
Tumor size (cm)	5.78 (5.0–8.0)
Number of tumors	
1	3 (27.3)
2–4	4 (36.4)
>5	4 (36.4)
Timing of embolization	
The day of TURBT	7 (63.6)
1 day before TURBT	3 (27.3)
4 day before TURBT	1 (9.1)
Operation time (min)	78.8 (33–149)
ΔHemoglobin (g/dL)	-0.76 (-2.6–0.6)
ΔSerum creatinine (mg/dL)	-0.055 (-0.28–0.22)
TURBT related complication	0 (0.0)
Embolization related complication	0 (0.0)
Duration of catheterization (d)	4.8 (1–8)
Postoperative length of stay (d)	2.7 (1–8)
Pathologic results	
Ta, low grade	5 (45.5)
Ta, high grade	1 (9.1)
T1, low grade	1 (9.1)
T1, high grade	4 (36.4)
Intravesical therapy	4 (36.4)
Recurrence	6 (54.5)
Progression	0 (0.0)

Values are presented as number (%) or mean (range).
TURBT, transurethral resection of bladder tumor.

3. Postoperative outcomes

The mean duration of postoperative catheterization was 4.8 days, and the mean postoperative hospital stay was 2.7 days. Pathology results showed that five cases (45.5%) were Ta, low grade; one case (9.1%) was Ta, high grade; and four cases (36.4%) were T1, high grade. Re-TURBT was performed

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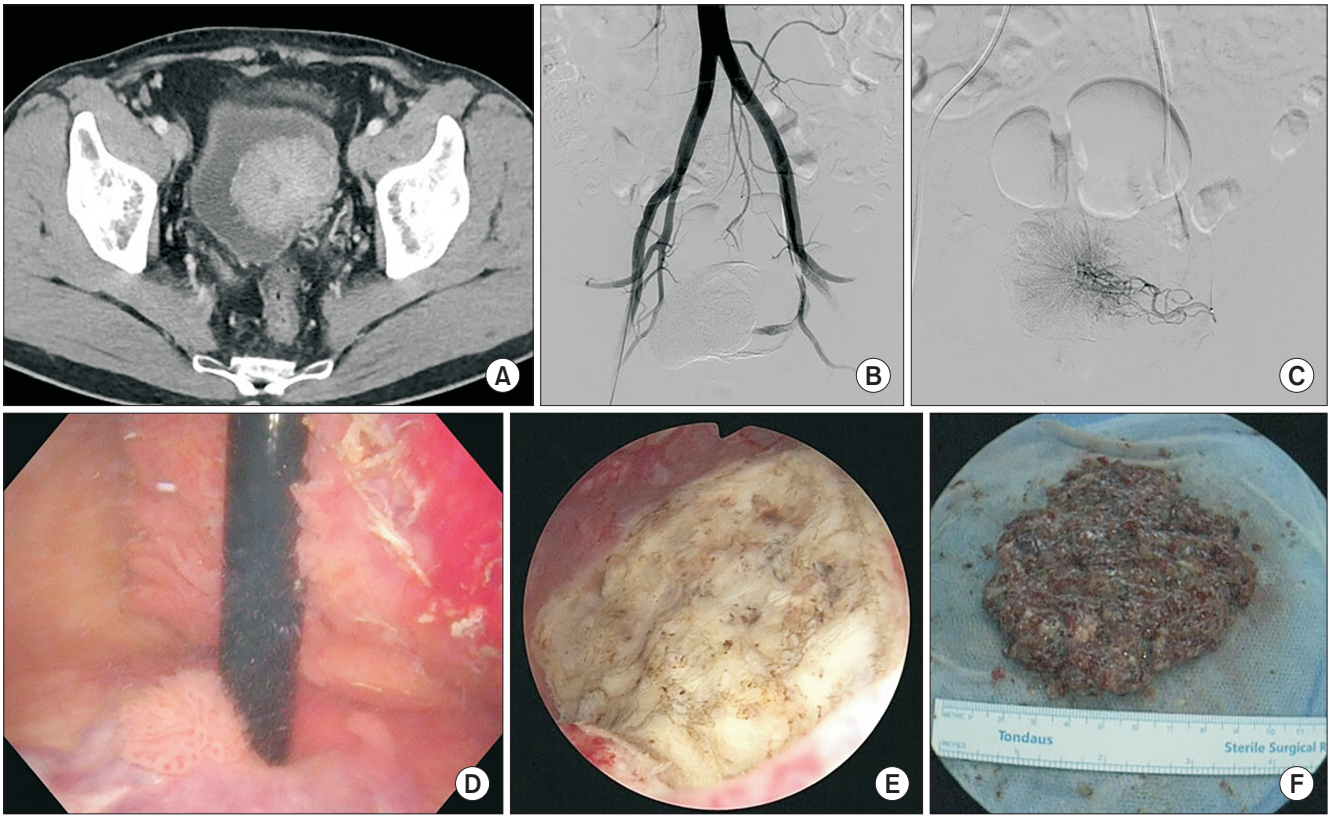

Fig. 1. A representative case managed with selective angioembolization followed by transurethral resection of bladder tumor (TURBT). Preoperative computed tomography reveals a large bladder tumor on the left lateral wall (A), whereas preoperative cystoscopy identifies two masses (D). (B, C) Angiography demonstrates a tumor-feeding vessel that was successfully embolized. (E) TURBT is performed to achieve a complete resection without complications. (F) The volume of the postoperative resected tissue highlights the substantial size of the tumor.

in the four pT1, high grade patients, revealing no residual tumor. Two patients experienced recurrence at 3 and 4 months postoperatively, despite receiving intravesical instillation of Bacillus Calmette–Guérin (BCG). The remaining four patients had not received intravesical therapy; recurrence occurred at 3, 6, 8, and 42 months postoperatively. Nevertheless, no cases demonstrated disease progression during a median follow-up period of 24 months (range, 6–44 months). We have added box plots for the visual demonstration of our data in Supplementary Fig. 1.

DISCUSSION

SAE is currently the standard technique for the clinical management of hypervascular and inoperable tumors [7]. Preoperative SAE is used to minimize intraoperative blood loss and facilitate surgical resection for various tumor types, including spinal tumors, brain tumors (e.g., meningiomas and hemangioblastomas), paragangliomas (e.g., glomus jugulare tumors and carotid body tumors), hepatocellular carcinoma, and renal cell carcinoma. In urology, SAE is used to reduce lesion size and control bleeding. For kidney tumors, it is employed to treat angiomyolipoma and control tumors prior to partial or radical nephrectomies [8]. In advanced prostate cancer, prostatic artery embolization helps control lower urinary tract symptoms and bleeding, and reduces tumor size prior to radical prostatectomy, external beam radiation therapy, or brachytherapy [9]. For bladder diseases, SAE is used to control intractable hemorrhage secondary to radiation cystitis or chemotherapy-induced cystitis [10]. We aimed to perform SAE, targeting tumor-feeding vessels originating from the superior or inferior vesical arteries prior to TURBT. The procedure was successfully completed in all patients. During TURBT, most tumors appeared pale, indicating embolization-induced ischemic changes. Through our initial experiences, we have shown that preoperative SAE followed by TURBT for large bladder tumors (≥5 cm) is a safe procedure. It facilitates complete resection, reduces operative time, and improves surgical visualization by minimizing bleeding.

Although TURBT remains the gold standard for treating NMIBCs, which is potentially curative, NMIBC recurrence rates remain high, with recurrence observed in 15%–61% of cases at 1 year and 31%–78% at 5 years post-TURBT [11].

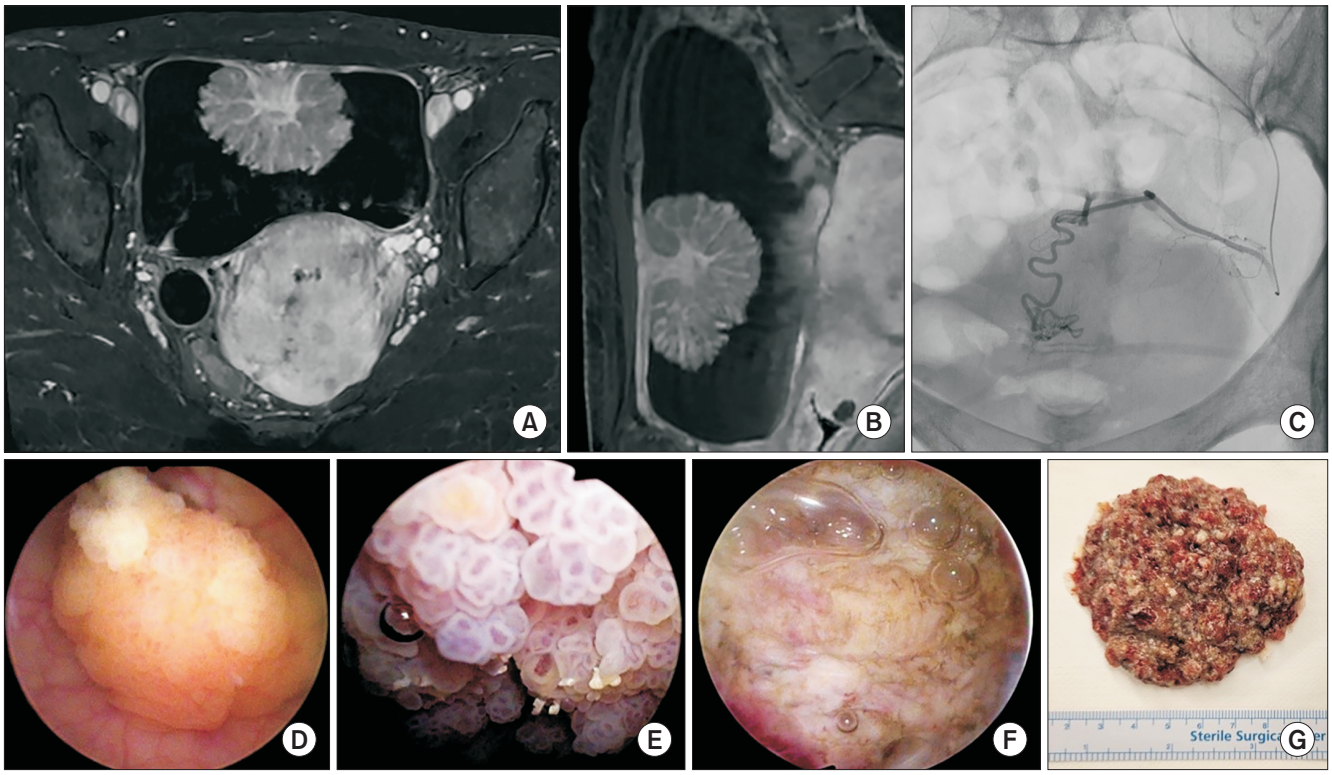

Fig. 2. Another representative case managed with selective angioembolization followed by transurethral resection of bladder tumor (TURBT). (A, B) Preoperative magnetic resonance imaging reveals a large bladder tumor on the anterior wall and a small bladder tumor on the posterior wall. (C) Angiography demonstrates a feeding vessel to the anterior wall tumor that is successfully embolized. Cystoscopy reveals that the unembolized posterior wall tumor remains vascularized (D), whereas the embolized anterior wall tumor appears pale (E). (F) Complete TURBT is performed without complications. (G) The gross photograph of the resected tissue indicates the significant size of the tumor.

To mitigate the risk of recurrence, ensuring quality control during TURBT—particularly through the initial detection of all lesions and achieving complete resection—is crucial [12,13]. Even when clinically suspected to be NMIBC, very large bladder tumors present significant challenges during TURBT because of extensive bleeding and difficult hemostasis. These factors increase the risk of bladder perforation or incomplete resection, potentially leaving residual tumors. Golan et al. [14] reviewed 4,144 TURBT cases and found that bladder perforations occurred most frequently when tumors were large and located posteriorly. In their study, the average volume of the tumor removed during TURBT was 5.2 cm^3 (range, 0.5–20 cm^3) [14]. Furthermore, bladder perforation during TURBT for superficial tumors is associated with shorter disease-free survival and progression of the T stage [15]. Therefore, performing a safe and complete TURBT is essential for managing NMIBCs.

Another advantage of this approach, aside from facilitating complete resection, is its potential to reduce recurrence risk. Although this study involved a small patient population with varying follow-up periods, recurrence and progression rates were notably low, especially considering the large tumor sizes. One mechanism for bladder cancer recurrence is tumor reimplantation. Therefore, we hypothesized that ischemic and pro-apoptotic changes induced by SAE may reduce the recurrence rate. Preoperative SAE has already been proven to lower recurrence risks in meningioma, supporting the potential applicability of this approach. Prolonged operation time is known to be a risk factor for developing urethral stricture after transurethral resection of the prostate [16-18]. By reducing operation time through SAE, the risk of urethral stricture is lessened. Furthermore, this hybrid method could be integrated into the trimodality therapy to facilitate maximal tumor resection during TURBT [19-21].

Several concerns may arise with SAE, such as downstaging, embolization-associated artifacts, or misinterpretations. However, in our study, the pathologists encountered no such issues and confirmed that the tissue samples were comparable to conventional post-TURBT specimens. Although prolonged intervals between SAE and TURBT might raise concerns regarding pathology, our findings showed no significant differences between embolized and conventional TURBT specimens. SAE was mostly performed on the day of TURBT or 1 day before TURBT. These short latencies

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between SAE and TURBT do not compromise the specimen quality or lead to tumor downgrading. Furthermore, SAE may reduce thermal artifacts because cauterization artifacts often lead to understaging of urothelial cancer in large bladder tumors [22]. SAE potentially improves pathological accuracy by reducing the need for cauterization. Another potential concern is ischemic damage to the bladder wall. However, in our study, no such changes or abnormal bladder wall thinning were observed during follow-up, likely due to the use of vascular embolization rather than chemoembolization, which has a higher likelihood of affecting the normal tissues. Recently, Yamada et al. [23] also reported the effectiveness of transarterial embolization prior to TURBT in 13 patients with bladder tumors larger than 4 cm, showing reduced intraoperative blood loss and shorter operative times without significant complications. Their findings are largely consistent with ours, which involved 11 patients with bladder tumors larger than 5 cm. They suggested a tumor diameter of ≥4 cm as the criteria for performing SAE before TURBT, and their cohort included approximately half of the cases with muscle-invasive disease. In contrast, our study included only patients with NMIBC, and based on our experience, we suggest a threshold of 5 cm.

Fundamental concerns regarding the necessity of SAE may arise. Highly experienced surgeons might successfully perform TURBT on large tumors without significant obstacles by approaching the tumor base, cutting, and cauterizing repeatedly to minimize bleeding. This could avoid the additional medical costs associated with preoperative SAE. However, in real-world practice, TURBT for large (≥5 cm) and multiple tumors often inevitably leads to significant bleeding, exacerbated by multiple feeding vessels, where achieving effective bleeding control can be far more challenging than anticipated. Additionally, owing to tumor size, direct access to the tumor base is difficult or even impossible. In our study, two surgeons with over 15 years of expertise in bladder cancer and academic practice experienced immense benefits from preoperative SAE. Furthermore, this approach could be particularly valuable for novice surgeons, enabling them to perform surgeries more precisely, with greater confidence and safety.

Additional concerns include the potential acute kidney injury from contrast agents during SAE or infections caused by vessel punctures and manipulation. However, no SAE-related complications occurred in our patients. The cost of SAE may vary depending on the country and insurance system, and in some cases, it may significantly increase medical expenses. Nevertheless, when considering the bleeding risk, prolonged operative time, the inherent risk of bladder perforation and repair, increased hospitalization, and potential necessity for cystectomy due to incomplete TURBTs, the cost of SAE may ultimately be lower than these risks. At a median follow-up of 24 months, cystoscopic evaluation revealed no evidence of mucosal necrosis or ulceration in the bladder, thereby alleviating concerns regarding long-term ischemic complications of SAE. Therefore, careful candidate selection and balancing cost-effectiveness are crucial. In particular, patients with large NMIBCs (≥5 cm) may derive the greatest benefit from our approach. Recently, shorter tumor contact length at the tumor base on MRI has been reported to be associated with a lower risk of MIBC [24-26]. Thus, large tumors with shorter contact lengths may be ideal candidates for our sequential approach to ensure complete TURBT.

Our study has several limitations. First, the sample size was relatively small, which may have affected the generalizability of our findings. Additionally, we focused exclusively on treatment-naïve and newly diagnosed bladder tumors, which may not represent cases with extensive prior treatments or repeated TURBTs. In such scenarios, the 5 cm threshold used in this study may not be universally applicable, and further research is needed to determine whether SAE could benefit smaller tumors in more complex cases. Notably, this hybrid approach, involving preoperative SAE followed by TURBT, requires coordination and should be performed in hospitals with skilled interventional radiologists. Moreover, due to the BCG shortage, routine administration of postoperative intravesical instillation of BCG is not feasible. Finally, although our results are promising, validation and replication through larger, multi-center studies are needed to strengthen the evidence and broaden applicability.

CONCLUSIONS

For significantly large bladder tumors, with the longest diameter of the main mass measuring ≥5 cm in the present study, preoperative SAE followed by TURBT appears to improve resection completeness and surgical safety. Large comparative studies are required to validate our findings.

CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHORS' CONTRIBUTIONS

Research conception and design: Sung-Hoo Hong and Kang Su Cho. Data acquisition: Sungun Bang, Seung-Moon Joo, Do Kyung Kim, Jong Kyou Kwon, Seokhwan Bang, Dongho Shin, Jinhyung Jeon, Sung-Hoo Hong, and Kang Su Cho. Statistical analysis: Sungun Bang and Kang Su Cho. Data analysis and interpretation: Sungun Bang, Sung-Hoo Hong, and Kang Su Cho. Drafting of the manuscript: Sungun Bang and Seung-Moon Joo. Critical revision of the manuscript: Sung-Hoo Hong and Kang Su Cho. Administrative, technical, or material support: Seung-Moon Joo, Do Kyung Kim, Jong Kyou Kwon, Seokhwan Bang, Dongho Shin, and Jinhyung Jeon. Supervision: Sung-Hoo Hong and Kang Su Cho. Approval of the final manuscript: all authors.

SUPPLEMENTARY MATERIAL

Supplementary material can be found via https://doi.org/10.4111/icu.20250352.

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