Uro-Technology Journal 2026; 10(2): 33-35 ***33***
DOI: 10.31491/UTJ.2026.06.057

EDITORIAL

The price and promise of robotic surgery: are we over-prioritizing technology?

Francesco Greco[a, b, *]

[a] *Urology Unit, Centro Salute Uomo, Bergamo, Italy.*
[b] *Department of Urology, Policlinico Ponte S. Pietro, Gruppo Ospedaliero S. Donato, Bergamo, Italy.*

The rapid proliferation of robot-assisted surgical systems represents one of the most significant technological transformations in modern urology. Since the FDA approval of the da Vinci Surgical System in 2001, robotic surgery has been enthusiastically adopted worldwide, with over 8 million procedures performed as of 2024. Yet an uncomfortable truth is gradually emerging: despite the staggering costs of this technology—$1.5–2.5 million capital investment per system, $100,000–150,000 in annual maintenance, and $1,500–3,500 in disposable instrument costs per case—its clinical advantages over conventional laparoscopic surgery remain remarkably difficult to substantiate. Are we using the most expensive tools to achieve the most marginal gains? The articles assembled in this issue provide a timely opportunity to critically examine this question across four key domains—benign prostatic hyperplasia (BPH), pheochromocytoma/paraganglioma (PPGL), urethral strictures, and upper urinary tract urolithiasis.

For BPH, robot-assisted simple prostatectomy (RASP) was hailed as a paradigm shift over laparoscopic simple prostatectomy (LSP). Yet the evidence paints a more nuanced picture. Li *et al.* [1], in a meta-analysis of 1,928 patients, found that while RASP reduced hospital stay by 1.20 days and achieved superior Q_{max} improvement, there were no significant differences in operative time, blood loss, catheterization time, or overall complications compared to LSP—leading to the conclusion that treatment choice should depend on device availability and surgeon expertise rather than clinical superiority alone [1]. Pandolfo *et al.* [2], in over 6,500 patients, confirmed that RASP has become a size-independent treatment for large prostate glands, duplicating the functional outcomes of open surgery with a better safety profile. However, compared to LSP, the latter remains a valid lower-cost option, though it demands solid laparoscopic skills and is therefore unlikely to spread widely [2]. Compared to laser enucleation of the prostate (EEP), RASP offers a shorter learning curve but suffers from longer catheterization time and length of stay [2]. In other words, RASP's value depends entirely on what it is being compared to—and in the comparison that matters most for cost-conscious healthcare systems (RASP *vs.* LSP), the advantages are marginal at best. Is a 1.2-day hospital reduction and modest Q_{max} improvement worth the $2,000–$4,000 incremental cost of robotics?

For PPGL excision, the question is equally pointed. Mehta *et al.* [3], in this issue, report on 24 patients from a tertiary center in India—6 robotic and 18 laparoscopic cases. Mean operative time was significantly longer in the robotic group (190.0 *vs.* 143.3 minutes, $P = 0.021$)—nearly 47 minutes more. Yet hospital stay was comparable, and both approaches achieved 100% biochemical cure rates with no recurrences. The authors acknowledge robotic surgery may benefit complex locations (bladder, thoracic extension), but emphasize that poor insurance penetration means most patients bear substantial out-of-pocket costs [3]. Choosing robotic surgery for a standard para-aortic paraganglioma when laparoscopy offers equivalent outcomes is not surgical excellence—it is surgical extravagance.

Urethral stricture surgery offers a striking contrast. Here, innovation has focused on optimizing classical techniques and identifying risk factors—a welcome reminder that surgical excellence is not synonymous with technological sophistication. Plamadeala *et al.* [4], in this issue, report on 70 patients with pelvic fracture urethral injuries treated with posterior urethroplasty at Ghent University Hospital. After a median follow-up of 130 months, recurrence occurred in 15.8% of patients, and the 10-year recurrence-free survival rate was 83.8%. In multivariate analysis, postoperative complications (HR = 4.85, $P = 0.007$) and persistent urinary extravasation (HR = 6.36, $P = 0.006$) significantly increased recurrence risk [4]. Postoperative complications occurred in 21.4% of patients, all of which were low-grade and managed conservatively. Erectile dysfunction was present in 97.9% due to trau-

* Corresponding author: Francesco Greco
Mailing address: Urology Unit, Centro Salute Uomo, Via Palma il Vecchio 4a, 24122 Bergamo, Italy.
Email: francesco_greco@ymail.com
Received: 29 June 2026 / Accepted: 29 June 2026
Published: 30 June 2026

ma, with 12.2% improving postoperatively; *de novo* urinary incontinence occurred in 6.6% [4]. These findings underscore a fundamental truth increasingly lost in our technology-obsessed era: understanding patient-specific risk factors—such as identifying those at highest risk of recurrence—and optimizing postoperative care often yields greater clinical benefit than adopting expensive new machinery.

Similarly, in the field of urolithiasis, Zambudio Munuera *et al.* [5], in this issue, provide a comprehensive contemporary review demonstrating that while new laser platforms (TFL, p-Tm:YAG) offer promising technical advantages, their definitive superiority over conventional Ho:YAG systems remains unproven. The authors emphasize that extracorporeal shock wave lithotripsy (ESWL) remains a guideline-endorsed first-line option for appropriately selected patients, and that treatment selection should be driven by stone burden, anatomy, patient comorbidities, and local expertise—not by technological fashion [5]. Ying *et al.* [6] further demonstrate that for stones > 2 cm, non-papillary access approach retrograde intrarenal surgery (NPAA-RIRS) and percutaneous nephrolithotomy (PCNL) yield comparable final stone-free rates, with NPAA-RIRS offering advantages in reduced complications (lower hemoglobin drop, transfusion rates, and overall complications), while PCNL offers shorter operative time, higher initial stone-free rate, and lower secondary procedure rate [6]. Together, these findings reinforce that in urolithiasis—as in other domains—meaningful progress comes not from adopting the newest technology, but from individualized decision-making based on patient-specific factors and the understanding that each technique offers distinct trade-offs.

What emerges is a sobering reality: the robotic revolution in urology has produced, at best, context-dependent benefits while imposing substantial costs on healthcare systems and patients. For BPH, RASP offers clear advantages over open surgery and a shorter learning curve than laser EEP, but only marginal benefits over LSP—and at a significant cost premium. For PPGL, as Mehta *et al.* [3] demonstrate, robotic surgery offers no measurable oncological benefit while increasing operative time by 47 minutes—with benefits, if any, limited to select complex cases. For urethral strictures, as Plamadeala *et al.* [4] show, the most meaningful predictors of success are postoperative complications and persistent extravasation—factors related to patient management and healing, not to the technology platform. For urolithiasis, Zambudio Munuera *et al.* [5] and Ying *et al.* [6] illustrate that multiple techniques achieve comparable outcomes, and the choice should be driven by patient-specific factors rather than technological fashion. The costs are not trivial: a robotic system requires $1.5–2.5 million capital investment, $100,000–150,000 annual maintenance, and $1,500–3,500 per-case disposables. Mehta *et al.* [3] illustrate the equity crisis: poor insurance penetration means most patients pay out-of-pocket. When a procedure that offers marginal or context-dependent benefit comes at a cost many cannot afford, we must question whether such adoption aligns with the ethical principles of justice and equity that underpin medical practice.

The time has come to ask not "can we use robotic surgery?" but "should we?" Li *et al.* [1] show that for BPH, RASP and LSP offer comparable outcomes, with choice depending on device availability and surgeon expertise—not clinical superiority. Pandolfo *et al.* [2] demonstrate that RASP is a size-independent treatment with clear advantages over open surgery, but LSP remains a valid lower-cost option with high technical demands, and laser EEP offers shorter catheterization at the cost of a longer learning curve. Mehta *et al.* [3] demonstrate both techniques achieve 100% cure for PPGL, with robotic offering no advantage except in complex cases. Plamadeala *et al.* [4] remind us that outcomes in urethral surgery are driven by patient-specific risk factors and postoperative care—not by the technological platform. Zambudio Munuera *et al.* [5] and Ying *et al.* [6] illustrate that treatment selection in urolithiasis should be driven by patient-specific factors and the understanding that each technique offers distinct trade-offs—not by technological fashion. Surgeons should resist the pressure to adopt robotic surgery where evidence of superiority over existing, lower-cost alternatives is lacking; maintain proficiency in laparoscopic, open, and endoscopic techniques rather than becoming dependent on a single robotic platform; and ensure training programs cultivate competence in multiple surgical approaches. Healthcare systems should implement evidence-based guidelines for technology adoption with independent assessment of clinical benefit and cost-effectiveness. The future of urological surgery should be one of thoughtful, evidence-based, patient-centered decision-making—not blind technological pursuit.

Declarations

Availability of data and materials: Not applicable.

Financial support and sponsorship: None.

Conflicts of interest: Francesco Greco is a member of the editorial board of *Uro-Technology Journal*. The author declare that they have no conflicts and were not involved in the journal's review or decision regarding this manuscript.

Ethical approval and informed consent: Not applicable.

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Cite this article as: Greco F. The price and promise of robotic surgery: are we over-prioritizing technology?. *Uro-Technology Journal*, 2026, 10(2): 33-35. doi: 10.31491/UTJ.2026.06.057