Review

ClinicalPractice

Minimizing complications in endourological surgery

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Practice points

- A thorough preoperative assessment is mandatory to avoid untoward occurrences.
- Untreated urinary tract infection and uncorrected coagulopathy are the only absolute contraindications for endourological procedures.
- While choosing the optimal percutaneous access computed tomography urography is the key to define the renal and surrounding visceral anatomy along with the distribution of the stone bulk.
- Correct padding of pressure points is paramount in preventing pressure injury.
- With development of smaller ureteroscopes and new energy sources, the complications associated with ureteroscopy have decreased considerably.
- High irrigation pressures during endourological procedures can lead to bacteremia and should be avoided.
- Following existing anatomical landmarks during transurethral procedures avoids complications.
- Knowing when to stop and to stage the endourological procedure is of paramount importance to avoid complications.

The development of newer minimally invasive technologies has led to a paradigm shift in management of urological diseases. Although endourological procedures are effective, they too have their own set of complications. The aim of this study is to review contemporary literature and outline the various protocols one can utilize to prevent and mitigate complications in endourological procedures. This article is divided into three major portions covering percutaneous nephrolithotomy, ureteroscopy and transurethral resections. Untreated urinary tract infection and uncorrected coagulopathy are the only absolute contraindications for endourological procedures. Following existing anatomical landmarks during the procedure avoids complications. Finally, last but not the least, knowing when to stop and to stage the procedure is of paramount importance to avoid complications in endourological procedures.

Keywords: complications • endourology • imaging • laser • nephrolithotomy • percutaneous • resection • transurethral • ureteroscopy • urolithiasis

The development of newer minimally invasive technologies has led to a paradigm shift in management of urological diseases. With the rise of endourological surgery, open surgery has become almost obsolete in routine practice. Although endourological procedures are effective, they too have their own set of complications. The age-old adage 'prevention is better than cure' holds true even today. Complications not only add substantial morbidity to the patient but also add significant cost to the treatment process as well. The aim of this study is to review contemporary literature and outline the various protocols one can utilize to prevent and mitigate complications in endourological procedures.

Future Medicine part of fsg

Methods

A MEDLINE search was performed using the keywords: 'endo urology', 'complications', 'prevention', 'urolithiasis', percutaneous nephrolithotomy ('PCNL'; 'PNL'), 'percutaneous', 'nephrolithotomy', 'ureteroscopy', 'flexible', transurethral resection of the prostate ('TURP'), 'transurethral', transurethral resection of bladder tumor 'TURBT') and 'resection'. Additionally, textbooks such as Campbell Walsh Urology (10th Edition) [1] and Smith's Textbook of Endourology (3rd Edition) [2] among others, were also utilized for reviewing relevant chapters. The European Association of Urology (EAU) [3] and American Urological Association practice guidelines [4] were also reviewed for the purpose of the study. This article is divided into three major portions covering PCNL, ureteroscopy and transurethral resections.

Minimizing complications in PCNL

Preprocedural checks

While choosing the optimal percutaneous access, computed tomography (CT) urography with or without 3D reconstruction is the key to define the renal and surrounding visceral anatomy along with the distribution of the stone bulk [5]. According to the EAU guidelines (Urolithiasis Update, 2013) preprocedural imaging with a contrast study is recommended if removal of stones is planned and the anatomy of the renal collecting system needs to be assessed (level of evidence LE]: 3; grade of recommendation [GR]: A). Furthermore, a contrast-enhanced CT scan is preferable because it enables 3D reconstruction of the collecting system, as well as measurement of stone density and skin-to-stone distance (Figure 1) [6].

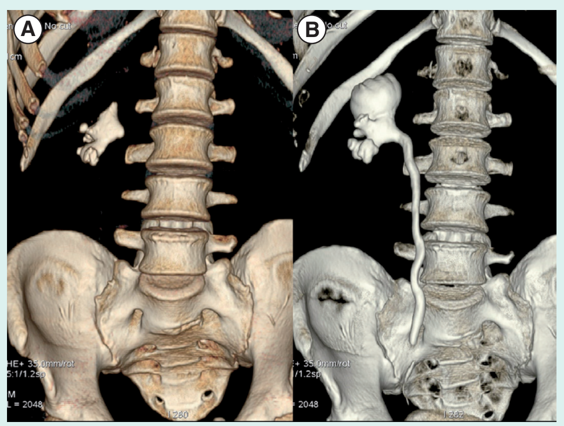

Figure 1. Computed tomography urography with 3D reconstruction. 3D reconstruction of **(A)** the plain and **(B)** the delayed excretory phases of computed tomography urography showing the distribution of the renal staghorn calculus in pelvis and calices. Detailed planning of the appropriate access site can be done on the basis of the reconstructed collecting system anatomy.

The routine general anesthesia contraindications are applicable for PCNL as well [6]. Careful pre- and post-operative monitoring is required for patients on anticoagulant therapy [6]. Because of the risk of significant hemorrhage, all forms of anticoagulant therapy must be stopped before PCNL [6]. Untreated urinary tract infection (UTI) and uncorrected coagulopathy are the only absolute contraindications for PCNL [7]. Whenever platelet counts are below 80,000/dl, a preoperative platelet transfusion is required to correct the thrombocytopenia [8]. Also, whenever international normalized ratio values are more than 1.5 they should be corrected with transfusion of fresh frozen plasma immediately prior to PCNL [9].

Postoperative fever for a transient period occurs in approximately 30% patients of PCNL. In patients treated with suitable prophylactic antibiotics, the incidence of sepsis is less than 3% [10–16]. Korets *et al.* found on multivariate analysis that positive pelvic urine or stone cultures, stone burden greater than 10 cm^2 and multiple punctures were the important risk factors for development of sepsis [16]. Korets *et al.* also found that 33% of patients who had positive intraoperative pelvic urine cultures had negative cultures prior to surgery, highlighting the discordance between the two samples [16]. This discordance makes diagnosis and management of post-PCNL sepsis challenging due to difficulty in selection of appropriate antibiotics. In conclusion, positive stone cultures and pelvic urine cultures are better at predicting urosepsis and hence routine collections of these are recommended [17]. Prophylaxis with appropriate antibiotics is valuable in patients with larger stones and hydronephrosis [18].

Intraoperative risk reduction strategies in PCNL

Choice of position

Surgeon preference usually dictates the choice of patient position and includes prone, supine, flank and modified supine positions. The traditional prone position used in PCNL has certain anethesiologic challenges, especially in patients with orthopedic deformities, cardiovascular or ventilatory problems in obese and hemodynamic instability (Figure 2) [19,20]. Correct padding of pressure points is paramount in preventing pressure necrosis (Figure 2). Similarly, minimizing hyperextension of extremities with appropriate head and neck positioning can avoid peripheral nerve injuries and visual disturbances [21]. Recent meta-analyses have shown supine position to be equally safe and efficacious as the prone position. The incidence of colonic injury was 0.5% in supine position, which was similar to that in prone [22–24].

Risk of radiation

In a study by Majidpour *et al.*, highest radiation exposure was received by the surgeon himself, maximum to legs and minimum to eyes. The assistant received lesser radiation, with the nurse receiving the least radiation [25]. The principles of as low as reasonably achievable (ALARA) should be adhered to whenever possible. Last-image hold, pulsed fluoroscopy (image refreshed in continuous mode at 30 frames/s) and surgeon-controlled fluoroscopy should be employed to decrease radiation [26]. Several modifications, such as acquiring as few images as possible, precisely collimating the beam to the region of interest and limiting magnification, can be utilized to optimize fluoroscopy [26].

Type of access

The long-standing debate on urologist versus radiologist gained access is far from over. A study by Watterson *et al.* found significantly higher complication rate in radiology access group (27.7 vs 8.3%) in spite of the fact that none of the patients in the radiology group required multiple tracts versus 14% in the urologist access group [27]. In a study from Egypt, there was no significant difference between urology or radiologist access groups as far as the stone clearance and complications rates were concerned [28]. Tomaszewski *et al.* did a comparative study between urologist- and radiologist-guided access in 233 patients. They found a significantly greater overall stone-free rate was in the urology access group (99 vs 92.1%; $p = 0.033$) [29]. 36.8% of patients required additional tract placement at the time of surgery in the radiologist-obtained access as the existing tracts could not be utilized [29]. This correlated with the 33% of patients in the radiology group that had the access made for renal decompression in the first place [29]. In conclusion, urologists who do not perform their own access should be in close communication with the radiologist for optimal tract placement in case future PCNL is required. Also training in percutaneous access should be imparted during urology residency programs [28].

Falahatkar *et al.* have shown that totally ultrasound guided complete supine PCNL is possible even in patients with prior surgery [30] with advantages such as zero radiation, no requirement of contrast material, visualization of the layers of tissues during tract formation and decreased energy expenditure due to absence of a lead apron [30]. In the CROES study of 5806 patients of PCNL, it was found on univariate analysis that fluoroscopic-guided percutaneous access had a higher incidence of hemorrhage (13.1 vs 6.0%; $p = 0.001$), as compared with ultrasonography-guided access [31] but this difference on multivariate analysis was found to be due to a greater access sheath size (≥27 F) and multiple punctures [31]. Further randomized trials are required to decide the best modality for gaining percutaneous access. A study by Tzeng *et al.* comparing B-mode with color Doppler ultrasound access in large >35 mm renal stones had shown a significantly lower blood transfusion rate in the color Doppler group (2 vs 6%) [32].

Hemorrhage in PCNL

Acute hemorrhage secondary to injury to major renal vasculature is rare and occurs in <0.5% of cases mostly during initial access [10]. The ideal tract in PCNL is the one that traverses a posteriorly facing papilla tip (relatively hypovascular area) along the axis of the calyx toward the stone, with the least degree of angulation (Figure 2). Multiple points of access increase the risk of bleeding significantly when compared with single access (18.5 vs 7.5%; $p < 0.05$) [33]. In contrast to this finding, Aron *et al.* found PCNL monotherapy with multiple tracts in staghorn calculus to be safe and effective with few complications [34]. Whenever an upper calyx access is required as part of multiple accesses, puncture should be done in full expiration to minimize the chances of pleural injury [35]. Alternately a flexible nephroscope from existing lower calyx tract can be utilized to gain access to fragments in upper calyx.

Hemorrhagic complications are associated with multiple punctures, prolonged operative time, intraoperative complications, [36] pelvic perforation and multiple tracts [37]. With advances in the technique, blood transfusion rates have decrease from 6.9% in early series to 2% in contemporary literature [7,12,38,39]. Other risk factors include upper pole access, solitary kidney, staghorn calculus and an inexperienced surgeon [40].

Kukreja *et al.* have suggested tactics to reduce hemorrhage, such as ultrasound-assisted renal access, amplatz dilatation/balloon tract expanding systems, decreasing total operative time and staging the surgery for large-sized stones or occurrence of intraoperative complications. Using reduced tract size in children, nondilated systems, slender infundibulum and utilizing secondary tracts in a multitract PCNL may also reduce blood loss [37].

Organ injury

Visceral injury is rare (<1%) [10,12,41]. Injury to the pleura is far more common in upper-pole access as compared with lower-pole access due to its close proximity. Higher incidence of pleural injury was noted in supracostal as compared with infracostal puncture in a series

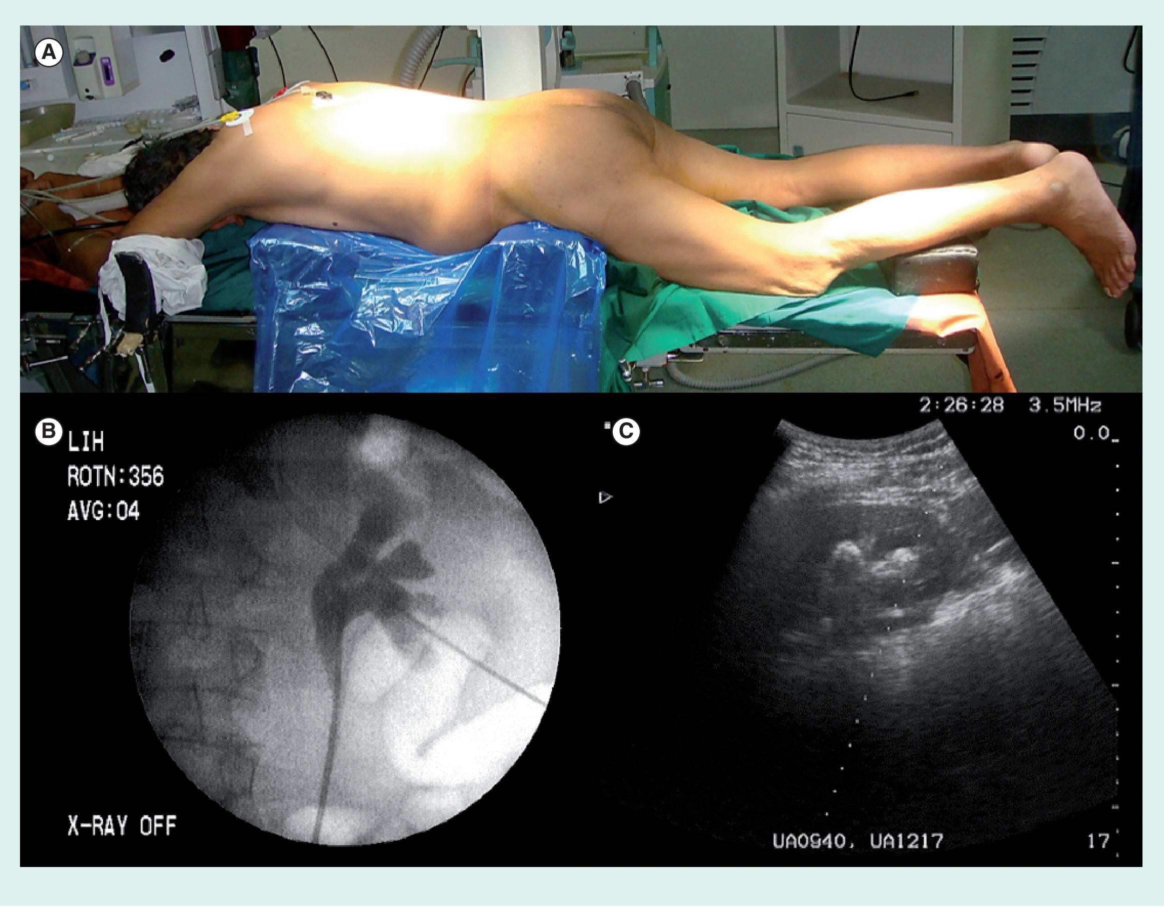

Figure 2. Position for percutaneous nephrolithotomy and fluoroscopy. Ultrasound and fluoroscopy-guided puncture. (A) Bolsters below the hip and chest to allow the abdominal contents to drop forward along with adequate padding in prone position. **(B)** The ideal tract in percutaneous nephrolithotomy traverses a posteriorly facing papilla tip of an end-on calyx seen here in fluoroscopy. **(C)** Ultrasound guided puncture of the lower posterior calyx to achieve access into the stone-bearing calyx. Note the puncture guide (dotted line), which acts a visual marker to help in gaining the access.

by Munver *et al.* (16 vs 4.5%) [42]. Pleural complications such as hydrothorax, pneumothorax and hydropneumothorax can often be identified with chest fluoroscopy during or at the end of PCNL. Nevertheless, a formal chest radiography is recommended postoperatively following all cases of supracostal access for early diagnosis and prompt institution of corrective measures such as aspiration or intercostal drainage tube placement.

Injury to spleen and liver can also occur especially if the puncture is made in the 10th intercostal space [43,44] or in presence of associated organomegaly. Colonic injury is also rare (0.2–1%) [10,12]. Risk factors associated with colonic injury are thin-body habitus, females, left side, horseshoe kidney and history of bowel or renal surgery leading to an altered positioning of bowel [45,46]. Preoperative planning on the basis of CT scan is vital in avoiding such injuries. The use of laparoscopic guidance aids in avoiding injury to surrounding viscera while performing PCNL in ectopic kidney [47].

Exit strategies

A nephrostomy tube at the end of PCNL provides drainage to infected urine, allows for a second-look nephroscopy, tamponades the tract and prevents urinoma [7]. Mishra *et al.* concluded that presence of a nephrostomy tube leads to a significantly lower incidence of early hematuria, better stone-free rates and preserves the option of check nephroscopy [48]. Tubeless PCNL on the other hand has certain advantages in the form of lesser pain and shorter hospital stay [49,50]. The decision to keep a nephrostomy tube is dependent on multiple factors such as presence of residual stones, possibility of a second-look procedure, substantial intraoperative blood loss, urine extravasation, ureteral obstruction, potential persistent bacteriuria due to infected stones, solitary kidney, bleeding diathesis and planned percutaneous chemolitholysis [6]. For the rest of the uncomplicated cases, current EAU guidelines on urolithiasis recommend tubeless PCNL as a safe alternative (LE: 1b; GR: A) [6].

Minimizing complications in ureteroscopy

Preoperative preparation

Ureteroscopy has evolved and is now considered the primary treatment modality for various pathology affecting the ureter and renal pelvicalyceal system. With development of smaller semirigid and flexible scopes with new energy sources, the complications associated with ureteroscopy have decreased considerably specifically the incidence of ureteral injury. Factors associated with higher complications include large stone burden, long operative time and decreased surgeon experience [51]. Other risk factors include past history of ureteral surgery, stones above the level of ischial spines, stone width more than 5 mm, dilatation of proximal ureter, delayed or nonexcretion of contrast by affected kidney and inexperienced surgeon (Figure 3) [52].

Active untreated infection is the only absolute contraindication. Treatment of infection with appropriate antibiotics and deobstruction by either stenting or nephrostomy are a must before any planned procedure. Routine urine culture and preoperative antibiotics are recommended in all cases [3].

Ongoing anticoagulation is a relative contraindication and, if required, procedures can be performed with appropriate instrumentation, meticulous hemostasis and use of contact energy source (laser).

Most cases of ureteroscopy require either spinal or general anesthesia. General anesthesia provides better control of respiratory excursions with decrease in renal movement and resultant improvement in the application of laser accounting for improved efficiency and decrease risk of injury.

Intraoperative measures for risk reduction

Ureteral access

Identification and negotiation of ureteric orifice is a primary step for any ureteroscopy. Failure to access the orifice and subsequent inappropriate manipulation may result in trauma making any future attempt difficult.

Factors predicting difficult access include musculoskeletal abnormalities, large prostatic median lobe, cystocele, history of ureteric reimplantation, ectopic and duplicated ureters. In case of difficult access, various tricks are used, such as using a glidewire over a ureteric catheter, keeping the bladder empty or ureteroscopic placement of the Glidewire (Terumo Corporation, Tokyo, Japan) [53]. With the advent of smaller scopes, routine dilatation of ureter is no longer recommended. Previous pelvic or retroperitoneal surgery or radiation may fix the ureter into the pelvis, which may lead to inadvertent damage with semirigid instruments leading to perforation. Flexible ureteroscopy may be better suited in such cases.

In cases where the wire does not pass beyond the obstructing stone, intraureteral lidocaine jelly, saline or contrast agent installation may be utilized (Figure 3). In impacted stones, ureteral dilatation distal to stone should not be done as the wire may pass submucosally beyond the stone. In some cases when retrograde access is impossible despite all the above measures, antegrade placement of wire or placement of nephrostomy for a few weeks followed by another retrograde attempt may be a reasonable alternative.

As with any endourological procedure, malfunction of instruments (inability to withdraw basket/forceps)

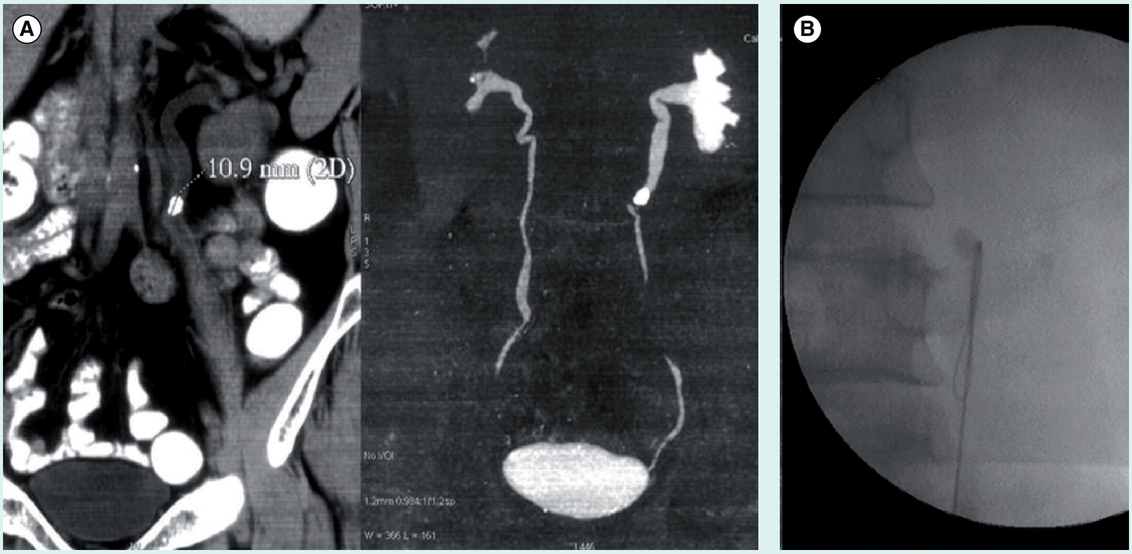

Figure 3. Impaced calculi and its management. (A) Computed tomography urography showing a 10.9-mm stone in left upper ureter with proximal hydroureteronephrosis. **(B)** Inability to pass safety glidewire across the stone into the proximal portion may necessitate certain additional maneuvers.

may be associated with significant problems. Incidence of mucosal abrasion has decreased considerably due to the advent of small flexible scopes; when multiple ureteroscopic movements in and out of the ureter are expected, placement of an access sheath is recommended. Bleeding is usually a minor complication of ureteroscopy (and may be secondary to mucosal abrasion and lacerations), but bleeding sometimes results in reduced visibility leading to staging of the procedure [54]. Careful use of energy sources can prevent injury by avoiding contact between the laser probe and the ureteral mucosa, and by keeping the probe parallel to the wall of ureter.

Perforation of the ureter should be recognized early by observing for a breach in the continuity of the ureteral wall, or by visualization of periureteral fat. Factors associated with increased risk of perforation include periureteral fibrosis, impacted stone, sudden movement of the patient during the procedure and use of large caliber scopes [55]. Most perforations can be managed by stenting for 2–6 weeks [56].

Minor extravasation of fluid is usually of no consequence. Sometimes, significant extravasation of hypotonic fluid may lead to volume overload, hyponatremia and hemolysis. Use of normal saline for irrgation decreases complications in case extravasation occurs.

Migration of calculi outside the ureter does not cause major long-term complications in the majority of cases [57]. On the contrary, submucosal migration may be associated with increased risk of ureteral stenosis. If causing significant symptoms, the number of such stones is visualized by CT, then they may be removed with laser incision after prestenting the ureter.

Intussusception and uretral avulsion are major complications of ureteroscopy and require open or laproscopic management, but are fortunately rare. Noncompliance with basic ureteroscopic techniques, improper use of instruments and lack of tissue respect are major factors associated with such conditions [58].

Postoperative complications

Infection, fever & sepsis

Infection is a major complication in ureteroscopy, and may range in severity from mild fever to systemic inflammatory response syndrome and septic shock. Sources of infection could range from inadequately-treated pre-existing UTI to secondary infection from the treatment of the stone itself. High irrigation pressure used during irrigation predisposes to bacteremia. Use of antibiotic prophylaxis, correction of any pre-existing urinary infection, decreasing the irrigation pressures and the use of an access sheath to reduce the intrarenal pressures are all recommended strategies to reduce the risk of infectious complications [59].

Other complications

Ureteral obstruction in the immediate postoperative period may be due to spasm, edema, clot or small fragments of residual calculi, predicting the likelihood of such complications, and judicious use of ureteral stents in such cases decreases the likelihood of such complications [55].

Long-term complications of ureteric stricture have decreased considerably due to the use of small scopes and improvement in energy sources. Careful use of scopes to minimize trauma, preoperative ureteral dilation of the narrowed segment with balloons (preferred) or serial dilators, preoperative stenting followed by ureteroscopy at later date, and early recognition of complications such as perforation are vital in decreasing the stricture rate [60].

Minimizing complications in transurethral procedures

Preprocedural checks

A complete assessment, including the renal, cardiac, pulmonary and general physiologic condition cannot be underestimated in cases of transurethral procedures, as the majority of patients undergoing such procedures are elderly people who may have multiple comorbid conditions. Suboptimal preparation may result in inferior postoperative outcomes.

Preoperative assessment with special emphasis on cardiac status is vital, as major circulatory fluctuations and fluid shifts may occur in some cases of TURP and other endoscopic procedures. Patients with deranged renal function secondary to obstructive gland benefit from bladder drainage, in order to relieve outlet obstruction, which allows stabilization of renal function preoperatively [61].

Urodynamic evaluation before the surgery is not indicated in all patients. EAU guidelines recommend filling cystometry and pressure-flow measurement usually before a surgical treatment as an optional test in patients who: are unable to void ≥150 ml on uroflow; have maximum flow rates of more than ≥15 ml/s; are young adults (<50 years of age); are very old (>80 years of age); have large postvoid residual volume (>300 ml); have a clinical suspicion of neurogenic bladder dysfunction; have bilateral hydroureteronephrosis; have a past history of radical pelvic surgery; or have failed previous invasive treatment for their symptoms (Figure 4) [62].

American Urological Association guidelines recommend appropriate antibiotic prophylaxis in all patients undergoing transurethral procedures [3]. After a meta-analysis, Berry *et al.* recommended antibiotic prophylaxis in all patients undergoing transurethral resection of the prostate, as prophylaxis was associated with significantly less bacteriuria and sepsis [63]. Other groups have made similar recommendations for TURP [64] as well in cases of transurethral resection of bladder tumors [65].

Bleeding may be severe and life threatening in certain cases of TURP and hence, in every case, hemoglobin, blood grouping and crossmatching are to be done. In case of large glands, if severe bleeding is expected it is safe to have two units of blood crossmatched and ready. Bipolar vaporization, holmium laser enucleation of the prostate (HoLEP) and photoselective vaporization (PVP) result in less bleeding and are preferred in patients in whom anticoagulants cannot be stopped [66].

Various methods including hypotensive anesthesia, cooling of irrigation and medications (ε-amniocaproic acid) have been used in the past, but have been abandoned as none have stood the test of time and have been associated with various complications. For patients with large and vascular glands, 5α-reductase inhibitors have been used for reduction of operative bleeding

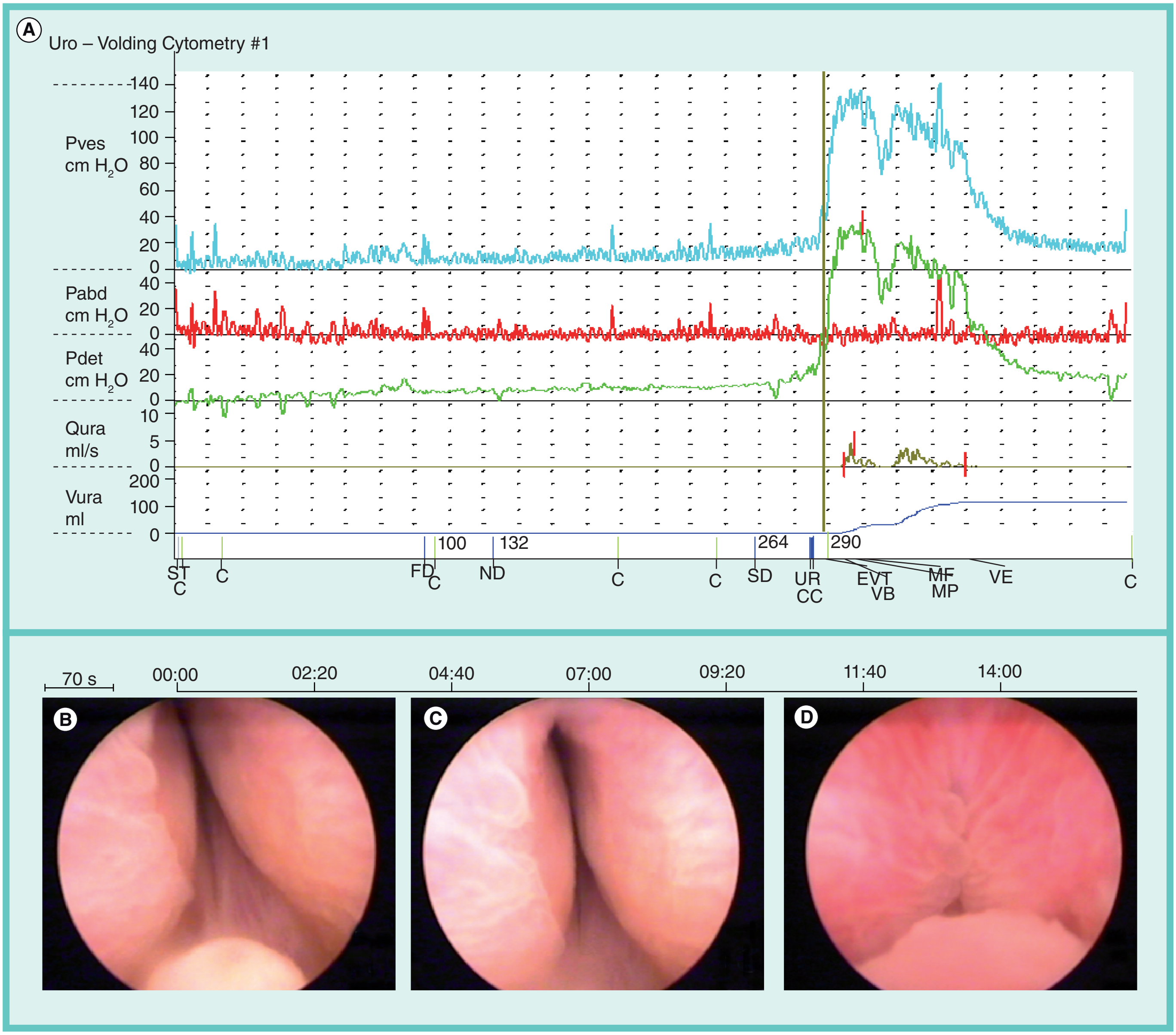

Figure 4. Urodynamic and cystoscopic evalution of bladder outlet obstruction. **(A)** Urodynamic study showing high voiding pressures of 132 cm H_2O and Qmax (voiding velocity) of 4.6 ml/s suggestive of bladder outflow obstruction. **(B)** Relation of the verumontanum to the enlarged lateral lobes and maintenance of these landmarks helps in avoiding complications such as injury to the sphincter. **(C & D)** Note the variation in the approximation of the prostate lobes with open and closed irrigation flow.
C: Cough; CC: Cystometric capacity; EVT: Event; FD: First desire; MF: Max flow; MP: Max pressure; ND: Normal desire; Pabd: Abdominal pressure; Pdet: Detrusor pressure; Pves: Intravesical pressure; Qura: Flow rate; SD: Strong desire; ST: Start; UR: Urgency; VB: Max flow; VE: Void end; Vura: Voided volume.

associated with transurethral resection. Both finasteride and dutasteride are considered effective [67,68].

Choice of anesthesia & position

Procedures can be performed under spinal or general anesthesia with similar results [69]. Spinal anesthesia is most commonly used as it provides good relaxation, and signs and symptoms of fluid overload as well as water intoxication can be recognized early, as the patient is awake. As the effect of spinal anesthesia is up to T10 level, signs of accidental perforation of the bladder (abdominal or shoulder pain) are recognized easily [70]. Rarely, procedures can be performed under local anesthesia in patients with significant medical comorbidities and small glands [71].

For transurethral procedures, the most commonly used position is lithotomy or modified lithotomy. Special care must be taken to avoid overextension of hip joints and adequate padding of bony prominences to prevent any neuropraxia and nerve injury. After induction of anesthesia, a note of the suprapubic region should be made so that the surgeon should be able to make the difference if intraoperative complications such as fluid extravasation occur.

Irrigation fluids

Endoscopic techniques require irrigation solutions. Commonly used solutions are distilled water, sorbitol-mannitol, glycine (1.5%) with monopolar current and normal saline with bipolar current. Some centers advocate glycine as it is nonconducting, not rapidly absorbed and carries reduced risk of hemolysis despite being hypoosmolar (200 mOsm/kg) [72]. Various studies have raised questions about the safety of glycine, the most commonly used irrigation solution in transurethal procedures.

Reported complications include changes in echocardiogram with an associated rise in troponin I [73]. Few experimental studies have shown cardiotoxic properties with devitalizing effects on the heart with glycine absorption; high serum levels of glycine are suspected to cause cerebral edema [74], visual disturbances, and even transient blindness [75].

Some authors recommend that either bipolar normal saline (0.9% resection) or monopolar glucose (5% resection) should be used as irrigating solution both during and after surgery, as they are associated with a decreased risk of complication [76].

Intraoperative complications of transurethral procedures: risk reduction strategies

Transurethral procedures are associated with various complications. There has been a considerable decrease in mortality, with reported rates as low as 0–0.25% [77]. Maintaining landmarks, such as the verumontanum with respect to the lobes while resecting, aids in avoiding complications (Figure 4).

Hemorrhage is the most frequent complication of transurethral resection; the amount of blood loss is related to mass of the gland excised and long duration of procedure (>90 min) with requirement of transfusion varying from 2 to 25% of patients depending on the surgeon's experience as reported from various series [78].

Care must be taken not to resect too deeply into the region of the bladder neck so as to prevent undermining of the trigone. The most common site of damage to the external sphincter is the 12 o'clock position. Special care must be taken when this region is approached while resecting apical region at the end (Figure 4). At the end of resection, one should always move the resectoscope distal to the verumontanum in order to note any remaining adenomatous tissue that may be carefully resected. Hemeostasis both during and at the end of procedure is of prime importance and must be achieved in every patient; arterial bleeders should be coagulated at the level of surgical capsule using spray coagulation [2].

A complication associated to TURP is the risk of transurethral resection (TUR) syndrome, believed to be caused due to hyponatremia, hypervolemia and hyperammonemia (with glycine). Urgent recognition of signs and symptoms such as yawning, seeing flashing lights, hypotension, bradycardia, confusion, nausea and vomiting should be recognized early to prevent drastic complications. Rarely, these complications may be associated with loss of vision [79]. Use of bipolar resection in saline is associated with a very low risk of TUR syndrome.

Limiting the height of irrigation bottle at 60 cm above the prostate reduces the intravascular fluid absorption [80]. Other strategies to reduce fluid absorption include leaving a rim of adenoma tissue on capsule till the end, in order to avoid the opening of sinus tissue, preventing absorption of large amount of fluid [81].

Obturator jerk is commonly associated with transurethral resection of bladder tumors. Measures need to be taken to prevent obturator jerk in cases when bladder tumor is situated near the lateral wall of bladder (just above and lateral to ureteric orifice) are important as it may lead to bladder perforation. These are reduction of monopolar current so it barely stimulates the nerve, to keep the bladder partially full, withdrawal of scope back into prostatic urethra with jerk helps in avoiding sudden perforation by resectoscope. General anesthesia with muscle relaxant or obturator block with spinal anesthesia are reasonable options to avoid jerk [82].

In the immediate postoperative period, arterial bleeding should be suspected if the irrigation catheter shows bright red colored urine, which seldom stops by itself and usually requires cystoscopy and coagulation of all bleeding points. On the other hand, venous bleeding is darker and can be managed conservatively by application of traction with overinflation of the balloon.

Stricture following transurethral procedures have decreased considerably. Limiting the resection time, use of nonconducting jelly and use of small-size resectoscopes help in decreasing the stricture rate. Stricture is considered by some as the most common late complication following transurethral procedures and should be suspected in any patient with a flow rate of <10 ml/s [83]. According to a large series, the factors associated with decreased risk of stricture are urethral calibration prior to surgery to determine anatomic adequacy before resection, gentle urethral dilatation before procedure and small size of catheter used postoperatively [84].

Minimizing complications in laser surgery of prostate

Kalium titanyl phosphate lasers: photoselective vaporization of the prostate

Intraoperative complications rates of PVP are comparable with TURP, with less blood loss resulting in significantly less need of blood transfusion [85,86]. Skolarikos *et al.* in their study required conversion to TURP in 7.69% cases with the most common cause being capsular perforation. Bleeding resulting from improper hemostatsis and resulting in loss of vision are associated with most of the complications of PVP [87]. During the early postoperative period there are more chances of retention of urine as compared with TURP (15.3 vs 2.7%; $p < 0.05$) with a high reintervention rate requiring recatherizatons (17.6 vs 0%) [86]. There is no statistically significant difference in other complication rates [6]. Retreatment is required in approximately 15% of patients with the common causes being recurrent/persistent adenoma (6.8%), bladder neck strictures (3.6%) or urethral strictures (4.4%) [88]. As complications increase with a gland size of more >80 g, PVP is recommended for small- and medium-size prostate (EAU Guidelines 2014: LE: 4; GR: A) [4]. Key steps to decrease complications with PVP are proper case selection and adequate hemostasis at every step to avoid loss of vision and resulting complications.

Holmium (Ho:YAG) laser in prostate surgery

HoLEP is considered a safe and effective method of treatment of adenoma of prostate. Complications are related to both enucleation and morcellation. They tend to decrease as the experience of the surgeon increases. Various studies have proven that HoLEP has a shorter catheterisation time, resulting in shorter hospital stay, less blood loss and consecutive need for transfusions, with good functional results when compared with TURP [89,90]. Some patients after HoLEP have transient urge incontinence (~35%; rates comparable with open prostatectomy and TURP) and dysuria (59–68%; more frequent than open surgery and TURP) [91,92]. According to the EAU guidelines, HoLEP can be offered to any patient with benign enlargement of the prostate (EAU Guidelines 2014: LE: 1; GR: A) [4]. HoLEP is technically a challenging surgery and has a steep learing curve, resulting in limited acceptance by most urologists [87].

Key points to prevent complications in HoLEP include adequate and mentored training and proper understating of anatomy. Special emphasis should be given to morcellation as it can potentially result in serious complications after an uncomplicated surgery. The bladder should be partially full to avoid injury during morcellation.

Finally, last but not the least, knowing when to stop and to stage the procedure is of paramount importance to avoid complications in endourological procedures.

Conclusion & future perspective

With rapid strides in technological advancement, endourological procedures are bound to benefit from miniaturization of scopes and instruments. Attempts should be made to encourage research and development of new strategies to tackle urological problems. This can be done in a twin-pronged approach by recognizing new inventions and promoting randomized controlled trials to answer long-standing dilemmas in the field of endourology. Development of smaller flexible scopes along with more effective energy sources could bring about the next revolution in the management of diseases. Also, hands-on skills lab training should be imparted to trainees to improve expertise before tackling real-life situations. Scenario-based virtual reality trainers could become the future of medicine in times to come.

Thorough knowledge of complications, with willingness to work towards the safe and effective outcome is key to endourologic surgery. The focus should always be to avoid complications, in case they do occur, early detection and rapid rectification helps to achieve better outcomes.

Financial & competing interests disclosure

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

No writing assistance was utilized in the production of this manuscript.

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