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REVIEW

Strategies to Improve Patient Outcomes and QOL: Current Complications of the Design and Placements of Ureteric Stents

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Abstract: Ureteric stents have played a vital role in relieving urinary obstruction in many urological conditions. Although they are extremely successful, stents have been associated with complications and reduced patients' health-related quality of life (HRQoL). There are many factors that may affect the quality and longevity of stents. In this review, we have highlighted the journey and innovation of ureteric stents through the modern day. A literature review was conducted to identify relevant articles over the last 20 years. There is a plethora of evidence with various indications for the use of ureteral stents and how they affect QoL. There is still ongoing research to develop the ideal stent with reduced encrustation, one that resists infection and is also comfortable for the patients. Stents made from metal alloys, polymers and biodegradable materials have unique properties in their own right but also have certain deficiencies. These have been discussed along with an overview of newly developed stents. Certain pharmacological adjuncts have also been highlighted that may be useful to improve patient's tolerance to stents. In summary, this paper describes the features of the different types of stents and the problems that are frequently encountered, including effect on patients' HRQoL and financial burden to healthcare providers.

Keywords: ureteral stent, encrustation, health-related quality of life, infection, stent symptoms

Introduction

Ureteric stents help drainage of urine from the kidney to the bladder and thereby bypass internal and external obstruction of the urinary tract.[1–10] With rising incidence of kidney stone disease (KSD), the use of stents is also likely to escalate.[4] The indications for stenting have increased as surgical techniques have expanded over the last few decades. The absolute indications for stent insertion are obstructed pyelonephritis, bilateral ureteral obstruction, complete obstruction from benign or malignant conditions, obstruction of solitary functioning kidney, post ureteric surgery such as pyeloplasty or ureteric reimplantation, and ureteric injuries. Relative indications include post-procedural management of urolithiasis, pain relief due to ureteric obstruction, in partial nephrectomy, in pregnancy and pre-shockwave lithotripsy of large stones to prevent ureteral obstruction from stone fragments.[5] The decision to use stents for other indications remains subjective.

Ureteric stents are used commonly by urologists worldwide and their failure rate can be high, with a negative impact on quality of life (QoL) in up to 80% of patients.[6] Indwelling ureteral stents have been associated with complications and

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physical distress to the patients.[7] The common reason of symptoms includes stent migration, ureterovesical reflux, tissue irritation, encrustation and biofilm formation (ie, particle deposition) that may lead to lower urinary tract infections (LUTS).[8,9] Urinary tract infections (UTIs) and LUTS have been associated with ureteric stents, with the incidence of stent bacterial colonisation estimated to be at 90% in some reports.[10] Occasionally, it might be beneficial to use other mechanisms of urinary diversion (UD) such as obstruction with underlying infection, small irritable bladders, underlying fistulae and high-pressure bladders. There has been a significant drive by clinicians and research groups to improve stent design thereby reducing the risk of complications, which could, in turn, improve patients' QoL.[11] Therefore, the quest for an ideal ureteric stent still continues.

Methods

In this narrative review, published literature on ureteric stents from January 1990 to February 2020 is outlined. A systematic MEDLINE search was done using MeSH terms "ureteric stent", "double J stent", "stent biofilm", "stent encrustation", "stent bacterial colonisation", "stent design", "stent material", "stent coating" and "UTI".

Innovation Driven by Patients' Health-Related Quality of Life (HRQoL) Outcomes

The original stent design was similar to the modern day urinary catheters and they were commonly placed in the renal pelvis and exited outside the urethra, which made them highly susceptible to displacement.[12] A modern day ureteric stent is a 22–32 cm long flexible polymeric tube with side holes. The "double-J" design, or commonly known as the pigtail design, was developed to reduce displacement. Nowadays, double-J ureteral stents are widely used and designed to anchor the stent in the renal pelvis and bladder to prevent migration. It can be deployed safely, is cost-effective and does not displace easily.[13,14]

The associated pain and other side effects have been quantified to evaluate their impact on the patients' QoL (Figure 1). There have been several attempts to improve patient tolerance to these ureteric stents (Table 1). A validated questionnaire called the Ureteral Stent Symptom Questionnaire (USSQ) was developed by Joshi et al to assess patient comfort after stent placement.[5,15] It has been endorsed in several languages and used in studies to compare different types of stents and stented versus non-stented patients. An initial study reported that 78% of stent-bearing patients complained of urinary symptoms; 80% of patients described pain due to the stent, 58% described reduced work output and 32% reported sexual dysfunction.[5,15] Several studies have compared different types of ureteric stent and analysis has shown no ureteric stent to be superior to others.[6] The common symptoms mentioned in these studies were frequency, dysuria, urgency, haematuria, flank pain, suprapubic pain and UTIs.[16] Patient education and monitoring are important to ensure appropriate management and patient satisfaction. The necessity to improve stent tolerance has led to modifications of its

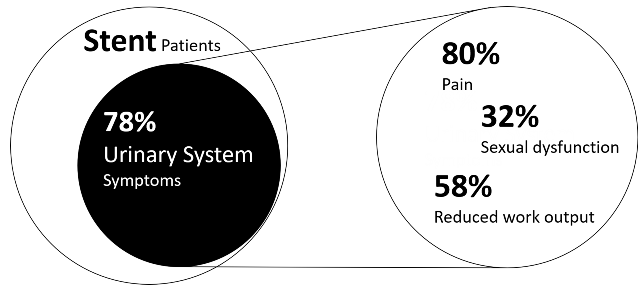

Figure 1 Effect of ureteric stent on patient symptoms and quality of life.

Table 1 Recent Innovations in Ureteral Stent Designs

Stent Issues	Innovative Design	Reference
Encrustation	Coating agent against biofilm formation	Szell et al[61]
Bacterial colonisation	Drug eluting stent	Lim et al[62]
"Forgotten stent"	Biodegradable stent	Barros et al[37] Soria et al[39]
Migration	Telescoping stent Helical stent to control drainage Non-coplanar pigtails to avoid migration	Pendleton et al[40] DeGraaf et al[42] Yachia et al[43]
Urine reflux	Proximal end – anchoring structure and distal end – J tail into the renal pelvis Self-expandable mesh in the bladder and valve mechanism to prevent reflux	McMahon et al[44] Shelton et al[45]

original design. Common type of stents include metallic stents[5,16,17] and polymeric stents.[27–36]

Polymeric Stents and Their Clinical Use

In recent years, polymers have been used to manufacture ureteral stents such as C-flex, Percuflex, Silitek, Dual Durometer, Sof-flex and Polyurethane stents.[5] Polymers are thought to be inert and stents with external grooves on the lumen were manufactured to increase the surface area for urinary drainage and stone clearance. Stents augmented with metal wires, shaped into spiral design showed superior flow and drainage.[27] To overcome bladder irritation in patients with ureteric stents, loops of polymer were incorporated instead of the classical pigtail at the distal end of the double-J stents. It was thought that this new "tail stent" would decrease bladder irritation. However, a study by Dunn et al demonstrated no significant difference in renal or flank pain between standard double-J stents and the new tail stents.[28] With the motive to reduce bladder irritation and improve patient acceptance, a novel stent with a hard tip at the proximal end (kidney) and a softer tip at the distal end was developed. Dual-durometer and Percuflex® manufactured by Boston Scientific are examples of this modified tail stent.[27]

In a recent study, patients with "intra-ureteral" Polaris Loop stents (Boston Scientific, Marlborough, Massachusetts, USA) reported lower pain scores, lesser voiding symptoms on the International Prostate Symptom Score (IPSS) questionnaire and less analgesic use when compared to patients with standard double-J stents. However, there were no differences in stent-related complications.[29] A porcine study of a segmental stent with a three-part design (proximal coil, braided mid-section and a distal nitinol basket for anchoring) showed its use in pyeloplasty to be safe and effective.[30]

Metallic Stents and Their Clinical Use

Researchers and commercial manufacturers have invested considerable time and resource to assess different stent parameters such as material used, size, shape and diameter to modernise ureteric stents; therefore, improving patients' quality of life (Table 1 and 2). [5] Stents are made using metal alloys, polymers and biodegradable materials. Metal alloys are ductile, mouldable and stiff, providing resistance to compressive forces. Therefore, they are extremely suitable for manufacturing stents.[5] Additional features such as self-expanding, balloon expandable and thermo expandable make the double-J metal stent very versatile. Self-expandable mesh

Table 2 Materials and Coatings Used for Novel Stents

Type of Material	Novel Material of Stents	Coating Used	Advantages/Key Points
Metal	Nickel Titanium (Nitinol)	Hyaluronic acid	Malleable – soft and durable Not indicated in patients with functional stenosis or stone formation
	Stainless steel	Silver	Easy to manufacture Retrieval can be difficult
	MP35N alloy (Nickel-cobalt-chromium – molybdenum)	Hyaluronic acid	Metallic pigtail stent with high tensile strength Resistant to corrosion
Polymeric	Silicone	Heparin	Highly biocompatible
	Polyurethane	Polyvinylpyrrolodine	High drainage performance and high epithelial erosion
	Silitek	Antibiotics	High tensile strength, weak coil retention, risk of oedema
	Percuflex	Chitosan Hydrogel Salicylic acid	Cost effective, efficient urine drainage and coil retention Low coil and tensile strength
	C-Flex	Carbon	Less surface friction, less particle adhesion, lower mechanical strength
	Dual durometer		Reduced bladder irritation
Biodegradable		Triclosan	Reduced secondary procedures

stents were developed to facilitate urinary drainage and reduce urinary reflux.[17] The idea behind the innovation was to use the mesh to reduce clogging and improve urine flow within the stent.[18] These self-expanding mesh stents did not influence the mechanical properties of the ureter.[19] Stents with broader lumen offer improved drainage and have been shown to have good efficacy in long-term urinary drainage.[20] Titanium stents have been shown to be effective in re-establishing urinary flow when there is blockage or obstruction due to benign prostatic hyperplasia.[21]

The widely used metallic stents are made of nickel and titanium mixed alloys, and these have several advantages in terms of greater patency, longer indwelling time, less morbidity and better management of stricture. The unique property of these stents is the ability to soften at temperatures below 7–13°C and then regain their shape when there is a rise in temperature above 55°C. This property makes the stent deployment and its removal technically feasible.[22] The Allium stent manufactured from Nitinol wire is self-expanding, segmented and packed between polymer strips (Table 3).[23] They are made with nitinol for high radial force and covered with a copolymer that prevents tissue ingrowth and encrustation and are used for ureteric strictures, ureteric fistulas and uretero-ileal fistulas.

A study by Song et al demonstrated the viability of nitinol stents in urethral strictures' treatment as well.[24] The Resonance stent is an alloy of nickel, cobalt, chromium and molybdenum. It does not have a lumen and the urine flows alongside the stent.[25] A small study by Wah et al showed Resonance stent to have improved urine drainage over 1 year when compared with traditional double-J ureteral stents.[26] The main disadvantages of metallic stents include ingrowth of tumour, epithelial hyperplasia, difficulty in removing impacted stents, higher cost and complexity of insertion.[5]

Table 3 Summary of Designs in Ureteral Stents

Type of Design	Key Features	Examples
Double-J	Commonly used design, reduced risk of migration	
Double-J 3D	Provides better proximal and distal retention	Silicon Figure Four (SFF) (Bard® USA)
Loop	Better patient comfort	Polaris™ Loop ureteral stent (Boston Scientific®, USA)
Mesh	Reduced risk of bladder irritation but technically demanding	Uventa self expanding metallic mesh stent (Taewoong Medical, Seoul, Korea)
Expandable	High luminal flow, ease of insertion and retrieval	Allium® Ureteral stent (Allium Medical Solutions®, Israel)
Magnetic tip	Allows effective retrieval	Magnetic Black-Star (Urovision, Germany)
String	Facilitates stent removal by patient or surgeon in clinic	Boston Scientific®, USA; Cook® Medical, USA
Coil-reinforced	Allows efficient drainage, reduces kinking and buckling	Silhouette® stent (Applied Medical USA)
Basket	Allows passage of small stones and prevents migration of bigger stones	Ureteral Stone Sweeper ® (Fossa® Medical, USA)
Spiral Cut	Potentially fewer upper tract symptoms	Boston Scientific®, USA
Helical	Better drainage of urine and passage of small stones	Boston Scientific®, USA
Grooved	Suitable for post lithotripsy to enable passage of stone fragments	Towers Peripheral Ureteral Stent (Cook® Medical, USA)
Streamlined side-hole	Providing reduced particle deposition by increasing the wall shear stress at side-holes and enhancing fluid exchange between intra- and extra-luminal stent compartments.	No clinical data available currently

Stent Size and Length with Their Clinical Use

Stent size can be modified by using different diameter or length as per clinical the need. Three different stent types were compared by Bellman et al, and there was no difference among the groups in terms of voiding symptoms, haematuria, pain, nocturia and incontinence.[31] Another study showed that pain and irritative symptom scores were similar in groups comparing two Bard inlay ureteral stents with different diameters.[32] A study by Ho et al showed that a longer stent was associated with substantially frequent urination, nocturia, urinary incontinence, haematuria and flank pain.[33] Similar findings were confirmed by Al-Kandari et al where patients with longer stents had worse quality of life scores when compared to patients with shorter stents.[34] However, multi-length stents are probably most used nowadays compared to fix sized stents, which maybe cost associated with keeping large inventory compared to one size fits all. Studies have focused on optimising ureteric stenting and evaluating the suitability of smaller stents. Patients with smaller stents for a reduced time period recorded better scores. These studies showed no differences between stone-free rates following planned and repeated unilateral ureteroscopy (URS).[35] Based on previously discussed modifications, a dual-lumen stent with two drainage pathways was tested by Hafron et al and reported improved urine drainage when compared to single lumen stents in an ex vivo kidney model.[36]

Variations in Stent Removal

Standard stent removal is done using a cystoscope usually under a local anaesthetic. Other methods are biodegradable stents, stents with magnetic tip and stent with strings.[37–52] Novel biodegradable ureteral stents were manufactured using Uriprene to improve urine drainage, provide good biocompatibility and avoid traditional removal.[37] The issues with these stents included axial rigidity leading to difficult placement, non-uniform degradation and the biodegrading time of 10 weeks which was longer than typical indwelling stents. The potential disadvantages are the complete degradation over a few days which limits the use for very short-term stenting. Longer duration degradable stents were shown to last for up to 6–10 weeks (in porcine studies) but the disadvantages were increased bacteriuria. However, studies by Barros et al and Soria et al have demonstrated degradation in a predictable and controlled fashion with no obstructive fragments.[37,39]

Certain stents have strings attached to help removal and some have baskets to improve the passageway for small stones and stop bigger stones' migration through the ureter.[4,38] There are other stents made from biodegradable/bioabsorbable metal mesh and some have polymeric flap valves to reduce reflux. Some studies have shown that these stents have improved patient comfort.[5] However, cystoscopy is often required to remove stents and is associated with potential complications and increased healthcare costs.[13]

Innovative New Stent Designs

An online review of recent patents shows plenty of ureteric stent models that have been studied and investigated. A novel telescoping ureteral stent developed by COOK® Medical comprises a proximal structure (located towards the kidney) telescopically sliding into a distal structure (located towards the bladder). This invention stops the stent from migrating into the ureter and prevents the extended proximal end from returning back into the ureter.[40] It comprises compressed springs without side holes and the indwelling stent can last for up to 12 months.[41]

A novel helical stent made of polymeric materials (Boston Scientific Corporation, Grove, MN, USA) developed to control urine drainage has been described by DeGraaf et al. It consists of filaments with controlled extensions combined with a dissolvable coating.[42] Another novel stent invented by Yachia et al (Innoventions Ltd., Akiva, Israel) relies on having both pig-tail ends non-coplanar with respect to the bladder trigone. Different materials are used at either ends of the stent which also prevents urine reflux from the bladder and into the kidney.[43] Similarly, another innovative stent to reduce ureterovesical reflux has a proximal J-end (kidney) and an anchoring structure at the bladder end. The lumen has been designed to have a narrower cross-section in the bladder, to reduce bladder irritation. A flapper valve was designed at the bladder end, which closes when the bladder pressure increases in order to prevent reflux.[44] A series of self-expandable ureteral stents were designed by Gyrus ACMI® (Massachusetts, USA) with projections of different shape, length, size and orientation; these have been trialled to reduce urothelial tissue irritation, at the bladder trigone and ureterovesical junction (UVJ). It contains a self-expandable mesh structure anchoring to the UVJ and includes a valve mechanism to prevent reflux.[45]

Ongoing Issues with Ureteral Stents and Strategies for Improvement

Stent designs have been constantly improving over the years, but the complication rate remains high. It has been established that side effects are directly proportional to the indwelling time of these stents. Therefore, removing the stent as early as possible is the best remedy to reduce the unwanted side effects and complications.[46] There have been reports where insertion of a stent can also cause displacement towards the kidney due to their effects of ureteric peristalsis.[47]

Stent Removal Issues

Stents need to be removed via flexible cystoscopy in the outpatient (OP) clinic or in the operating room (OR). A number of modern stents have integrated extraction strings and the patients can remove it themselves or the surgeon can remove them in the OP clinic.[38] The extraction strings are made of fine suture material secured to the distal end of the stent, runs through the urethra and is visible at the urethral meatus. The string can be left free or secured to the patient – on the mons pubis or thigh in women or to the penis in men. A systematic review by Oliver et al concluded that the majority of patients were able to remove the stents at home safely with reduced incidence of morbidity.[38,48] However, there is some evidence of increased lower urinary tract symptoms (LUTS) due to string irritation, stent dislodgement, infection, stent retention and broken strings. Up to 10% of these stents are expelled spontaneously. The advantages include patient self-removal, reduced stent dwell time, duration of morbidity, physical and financial burden to patients.

Magnetic tipped stents were developed to aid stent removal without the need for cystoscopy.[49] Studies by Netto et al and Taylor et al have demonstrated the cost-effectiveness and efficacy of this.[50,51] A randomised control trial by Rassweiler et al showed that a magnetic double-J stent removal was significantly less painful than the cystoscopic removal of the double-J stent.[52] Urotech (Achen, Muhle) developed a double-J stent with a small magnet attached to the distal coil which remained in the bladder. The idea is to insert another 9-Fr retrieval catheter which had a complementary magnet on its tip and the ureteral stent in situ could then be retrieved without direct visualisation.[13]

Issues with Urinary Tract Infections

Stent placement can lead to urinary tract infections (UTIs) in high-risk patients (diabetes and chronic kidney disease) and in those with prolonged indwelling time.[53,54] The surface within the stent provides an environment for colonisation by bacteria to form a biofilm. Paick et al demonstrated the presence of bacterial colonisation in over 50% of patients with ureteral stents.[55] Other studies have confirmed the presence of multiple Gram-positive and Gram-negative species on ureteral stents and antibiotic therapy has been shown to be ineffective. There is a significant association with encrustation, another common complication in ureteral stents.[10] Stent infections can be minimised by reducing the stent usage and dwell time. For patients with long-term stents,

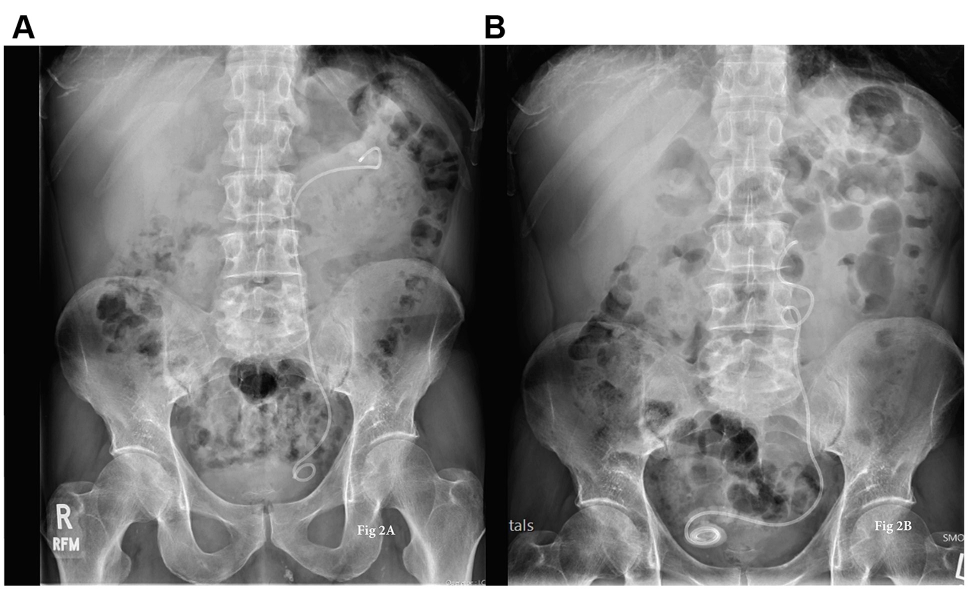

Figure 2 (**A**): Normal stent position. (**B**): Stent displaced, crossing the midline with encrusted bladder coil of the stent.

changing the stents is sometimes helpful to decrease recurrent UTIs as the stents are colonised by the bacteria.[49,50]

Issues with Stent Encrustations

Encrustation is a common complication of stents, and on occasions, surgical intervention is necessary to retrieve and/or replace the stent (Figure 2). The various factors effecting stent encrustation are urine composition, stent material, surface properties, stent design and dwell time, urinary pH and urine flow dynamics.[9,41] It has been attributed to the presence of bacteria (such as *Proteus mirabilis*) known to produce urease. This leads to increase in urinary pH and crystal formation.[56] A grading system – "Forgotten, encrusted and calcified" was advocated to characterise the encrustation and calcification.[57,58] The newer generation of inert biodegradable ureteral stents may resist biofilm formation and reduce encrustation. It is important that the stents are in place for the minimum amount of time and should be removed as early as possible. This has been associated with complications such as infection, sepsis, migration and fistula formation. Occasionally, these "forgotten" stents are identified when the patient undergoes abdominal imaging.[59,60] Silicone stents have been shown to reduce encrustations, and while the stent duration should be minimised, long-term stents should be used in patients who are stent-dependent for ureteric drainage.[3]

Issues with Stent Biofilms

To prevent biofilm formation on stents, coating of poly-hydrogel (poly N,N-dimethylacryleamide) with antifouling and protein repellent properties has been used by Szell et al. In vitro studies showed a 5-fold decrease of bacterial load on the stent surface.[61] By coating hydrophilic hydrogels on certain stents (Universa® Soft Ureteral Stent; COOK® Medical, Bloomington, USA) deployment has become easier and effective due to reduced surface friction and improved lubrication. The hydrogel layer prevents the drug being washed away by the urine flow and this property can make the stent very effective in treatment of conditions affecting the urothelium such as tumours and strictures. This concept allowed Lim et al to develop a drug-eluting ureteric stent to ensure a sustained drug release over 4–6 weeks and improved drug absorption by the urothelium. An in vivo porcine study was shown to be safe with no evidence of hydronephrosis or systemic toxicity.[62] In certain self-expanding ureteric stents, the mesh can be used as a reservoir for elution of pharmacological agents.[63] Anti-inflammatory and anti-cancer agents have also been incorporated in these stents with favourable outcomes.[64] However, these stents are technically challenging with mixed results and involve high costs.[17]

Stent Coating to Reduce Complications

A succinct synopsis by Mosayyebi et al has highlighted several strategies that are helpful to reduce biofilm and encrustation.[41] These include using different metallic alloys to produce stents (nitinol, superalloy titanium and chromium cobalt) as they have shown different tendencies to encrustation. In an in vivo study, the new generation spiral cut stents showed no significant reduction in encrustation, infection rate and stent migration.[65] The best resistance against encrustation was achieved by silicone, followed by polyurethane stents.[20,66] To prevent biofilm, heparin (anti-coagulant), diamond-like carbon (DLC) and hydrogel coatings have been used, to coat the stents with moderate success in various in vivo and in vitro studies. John et al demonstrated that hydrogel did not reduce bacterial load but integrated well with antibiotics.[67] The efficacy of antibiotic-coated ureteral stents has proven to be successful in reducing bacterial load, although combination of antibiotics was often found to be more effective.[68–71] Other anti-microbial agents described are polytetrafluoroethylene (PTFE), triclosan, silver and chitosan. These materials also have another unique property of reduced coefficient of friction, allowing efficient urine flow and reduced bacterial growth.[72–75]

Stent Malpositioning

Improper placement is associated with haematoma or urinoma due to penetration and iatrogenic damage.[76] Stent migration can occur due to peristalsis, more so when the stent is made of softer materials or if coated with hydrophilic material (Figure 2). This can be avoided by using a double-J or pigtail stent design. Imaging modalities play a vital role in identifying the stent position. Polyurethane stents have been recognised to have better shape memory and can conform to the urinary tract when compared to silicone, reducing the incidence of ureteral stent migration. However, stent fractures have been observed in the ones made of polyethylene and it has been attributed to crystallisation and encrustation.[77]

Stent Erosion

Ureteral erosion and fistula formation are rare and potentially devastating and can happen due to erosion of the adjacent arterial system. Intermittent haematuria in a patient with a stent is a common presentation, and massive haematuria leading to circulatory collapse may occur when stent is manipulated. Extensive pelvic surgery and irradiation have been associated with fistula formation as it is thought that both may lead to ureteral ischaemia. Diagnosis can be difficult, and angiogram is the gold standard. Management of the fistula can be done via open procedure and interventional radiology technique or a combination of both.[78,79]

Stent Blockages

Failure to relieve obstruction is usually caused by haematuria, increased viscosity of urine and debris deposition affecting the stent lumen. Therefore, in some patients, stents with larger lumen diameter (7Fr-10Fr) should be used.[5] Although stent blockages are relatively uncommon, diagnosis is usually made by recurrence of symptoms such as loin pain, confirmed by either deterioration of renal function or presence of hydronephrosis on scans. Treatment is usually stent replacement, although alkaline medication such as sodium or potassium citrate can also reduce encrustations.[12,13]

Pharmacological Strategies to Improve Stent-Related Symptoms

Alpha Blockers

The American Urological Association and Endourology Society guidelines recommended medications to reduce stent discomfort.[80] The most commonly used alpha-blockers (alpha-adrenoreceptors antagonists) after ureteral stent insertion are tamsulosin, alfuzosin and terazosin.[5] Liu et al demonstrated that patients on alfuzosin regimen following ureteral stent insertion had significantly lower IPSS and visual analogue scale (VAS) scores in the initial period.[81] Wang et al showed that patients undergoing insertion of double-J stents after ureteroscopic stone removal had better pain relief when given tamsulosin, when compared to patients given placebo.[82] Gupta et al demonstrated significant reduction in post-operative pain and narcotic use after injection of botulinum toxin type A, but no differences in irritative symptoms.[83]

Anticholinergics

Anticholinergic agents decrease voiding symptoms through direct actions on the muscarinic receptors present in the bladder. A randomised controlled trial reported that the patients undergoing double-J stent placement after ureteroscopy and laser lithotripsy receiving solifenacin showed significantly lower total symptom scores – urgency and urge incontinence, flank, abdominal, urethral pain and haematuria.[84]

Beta-3 Adrenergic Agonists

A well-designed multi-centre randomised controlled trial investigated the use of Mirabegron during the stenting period and the patients' outcomes were recorded using two validated questionnaires – International Prostate Symptom Score (IPSS) and Ureteral Stent Symptom Questionnaire (USSQ). The authors concluded that 50 mg Mirabegron had the potential to reduce ureteric stent-related discomfort.[85]

A large RCT by Ragab et al highlighted that patients with both pregabalin and solifenacin had better USSQ scores and pregabalin alone was well tolerated and safe in patients with stent-related symptoms.[86,87] A small study by Tharwat et al showed that sildenafil was tolerated in men with ureteral-related symptoms.[19] A combination therapy with tamsulosin and oxybutynin has been shown to be effective in improving irritative symptoms, work performance and sexual function.[88] The meta-analysis by Zhang et al concluded that there are significant advantages of combination therapy when compared to monotherapy with alpha-blockers based on the International Prostate Symptom Score (IPSS).[89]

Improvement of Quality of Life and Future Areas of Interest

The presence of ureteric stents effects patient QoL. More work needs to be invested on improving stent design, material and coating, and minimise stent usage and stent dwell time. The dwell time can increase stent-related complications such as urinary tract infections, sepsis and stent encrustations.[90] Patients also need to be better informed about stent-related symptoms and communication is vital through counselling and patient information leaflets.[91] Similarly, stent registries and timely stent removal are also of utmost importance.[92]

The incidence of kidney and ureteric stones will increase over time, leading to more procedures and stent usage related to it.[93,94] It is prudent to have mechanisms in place to shorten the dwell time using office-based ISIRIS disposable cystoscope stent removal, stent on string or magnetic stents.[95] Stent positioning and antimicrobial coated stents might also need further investigating.[96,97] Similarly, pre-stenting prior to ureteroscopy should be avoided thereby avoiding unnecessary stenting of patients. Future work would need to be done on biodegradable stents and coated stents, although patient involvement and use of patient-reported outcome measure and validated stent questionnaire would be helpful in understanding and comparing these stents.

Conclusion

Placement of ureteral stents has been common practice in the management of various urological conditions. Most patients experience stent-related side effects, and some have complications related to it. The ureteral stents have evolved over the years with new innovations in materials, coatings and designs. Quality of life outcomes have been one of the key factors behind the constant innovation and evolution. Standard practice must include patient education, stent monitoring and removal at the appropriate time. It is important that these patients with stents be monitored via emails, mobile-based app reminder systems. Moreover, further scientific efforts are required to develop stents that improve patients' QoL and reduce the financial burden for healthcare providers arising from clinical complications. In summary, the key features of an ideal stent should reduce patient discomfort and pain, improve urinary drainage, reduce incidence of encrustation and allow easy removal with minimal complications and morbidity.

Disclosure

The authors declare no conflict of interest.

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