Forgotten Ureteral Stent Syndrome

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1 Introduction

Ureteral stents are one of the most widely employed tools in urology and have been in use for more than four decades. Their indications have widened over the years, making the management of their complications an essential role in the urologist's practice. In this regard, the "retained or forgotten ureteral stent" syndrome remains a challenge. This syndrome is defined as the group of signs and symptoms produced by a JJ stent that has not been removed 2 or more weeks after the end of its maximum life [1].

Data on the frequency of forgotten ureteral stents vary widely between series, ranging from 3% to 51% of stents that are placed [1, 2]. Identification of the forgotten stent occurs on average 29 months after placement, with a range of 7–180 months [3].

2 Risk Factors for Forgotten Ureteral Stent Syndrome

The main risk factor for the development of forgotten ureteral stent syndrome is the time since placement of the stent [4]. However, the time to onset of the syndrome will depend on the chemical characteristics of the urine, its hydrodynamics, the catheter material itself and other factors related to the patient and the care provided.

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Table 1 Conditions that promote the development of forgotten ureteral stent syndrome

Factors modifying the chemical characteristics of urine	Factors affecting urine dynamics	Stent related factors	Patient-related factors
Personal history of lithiasis (9,10) Hyperuricosuria Hypercalciuria Hyperoxaluria Hypocitraturia Metabolopathies (10) Urinary pH alterations Renal failure Dehydration Urinary sepsis Chemotherapy (10) Pregnancy (9)	Intrinsic and extrinsic obstructive uropathy Congenital urinary malformations (10) Functional pathology of the lower urinary tract	Time since placement (4.9) Internal diameter Stent manufacturing material (10) Stent replacement by cystoscopy (1) Double-loop stents (11)	Low sociocultural level (1,3,12) Lack of health system or health insurance protection Good tolerance to the catheter Low adherence to treatment and follow-up (6,10) Poor doctor-patient communication (3) Age >60 years (1) Cognitive impairment History of urological, abdominal or pelvic surgery (13)

Matthew F et al. found that 75.5% of ureteral stents were encrusted within 6 months, 42.8% were encrusted within 4 months and 14.3% within 2 months. The time of highest incidence was between the fourth and fifth month (36.7%). Furthermore, in those patients who had experienced previous stents encrustation, the time to encrustation of the second was shorter, 3.3 months, than that of the first, 6 months, [5, 6].

Although it is not possible to estimate an incidence of encrustation, these data suggest that stents should be changed at least within 4 months of placement and preferably every 2 months. In patients with a previous history of encrustation, it is recommended that the dwell time of the stent be shortened to the minimum necessary, every 6 weeks [5, 6].

Other factors that favour the development of forgotten ureteral stent syndrome (FUSS) are detailed below [7–9] (Table 1).

3 Pathophysiology of the Forgotten Ureteral Stent

The forgotten ureteral stent syndrome depends on several factors. First of all, we will pay attention to the factors that favour encrustation, both of the internal channel of the stents and their external surface.

On the one hand, the surface of ureteral stents can become damaged, especially in their bend parts, making these areas more susceptible to crystal deposition. In addition, ureteral catheters can cause mechanical irritation of the urothelium, which favours colonisation by bacteria. These uropathogenic bacteria can be carried during stenting into the upper urinary tract.

Under the right conditions, crystals will be deposited both inside the ureteral stent and on the outside. The deposited material consists mainly of calcium oxalate mono- and dihydrate. It may also be associated with the deposition of phosphate crystals, uric acid and/or struvite and/or cystine. In addition to crystals, protein material such as Tamm-Horsfall or alpha 1-microglobulin may be deposited.

Crystal deposition can occur in the absence of bacteria, but when bacteria are present, and maintain high enzyme activity, the adhesion, persistence and proliferation of fouling sites increases. In addition, bacteria cause a change in urinary pH that causes the solubility of calcium and magnesium in urine to be altered, creating a vicious circle. Up to 90% of ureteral stents are colonised by microorganisms and according to published patient series a frequency of recurrent UTIs between 27% and 73.6% is reported [3, 10].

The biofilm development is often essential in the encrustation of ureteral stents [11] and is closely associated with the presence of urease-positive bacteria. Biofilms have a very complex formation and development process that is divided into four phases: (1) reversible agglomeration of proteins, polysaccharides and macromolecules; (2) irreversible deposition of proteins and bacteria; (3) maturation of the biofilm; and (4) spreading of the biofilm.

Singh et al. [12] found a higher percentage of encrustation in the proximal tip of the JJ stent, with the proximal segment of the ureter being the second most frequently affected area. In that study, encrustation of the bladder tip was rare.

Encrustation or mucoprotein deposits affect up to 68% of JJ stents, but only 4% of these patients show clinical signs of obstruction [13]. Furthermore, it appears that extraluminal obstruction reduces urinary flow to a greater degree than intraluminal obstruction [14]. Legrand et al. [15] have demonstrated a higher rate of encrustation in stents placed for lithiasis indication (8% before 4 months, almost 17% after), than in those patients with non-lithiasis indication (e.g. malignancy) with encrustation rates of 1.3% at 4 months and 5.2% at 6 months.

4 Symptoms and Complications Associated with the Forgotten Ureteral Stent

Patients with ureteral stents can present with a number of symptoms that make up the “ureteral stent syndrome” [2, 5, 6, 10, 16, 17] (Table 2).

Although the pathophysiology of the development of these signs and symptoms is not fully understood, the irritation produced by the distal end of the stent on the

Table 2 Symptoms of ureteral stent syndrome

Filling symptoms
Dysuria
Haematuria
Hypogastric or suprapubic abdominal pain
Ipsilateral renal fossa pain

bladder mucosa (mainly the bladder trigone), as well as the presence of vesicoureteral reflux seem to be related to the described symptoms. The use of catheters made of harder materials has also been associated with a higher incidence of symptoms such as dysuria, hypogastric or renal fossa pain [18].

Some patients may be unaware of a history of ureteral stent placement during the anamnesis, but the presence of these symptoms in a patient with a surgical history should lead us to believe that he or she may have a stent [2]. Furthermore, it is not uncommon for forgotten ureteral catheters to be asymptomatic and to be an incidental finding when they are incidentally found in an abdominopelvic imaging test [9].

The previously described symptoms, in addition to being present in patients with a ureteral stent who are aware of this condition, may also be present in FUSS. In this scenario, the symptoms depend on the complications generated by the time elapsed and the risk factors described above.

From compliance with the maximum ureteral stent dwell time to the occurrence of complications related to excess stent placement time is considered to take on average between 3 and 24 months [19].

Although most authors consider that the longer the stent placement time, the retrospective study by Lin TF et al. [1] found no significant differences in this regard. However, in this study, patients with a forgotten JJ stent placement accounted for 3.8% (18 patients) of the 479 patients analysed. Thus, only three of the patients with forgotten catheter placement developed complications. The sample size might be insufficient to draw conclusions [1].

4.1 Flank Pain

Pain may be due to vesicoureteral reflux or hydronephrosis. During micturition, the increased bladder pressure is transmitted through the stent placement and retrograde to the renal pelvis. The stent placement overrides the anti-reflux mechanism of the distal ureter causing a sudden increase in intra-pelvic pressure.

Hydronephrosis may be due to lithiasis formation, displacement or migration of the catheter placement, fragmentation or obstruction, among other causes.

On the one hand, the frequency of ureteral JJ stent migration ranges between 3% and 10% of the stents that are placed. It should be specified that migration can be proximal or distal; the latter being up to three times more frequent [20]. Factors involved in intraureteral stent movements include length, diameter and stent material. In general, stents made of softer, hydrophilic materials have a greater trend towards dislodgement [21]. Although stent length is usually chosen based on the patient's height, some studies suggest radiographic measurement of the distance between the pyeloureteral junction and the uretero-vesical junction as a strategy to further adjust the stent to the patient [21]. Also to prevent migration, double-J retention systems for stents were designed. Even so, sometimes even the proximal J-end can descend from the renal pelvis into the ureter or even the bladder, leading to urinary obstruction [7, 10].

Finally, the risk of catheter fragmentation is particularly high 14 weeks after stenting. Long-term exposure of stents to urine components produce the degeneration of the polymers. Thus, in cases of urinary tract infection and/or urothelial inflammation, the rate of degradation is higher. Stents composed of polyethylene polymers are the most easily degraded and are more prone to fragmentation. It is noted that the fragmentation lines usually coincide with the stent placement holes, so reducing the number of these holes could reduce the risk and/or the number of stent fragments [6, 18, 22].

4.2 Urinary Tract Infections

The stenting duration time also increases the likelihood of persistent UTI, since the longer the stent placement time, the higher the level of colonisation (up to 75% of stents that have been in place for more than 90 days are colonised).

As we have already indicated, bacteriuria is almost a constant in these patients, and up to 27–73.6% of cases develop UTIs that are likely to be recurrent and multi-resistant to antibiotics. This is because microorganisms remain in biofilms [3, 10, 23]. Biofilms hinder antimicrobial penetration and, in their matrix, microorganisms tend to express antimicrobial resistance genes and remain metabolically dormant, making antimicrobials even less effective [24]. Other factors that may favors the persistence of UTIs include the high prevalence of diabetes or renal failure in these patients.

The severity of infections generated by a forgotten ureteral stent varies widely: from simple cystitis [24] to severe acute pyelonephritis and septic shock of urinary origin [1, 2].

In renal transplant recipients, the most common presentation is recurrent UTIs and deterioration of renal function [25, 26]. In these patients the most common composition of the deposited material is struvite. Immunosuppression in transplant recipients favours colonisation of the urinary tract by urease-positive bacteria. In contrast to non-transplanted patients, patients with a renal graft do not have episodes of renal colic due to denervation of the graft [25].

4.3 Problems in Removal of Ureteral Stent

As mentioned above, the percentage of stent with surface encrustations increases with the stenting duration, with up to 75.5% of stents being found to be encrusted to a lesser or greater extent 6 months after placement [2, 6, 9, 15, 19, 27].

Extensive encrustation can lead to difficulties or impossibility in retrieval of the ureteral stent. This is why each case must be assessed individually to propose the method of stent removal depending on the degree of encrustation. Ureteral stents

can be removed under local anaesthesia and using the flexible cystoscope in uncomplicated cases with low risk of encrustation. In patients with extensive stent encrustation rate, the removal should be performed under general anaesthesia, using fluoroscopy to monitor the procedure.

4.4 Irritation and Tissue Injury

Long-term stents can alter ureteral tissue vascularisation and cause tissue injury, potentially leading to urinary fistulae and even uretero-arterial fistulae [28]. It should be highlighted that although polyurethane stents combine the flexibility of silicone and the rigidity of polyethylene, they appear to be the least biocompatible devices and are associated with the highest degree of urothelial injury and erosion in animal models. In contrast, silicone stents have been associated with the least ureteral tissue reactions in animal models [18].

4.5 Renal Failure

Recurrent infections, vesicoureteral reflux and encrustation, fragmentation or migration of the ureteral stents are conditions that may finally lead to deterioration of renal function. In some clinical series, up to 18.4% of patients with forgotten stents have been found to have chronic kidney disease at different stages, and up to 5.2% of patients eventually require renal replacement therapy [3].

5 Diagnosis of Forgotten/Encrusted Ureteral Stent

In patients with the signs and symptoms described above, an X-ray of the urinary tract, blood tests and urine culture should be considered initially [29]. Urinary tract X-rays can not only confirm the existence of the stent but also show whether it is encrustated. The degree of encrustation can be more precisely defined by performing an abdominopelvic CT scan without iodine contrast. Grades of stent encrustation are listed in the FECal Ureteral Grading System classification [2, 29]:

- Grade 1: minimal linear encrustation at one of the two J-ends of the stent.
- Grade 2: Circular encrustation totally encompassing one of the two J-ends of the stent.

- Grade 3: Circular encrustation totally encompassing either of the two J-ends together with linear encrustation in some segments of the ureteral section of the stent.
- Grade 4: circular encrustation completely encompassing both J-ends of the catheter placement.
- Grade 5: extensive encrustation encompassing both J-ends and the entire ureteral segment of the catheter placement.

This classification makes it possible to standardise the assessment of the extent of encrustation of stents and can guide decision-making on the treatment required [1].

Ultrasonography of the urinary tract is of interest to assess the existence or not of hydronephrosis, which may suggest obstruction and/or encrustation of the stent [29]. Assessment of the proximal end should be done with an empty bladder to avoid artefact due to excessive bladder distension.

Other anatomical-functional studies such as intravenous urography or CT urography can complete the evaluation of patients with forgotten ureteral stents. If the loss of renal function is severe, these studies may not be performed. For the assessment of the degree of functionality of both renal units, the isotopic renogram is of interest, mainly for individualised therapeutic options [12] (Figs. 1, 2, 3 and 4).

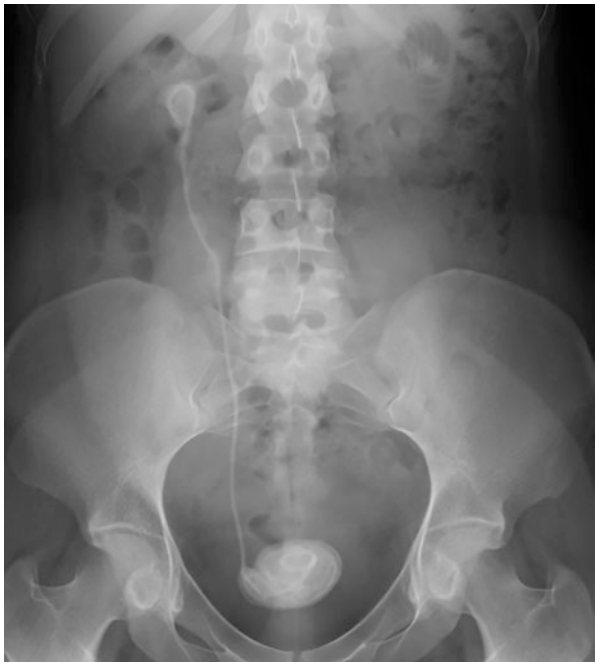

Fig. 1 Urinary tract X ray. Patient with 5 level FeCal score

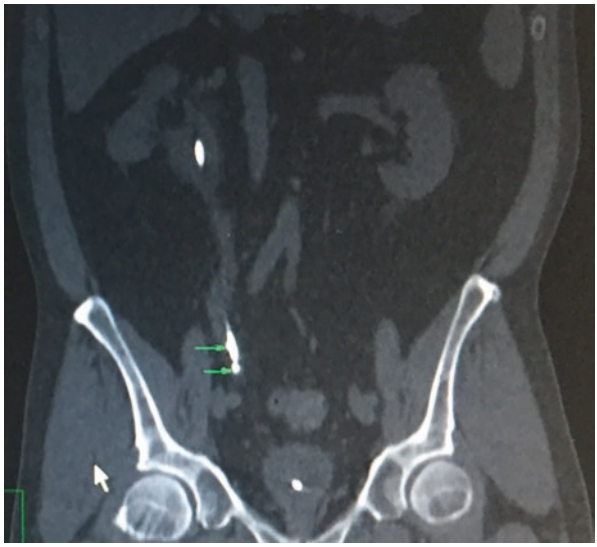

Fig. 2 Urinary tract CT. Patient with 5 level FeCal score

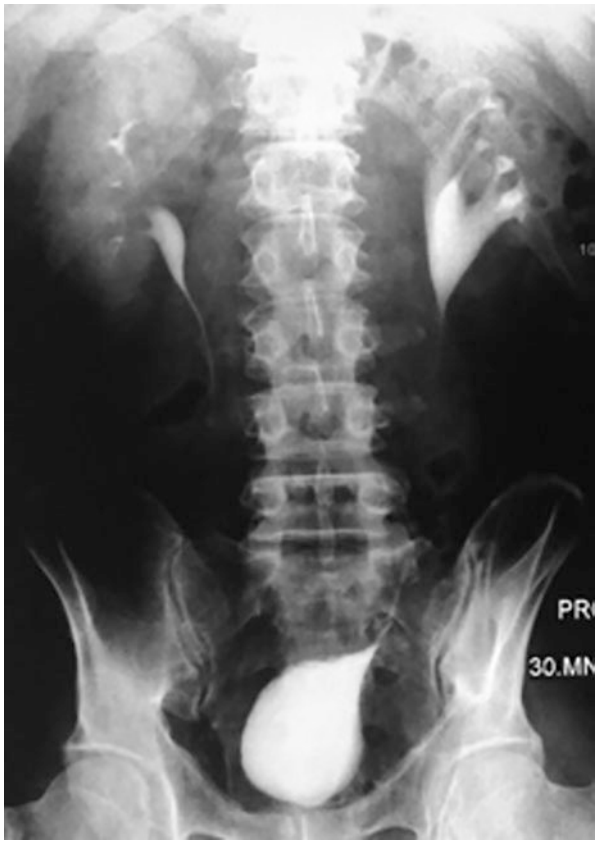

Fig. 3 Excretory urography. Ureteral stent encrustation

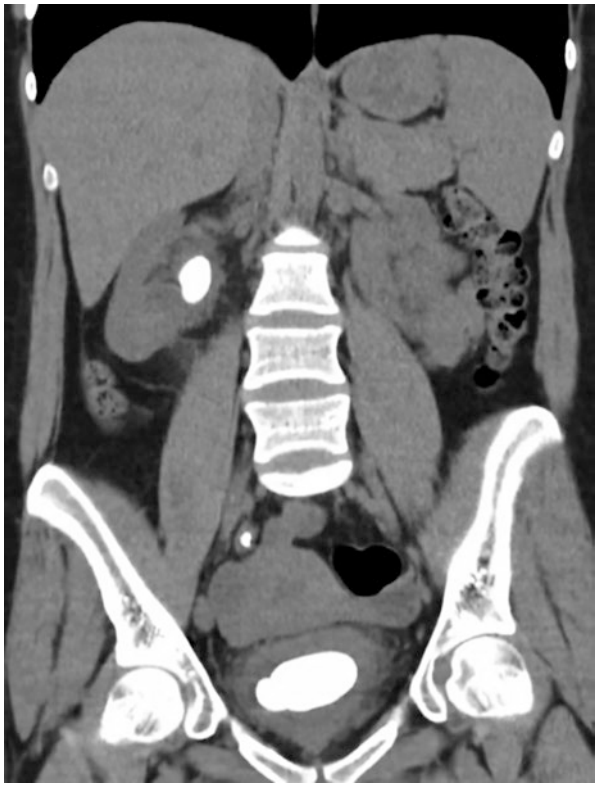

Fig. 4 CT Urography. Ureteral stent encrustation

6 Preventive Strategies for Forgotten Ureteral Stent

The development of protocols to reduce unnecessary JJ ureteral stent placement and minimise dwell time is the first step in preventing the occurrence of FUSS.

Additional strategies in the same direction include patient follow-up and education as well as the development of new materials that may prevent or delay the development of complications.

6.1 Health Education

Healthcare professionals are responsible for establishing the follow-up of patients with ureteral stents, and for determining the length of time placement according to the type of stent. Before discharge from hospital, the patient should be adequately educated about his or her condition [19, 27].

It is essential to inform and convey the importance of stent placement time to the patient so that he/she is involved in the removal planning process [16].

Patients who move between regions or countries are a major concern and should be informed of the implications of not withdrawing the stent placement in a timely manner [10].

6.2 Surveillance and Monitoring Systems

Its purpose is to remove the catheter placement within the required timeframe.

Notebooks and paper card recording, in which the operator records patient details on paper. It has proven to be an unreliable system, with a failure rate of 22.4% [25].

Computerised tracking: Several computerised registries have been developed and implemented showing significant improvement in the follow-up of patients with ureteral catheters. The computerised tracking system proposed by Ather et al. demonstrated a significant decrease in the incidence of forgotten catheters from 12.5% to 1.2% after the first year of its application [25].

Registration using new software applications is developed below.

6.3 Simple Removal System

In uncomplicated cases, stents can be externalised by attaching them to the bladder catheter after procedures such as ureterorenoscopy. This facilitates removal and reduces the risk of FUUS [9, 19].

6.4 Innovation in Stents

Development of biodegradable stents, which dissolve after a predictable time (14–28 days from insertion), leaving no fragments that could cause obstruction (polyglycolic acid and glycomer 631). This would eliminate the need for stent withdrawal [9, 25, 30, 31]. However, there is currently non-evidence on their use as results are only available from animal studies [18].

6.4.1 Use of Stents with Coatings of Different Materials

- Glycosaminoglycans, heparin or silver reduce or prevent stent biofilm formation [9, 18, 25].
- PDMMA (dimethylacrylamide) polyhydrogel, triclosan, polyacrylonitrile or antiseptics such as chlorhexidine: reduce biofilm formation and catheter-associated UTIs [9].

6.4.2 Anti-reflux Stents [17, 30, 32]

- Stent with a very thin distal end, thinner than the rest of the stent. This allows minimal interference at the ureterovesical junction.
- Traditional ureteral stent placement with a valve attached to the distal end, which functions as an anti-reflux valve.
- Intraureteral stent placement that does not cross the ureteral orifice and therefore does not generate vesicoureteral reflux.
- Stents in which the distal pigtail is replaced by a 0.3Fr thread suture.

6.4.3 Use of New Technologies in the Prevention of Forgotten Ureteral Stent Syndrome

The main drawback of traditional ureteral catheter patient follow-up strategies (paper card registry, electronic registry) is that the information is only available at the centre where the registration takes place. In addition, this register requires infrastructure and personnel to perform enrolment and follow-up [33].

To overcome this shortcoming, the Ureteral Stent Tracker™ (UST) has been developed (P Visible Health, Inc., in partnership with Boston Scientific). It is a mobile application to track patients with ureteral catheters [34].

A unique profile with name and registration number is created for each patient. Within the profile, the date of insertion, laterality, expected removal date, and confirmed date of removal are included. Care plans are visually coded to allow easy identification of patients with catheters that have exceeded their planned removal date. This information is also sent as a weekly email reminder to all involved healthcare professionals [34].

Comparing the effectiveness and usefulness of the app with the classical card-based appointment system to prevent FUSS, it was concluded that patients followed up via the mobile app had fewer delays and losses to follow-up [35].

Unlike paper-based systems, computer tracking has improved data entry, rapid search capability, and access from multiple sites [34].

7 Conclusions

The growing importance of the use of double j ureteral stents for several indications makes the FUSS a complication with a not insignificant frequency. The properties of urine and the presence of bacteria can promote catheter encrustation. This can result in a highly variable range of signs and symptoms. Patients may have no clinical presentation or may have severe urinary tract infections and/or renal failure.

New biomaterials for stent manufacture and coatings should reduce the main complications associated with this syndrome are currently under development. New technologies aimed at planning and remembering stent removal or replacement could dramatically reduce the incidence of this syndrome.

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