SUPRAPUBIC CYSTOSTOMY CATHETER KNOTTING. PRESENTATION OF THE FIRST NATIONAL CASE AND REVIEW OF THE LITERATURE

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* Dedicated to the memory of my father, Pedro Romero Carceles, who died in the course of preparing this manuscript.

Summary.- OBJECTIVE: This study presents the first Spanish case of a spontaneous knot in the catheter of a suprapubic cystostomy and review the national and international literature.

METHODS: The case of an 87-year-old patient who was diagnosed with adenocarcinoma of the prostate is presented. A suprapubic vesical puncture for urinary retention was urgently performed in this patient because of the impossibility of urethral catheterisation. A spontaneous knot in the catheter was detected upon removal; the tightened knot could be removed by gentle and sustained traction without surgery.

RESULTS: Knotting or calcification of the catheter was suspected when the catheter remained anchored in the bladder during a removal attempt 5 days after initial catheterisation. Plain pelvis x-ray was taken, but no calcification or knots were observed because the catheter was radiolucent. An ultrasound would have offered more information, but it was not requested. Gentle and sustained traction of the catheter reduced the knot size and allowed catheter removal without complications. Worldwide cases and national publications were reviewed.

CONCLUSION: The formation of spontaneous or manipulation-induced knots in urinary cystostomy catheters is an extremely rare complication. The presented case is the first Spanish case of catheter knotting; it is only the 17th reported case worldwide.

Keywords: Catheter knotting. Cystostomy catheter. Urinary catheters. Complications. Review.

Resumen.- OBJETIVO: Presentar el primer caso español de nudo espontáneo en un catéter de cistostomía suprapúbica y revisar la literatura nacional e internacional.

MÉTODOS: Presentamos el caso de un paciente de 87 años, diagnosticado de adenocarcinoma de próstata, al que se le colocó de urgencia una punción vesical suprapúbica por retención urinaria ante la imposibilidad de sondaje uretral, produciéndose un nudo espontáneo en el catéter, detectado a su retirada, que se resolvió mediante tracción suave y sostenida del catéter, sin requerir cirugía.

RESULTADOS: Se sospechó anudamiento o calcificación del catéter al intentar retirarlo a los 5 días de su colocación y permanecer éste anclado en la vejiga. Se
The formation of spontaneous knots in probes and catheters is a very rare complication.

The first description of the formation of a knot in a urinary catheter was made by Anderson and published in JAMA on June 22nd, 1912. The case was a 35 year old Russian admitted to a hospital in Chicago with a knot in a catheter after urinary retention.

Catheter knotting has been described in diverse medical specialties, including Thoracic Surgery, Intensive Care, Neuroradiology, Anaesthesia, Cardiology, and Urology.

Knotting of non-urological catheters has been reported in the case of the Swan-Ganz catheter in the right pulmonary artery (2), catheters of ventriculoperitoneal derivation (3), peripheral nerve-block catheters (4), and epidural catheters (5).

Knotting of urological catheters has been reported in double J ureteral catheters (6,7), Foley-type probes for cystourethrography in children (8), suprapubic cystostomy using Cystofix® catheters (9), and the metallic guide of double J catheters (10).

Knotting in urinary catheters is usually undiagnosed because the knot occurs because of traction by the patient or health professionals during removal attempts. The knot prevents removal of the catheter. Urinary outflow is obstructed, which creates a urological emergency until the catheter is extracted, and the obstruction is corrected.

Only 5 cases of spontaneous knotting in urinary catheters have been reported in Spanish national literature during the past 14 years (1998-2011). Approximately 40 cases worldwide have been described by Raveenthiran (11).

Because this case represents the first incidence of cystostomy catheter knotting in Spain and only the tenth case worldwide, a detailed report of our personal experience and a review of the subject is warranted.

CASE REPORT

An 87-year-old patient receiving complete androgenic suppression for prostate adenocarcinoma for 5 months presented in the Emergency Department with a 6-hour urinary retention and previous attempts of unsuccessful vesical probing.

The urologist on duty failed to pass a urethral catheter because of an impassable stop in the posterior urethra or a false tract. A suprapubic vesical puncture was performed using a Cystofix® 10 Fr catheter, which drained 700 ml of clear urine.

A vesical probe was placed using a Foley 16 Fr 5 days later. Removal of the suprapubic catheter was unsuccessfully attempted at various times. The Foley balloon was emptied and mobilized in case the suprapubic catheter had knotted onto the probe, but this manoeuvre was unsuccessful.

Simple abdominal x-ray revealed no evidence of catheter calcification or knotting because these catheters are radiolucent. An ultrasound scan, which would have supplied more information and images of potential knotting, was not performed despite the suspicion of a knot at the end of the catheter. A firm, gentle and sustained traction of the catheter tightened the knot, which permitted the removal of the suprapubic catheter through the cutaneous orifice of the puncture. The catheter had a compound figure-of-eight knot which formed a snare two cms from the end of the catheter (Figures 1 and 2).

MATERIAL AND METHODS

A bibliographic search was performed in MEDLINE/PubMed and Google.es using the
keywords, “knotting catheter,” and 110 articles from 1912 to 2012 were found. A search of the keywords, “suprapubic catheter knotting” yielded 15 published articles between 1998 and 2010.

DISCUSSION

The complications of suprapubic cystostomy include catheter placement outside the bladder, visceral perforation of the intra-abdominal cavity with peritonitis, enterocutaneous fistula, catheter expulsion, migration of the catheter to the ureter with obstructive uropathy, haematuria, urinary infection, catheter incrustations or calcification, catheter end fragmentation, and catheter retention from calcium conglomeration or knot formation. The formation of knots is the rarest complication; only 15 articles worldwide (16 cases) have been reported (9,11-24).

Knotting is a mechanical complication of external (e.g., Foley vesical probes, suprapubic cystostomy Cystofix catheters, and nephrostomy catheters) and internal (double J stents and their metallic guides) urinary catheters.

Catheter knotting constitutes an infrequent and surprising complication that abruptly creates a new urological emergency. Knotting of autostatic (self-retaining) or nonautostatic (cystostomy) catheters must be considered as a possible cause of a retained catheter.

According to Foster et al. 1992 (14), the knotting of a bladder catheter is a rare complication, whose frequency is 0.2 per 100,000 (two cases per million of catheterisations).

The “spontaneous” knotting of probes and catheters has been reported in other medical specialties. Review of the literature revealed surprising descriptions of knots in other anatomical locations that entailed potential vital risks or important consequences of the extraction manoeuvres.

Knot formation in non-urological catheters has been described in the Swan-Ganz pulmonary flotation catheter in the right pulmonary artery (2), the ventriculoperitoneal drainage systems (3), continual peripheral nerve block catheters (4), obstetric epidural catheters (5), pulmonary artery catheters in cardiovascular and thoracic surgery (25), a pulmonary artery catheter in the right atrium after a tricuspid valve annuloplasty (26), and a peridural catheter (27).

Case studies on knots in urinary catheters have been published more frequently in English literature than Spanish literature.

In the English literature from 1912 - 2012 we have located 110 articles on knots in different types of urinary catheters, which complements and enhances the 40 cases brought during the last global review on urinary catheters knots by Raveenthiran in 2006 (11) and that will be grounds for another publication.

Only 4 reports of knots in diverse urinary catheters types were located in the Spanish literature from 2000-2011: 3 Spanish authors from Valencia.
P. Romero Pérez, F. E. Lapuerta Torres, M. Amat Cecilia, et al. (7), Albacete (8), Madrid (10), and 1 South American author from Santiago, Chile (9).


Cystostomy catheter knotting is an infrequent complication, and this report is the tenth published case worldwide in the past 20 years (12,14,15,11,16,9,17,21).

This report is the first Spanish case of a cystostomy catheter knot.

Only 4 publications in the Spanish literature in Castilian reference “urinary catheter knots” as a complication (Table I). However, only 4 of these reports are by Spanish authors who reference knots in Foley probes, Double J catheters and Double J catheter guides. The other publication is by South American (Chile) authors who reference suprapubic cystostomy catheter knots.

This report is the 111 case of a urinary catheter knot, and the 17th worldwide case of a cystostomy catheter knot.

This report is the 5th national case of a knot in any type of urinary catheter, and it is the first national case of a suprapubic catheter knot.

The occurrence of spontaneous suprapubic cystostomy catheter knotting is even rarer, only 16 case studies have referred suprapubic catheters knots in the last 38 years. This report is the first national case of a cystostomy catheter knot published by Spanish authors and the 17th report in the worldwide literature (Table II).

The word “knot” (from the Latin nodus for node) in the Royal Spanish Academy Dictionary makes reference to a “Loop that tightens and closes in such a way that only with difficulty can it be loosened on its own, and the more either one of the sides is pulled, the tighter it becomes.” Synonyms for knot include ligature, link, grasp, junction, loop, link, binding, connection, entanglement, net, and thicket (28).
### Table II. Case studies of suprapubic cystostomy catheter knots in the worldwide literature.

<table>
<thead>
<tr>
<th>CASE NUM</th>
<th>YEAR</th>
<th>AUTHORS</th>
<th>No. CASES</th>
<th>CATHETER TYPE</th>
<th>DIAMETER Fr</th>
<th>SPECIALITY</th>
<th>CITY</th>
<th>COUNTRY</th>
<th>PUBLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1º</td>
<td>1974</td>
<td>Lissoos (12)</td>
<td>1</td>
<td>Suprapubic polythene vynil chloridre (PVC)</td>
<td>Not referred Fr</td>
<td>Urology</td>
<td>Johannesburg</td>
<td>Sudafrika</td>
<td>Br J Urol</td>
</tr>
<tr>
<td>2º</td>
<td>1992</td>
<td>Mishra, et al. (13)</td>
<td>1</td>
<td>Suprapubic epidural catheter + Urethral infant feeding tube (IFT)</td>
<td>Knot between catheters 5-10</td>
<td>Urology</td>
<td>Lucknow</td>
<td>India</td>
<td>Br J Urol</td>
</tr>
<tr>
<td>3º</td>
<td>1992</td>
<td>Foster, et al. (14)</td>
<td>1</td>
<td>Suprapubic (unspecified) + Urethral IFT</td>
<td>Knot between catheters 8-8</td>
<td>Urology</td>
<td>Ann Arbor</td>
<td>USA</td>
<td>J Urol</td>
</tr>
<tr>
<td>4º</td>
<td>2001</td>
<td>Polychronidis et al. (15)</td>
<td>1</td>
<td>Suprapubic NÉLATON + Urethral FOLEY</td>
<td>Knot between catheters 12-18</td>
<td>Second Surgery Department</td>
<td>Alexandroupolis</td>
<td>Grecia</td>
<td>J Urol</td>
</tr>
<tr>
<td>5º</td>
<td>2001</td>
<td>Arda y Ozyaylali (16)</td>
<td>1</td>
<td>Suprapubic CYSTOFIX® + Urethral FOLEY</td>
<td>10</td>
<td>Paediatric Surgery and General Surgery</td>
<td>Ankara</td>
<td>Turquia</td>
<td>Int J Urol</td>
</tr>
<tr>
<td>6º</td>
<td>2004</td>
<td>Gardikis, et al. (17)</td>
<td>1</td>
<td>Suprapubic EASYCYCT + Urethral IFT</td>
<td>Knot between catheters 10-8</td>
<td>Paediatric Surgery</td>
<td>Alexandroupolis</td>
<td>Grecia</td>
<td>Int Urol Nephrol</td>
</tr>
<tr>
<td>7º</td>
<td>2006</td>
<td>Raveenthiran (11)</td>
<td>1</td>
<td>Suprapubic Cystofix + Urethral FOLEY</td>
<td>Knot between catheters 8-16</td>
<td>Paediatric Surgery</td>
<td>Tamilnadu</td>
<td>India</td>
<td>Urol Int</td>
</tr>
<tr>
<td>8º</td>
<td>2006</td>
<td>Sithasanan, et al. (18)</td>
<td>1</td>
<td>Suprapubic CYSTOFIX® + Urethral FOLEY</td>
<td>Knot between catheters 8-16</td>
<td>Paediatric Surgery</td>
<td>Kuala Lumpur</td>
<td>Malaysia</td>
<td>Med J Malaysia</td>
</tr>
<tr>
<td>9º</td>
<td>2007</td>
<td>Villete, et al. (9)</td>
<td>1</td>
<td>Suprapubic CYSTOFIX® + Urethral FOLEY</td>
<td>Knot between catheters 8-20</td>
<td>Urology</td>
<td>Santiago de Chile</td>
<td>Chile</td>
<td>Arch Esp Urol</td>
</tr>
<tr>
<td>10º</td>
<td>2007</td>
<td>Farook, et al. (19)</td>
<td>1</td>
<td>Suprapubic CYSTOFIX® + Urethral FOLEY</td>
<td>Knot between catheters 6-8</td>
<td>Paediatric Surgery</td>
<td>Leeds</td>
<td>UK</td>
<td>The Scientific World J (TSWJ)</td>
</tr>
</tbody>
</table>
A clinical and experimental study of spontaneous urinary catheter knots by Raveenthiran in 2006 (11) contributed 4 cases and compiled the 40 published cases in the worldwide literature.

This author identified 3 risk factors for knot formation in urinary probes based on the clinical observations of 4 children and simulation experiments using a ball model that substituted for the urinary bladder:

1. Thin catheters with a diameter of < 10 Fr (3.3 mm);
2. Overextended bladder; and
3. Insertion of > 10 cm catheter inside the bladder.

The stream that is generated by urinary flow plays an important role in the pathogenesis of catheter knotting.

We added 4 risk factors for cystostomy catheter knot formation based on our review of the literature and the contributions of GAISIE and BENDER, 1983 (29) (Table III).

Catheter knot formation is possible. Numerous articles in the existing literature reference "spontaneous knots" or "spontaneous knotting" of catheters or urinary probes in their titles. However, spontaneous knots do not exist according to our criteria; it is the human hand (a patient, healthcare professional, etc.) that manipulates the catheter to form a definitive knot.

Five conditions must exist for the production of a cystostomy catheter knot: the catheters must be too long, fine and soft, and enter too far into an overextended bladder. The catheter winds over itself and forms "loops" or "curls" that remain inside the bladder as potential knots. The manipulation of the catheter by healthcare professionals (e.g., nurses, doctors, urologists) or the patient favours the creation of catheter knots.

The natural sequence of knot formation would be the following (Table IV).
A knot is almost impossible to reverse using instrumental or endourological methods. Emergency surgery is required for the majority of cases when the knotted catheter cannot be entirely removed using traction.

The following conditions are recommended for non self-retaining catheters to prevent the formation of knots: the catheters should not be too long or fine; catheters should not be inserted too far into the interior of the bladder; and, above all, long

Table III. Risk factors for cystostomy catheter knot formation. Modified from raveenthiran 2006 (11) and gaisie and bender 1983 (29).

<table>
<thead>
<tr>
<th>Catheters that are thin in diameter &lt; 10 Fr (3.3 mm).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overdistended Bladder.</td>
</tr>
<tr>
<td>Insertion of &gt; 10 cm of catheter inside the bladder.</td>
</tr>
<tr>
<td>Presence of two or more different catheters in the urinary tract.</td>
</tr>
<tr>
<td>Overly soft or ductile catheters that become more flexible after warming by urine.</td>
</tr>
<tr>
<td>Catheters that are too long and soft.</td>
</tr>
<tr>
<td>Urinary warming of the catheter that increases its softness and flexibility, which allows for loop formation.</td>
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<tr>
<td>Blind introduction without echography.</td>
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</tbody>
</table>

Table IV. Natural sequence of urinary catheter knot formation.

<table>
<thead>
<tr>
<th>1st Risk Factors</th>
</tr>
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<tbody>
<tr>
<td>Catheter:</td>
</tr>
<tr>
<td>Fine &lt; 10 Fr diameter</td>
</tr>
<tr>
<td>Long &gt; 30-40 cm longitude</td>
</tr>
<tr>
<td>Soft or ductile</td>
</tr>
<tr>
<td>Insertion &gt; 10 cm</td>
</tr>
<tr>
<td>Overdistended bladder</td>
</tr>
<tr>
<td>Blind introduction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2nd Spontaneous</th>
</tr>
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<tbody>
<tr>
<td>Spontaneous Formation of LOOPS or CURLS</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>3rd Human</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catheter manipulation by health professionals TRACTION</td>
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</table>

<table>
<thead>
<tr>
<th>4th Knot Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knotting of the catheter: KNOT</td>
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</table>

<table>
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<tr>
<th>5th Retained Catheter</th>
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</thead>
<tbody>
<tr>
<td>Retained catheter</td>
</tr>
<tr>
<td>Stuck catheter</td>
</tr>
<tr>
<td>Embedded catheter</td>
</tr>
<tr>
<td>Is unremovable</td>
</tr>
<tr>
<td>Urinary obstruction</td>
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<tr>
<th>UROLOGICAL EMERGENCY</th>
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</table>

The following conditions are recommended for non self-retaining catheters to prevent the formation of knots: the catheters should not be too long or fine; catheters should not be inserted too far into the interior of the bladder; and, above all, long
segments of the catheter should not be introduced into the bladder.

The diagnosis of knot formation in cystostomy catheters should be suspected when the following conditions exist:

- cessation of urine flow through the catheter with an overdistended bladder because of urinary retention;
- resistance or difficulty in catheter removal.

The clinical diagnosis is confirmed using a simple abdominal radiograph if the catheter is radiopaque. However, as in this case, a simple radiograph of the urinary tract is equally necessary for radiolucent catheters to exclude the calcification of the distal catheter end with stone formation as the underlying cause of retention.

Simple contrasted radiology using radiopaque contrast through the catheter (i.e., cathetergraphy) should be considered for the identification of knots in the urinary apparatus.

Echography or ultrasound can determine the knot characteristics in the majority of cases:

- location (vesical, extravesical or urethral)
- diameter
- number of knots
- complexity
- knotting between 2 distinct catheters
- association with calculi in the catheter

Carrillo Esper et al. (2) divide knots into simple and complex based on the echographic findings and knot characteristics:

- Simple knots are characterized by one fold, looseness and a diameter equal to or less than 2 to 3 mm. These knots also form large unique knots that are normally loose.
- Complex knots are characterized by various loops that are interlaced, tightness and a diameter larger than 3 mm.

Extrapolating from techniques in other specialities, once knot formation is established, an attempt to untie the knot by catheter manipulation should be performed. If this attempt fails, the knotted catheter will be removed using nonsurgical or surgical techniques, such as endoscopy or open surgery (2) to cause the least amount of possible damage.

Non-surgical techniques

Various nonsurgical techniques to untie knots or remove knotted catheters have been described. Each technique has a particular indication depending on the characteristics of the knot that must be resolved.

The following techniques should always be performed under fluoroscopic or radioscopic control and antibiotic prophylaxis:

1) Counterclockwise axial rotation: This technique is suggested to untie loose knots that are formed by the folds of large loops.

2) Internal wire guide: The use of a wire guide to untie knots is suggested when knots are loose or formed by large loops (i.e., simple knots). A wire guide is introduced through the catheter, and the pressure that is exerted on the loop straightens the knot by increasing catheter rigidity.

3) External wire guide: The tightest knots, which are small and possess only one loop, can be untied using an external flexible wire guide that ends with a “pigtail.” The technique introduces a guide using a different vesical access. Once the guide arrives at the knot, the pig-tail end of the guide is introduced to the inside of the knot, and a soft progressive traction is applied until the knot is untied.

4) Inflatable balloons: This technique yields good results with loose small knots that are distal (approximately 10 cm from the catheter end) and impossible to resolve using the aforementioned techniques. FOGARTY catheters have been used with angioplasty balloons. The technique introduces the catheter with the ball through a different bladder approach, and this apparatus is advanced until it reaches the knot. The uninflated balloon introduced to the inside of the knot, and it is inflated until the knot is untied.

5) Traction or percutaneous extraction: This technique can be the first option when a catheter cannot be removed or as an alternative when it is impossible to untie the knot and extract the catheter. In the current case, the catheter should be extracted with the knot. The technique uses a continuous and progressive traction of the catheter to reduce the knot size, which permits the catheter to exit through the cutaneous orifice of the skin in the cystostomy.
In some cases, the catheters knot over each other or over a Foley catheter (i.e., double catheter knot) instead of knotting over itself. These types of knots may occur when a suprapubic puncture coincides with an exploratory or simultaneous urethral catheter.

The knotting of a cystostomy catheter over a Foley catheter has been reported previously (15,11,18,9).

In these cases, neither of the two catheters can be removed. The size of the knot can be assessed using echography. If the knot is <8-9 mm and urethral extraction is permitted, the suprapubic catheter should be cut and traction should be applied on the urethral catheter until the withdrawal of both catheters through the urethra is achieved.

6) Baskets: The use of baskets for complex knots with various tight and large (> 5 mm) loops has been described (2).

**Surgical techniques**

The following techniques should be used when the former methods have failed. These techniques can be categorized as endoscopic or open surgery.

1) **Endoscopic:** These techniques use cystoscopy to access the bladder. The knot is cut with endoscopic scissors, and foreign body forceps extract the knotted fragment. The remainder of the catheter is removed through a percutaneous pathway.

This method allows for the simultaneous resolution of the pathology that impeded urethral catheterization, which is generally urethral stenosis or a false way.

2) **Open surgery:** This technique removes the catheter through a minimal cystotomy. This technique should be used for large or calcified knots that impede the use of an endoscopic approach.

Numerous complications are associated with cystostomy catheter knots, including urinary retention, pain caused by bladder overdistension or traction during manipulation or extraction, haematuria, catheter break or fragmentation, partial break of the catheter, knots that remain in the bladder, urinary infection and sepsis.

We recommend the following factors to prevent knots in cystostomy catheters:

- The use of larger catheters (> 10 Fr);
- The use of echography to ascertain the knot position (this method is infrequently used by urologists);
- The use of shorter catheters (< 30 cm.)
- The introduction of a shorter catheter length (< 10 cm).
- Precaution in hyperdistended bladders and urine retention.
- The use of harder and less ductile catheters because body temperature increases catheter flexibility, which facilitates loop formation.

**CONCLUSIONS**

The formation of knots in urinary catheters is a rare complication. However, knot formation quickly becomes a urological emergency.

The treatment of catheter knots often requires difficult manoeuvres or surgical interventions that are more aggressive than simple catheter placement.

The difficulties of haemorrhage during catheter manipulation are greater in patients taking anticoagulants or platelet antiaggregants.

The prevention of knot formation is simpler than knot treatment. Knot formation can be prevented through the use of catheters that are less fine (>10 Fr), shorter (< 30 cm), and harder, and the introduction of the catheter less than 10 cm inside the bladder.

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**REFERENCES AND RECOMMENDED READINGS**

(*of special interest, **of outstanding interest)


