

Acute kidney injury due to bilateral ureteral obstruction in children

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Abstract

Bilateral ureteral obstruction in children is a rare condition arising from several medical or surgical pictures. It needs to be promptly suspected in order to attempt a quick renal function recovery. In this paper we concentrated on uncommon causes of obstruction, with the aim of giving a summary of such multiple, rare and heterogeneous conditions joint together by the common denominator of sudden bilateral ureteral obstruction, difficult to be suspected at times. Conversely, typical and well-known diseases have been just run over. We considered pediatric cases of ureteral obstruction presenting as bilateral, along with some cases which truly appeared as single-sided, because of their potential bilateral presentation. We performed a review of the literature by a search on PubMed, CrossRef Metadata Search, internet and reference lists of single articles updated to May 2014, with no time limits in the past. Given that we deal with rare conditions, we decided to include also papers in non-English languages, published with an English abstract. For the sake of clearness, we divided our research results into 8 categories: (1) urolithiasis; (2) congenital urinary tract malformations; (3) immuno-rheumatologic causes of ureteral obstruction; (4) ureteral localization of infections; (5) other systemic infective causes of ureteral obstructions; (6) neoplastic intrinsic ureteral obstructions; (7) extrinsic ureteral

obstructions; and (8) iatrogenic trigonal obstruction or inflammation. Of course, different pathogenic mechanisms underlay those clinical pictures, partly well-known and partly not completely understood.

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Key words: Acute kidney injury; Bilateral ureteral obstruction; Hydronephrosis; Anuria; Pediatrics; Ureteral stenting; Henoch-Schönlein purpura; Tuberculosis; Masses; Congenital malformations

Core tip: Bilateral ureteral obstruction in children is a rare condition related to several medical or surgical pictures. It needs to be promptly suspected in order to attempt a quick renal function recovery. It is a rare event, but to be kept in mind. We identified many potential causes grouped as follows: (1) urolithiasis; (2) congenital urinary tract malformations; (3) immuno-rheumatologic causes of ureteral obstruction; (4) ureteral localization of infections; (5) other systemic infective causes of ureteral obstruction; (6) neoplastic intrinsic ureteral obstructions; (7) extrinsic ureteral obstructions; and (8) iatrogenic trigonal obstruction or inflammation.

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INTRODUCTION

The definition of acute kidney injury (AKI) has been deeply changing over the last decade, starting off with adult patients^[1] and followed by a still debated extension to children^[2-4], with some new biomarkers for AKI early detection proposed^[5,6].

In particular, AKI in children has been widely discussed in several reviews and meta-analysis^[2,3,7], including

some papers focused on AKI in newborns^[8] and very preterm infants^[9], while some articles concentrated on kidney injury due to urinary tract obstruction^[10-13], especially on nephrolithiasis, which accounts for up to 30% of AKI in pediatrics^[10].

Aim

Aim of the present paper is to give a diagnostic overview of rare or very rare causes of pediatric AKI due to sudden bilateral ureteral obstruction, which can be related to lots of different conditions - either medical or surgical - and needs to be promptly suspected in order to attempt a quick renal function recovery.

We decided not to focus on typical and well-known diseases, which have been just run over in this paper, while we intended to concentrate on uncommon pictures, with the aim of giving a summary of such multiple, rare and heterogeneous conditions joint together by the common denominator of sudden bilateral ureteral obstruction, which appears difficult to be suspected at times.

Thus, our purpose was to provide a sort of companion to causes of bilateral or potentially bilateral ureteral obstruction in pediatrics, given the lack of such a paper in the literature. We did not address the issue of different imaging modalities - for example, see Riccabona^[12] about - and we just outlined some therapeutic aspects, with no intention of a systematic analysis.

Research

We performed a review of the literature by a search on PubMed, CrossRef Metadata Search, internet and reference lists of single articles updated to May 2014, with no time limits in the past. Given that we deal with rare conditions, we decided to include also papers in non-English languages, published with an English abstract.

We considered pediatric cases of ureteral obstruction presenting as bilateral, along with some cases which truly appeared as unilateral, but still at risk of bilateral involvement.

For the sake of clearness, we divided our research results into 8 categories: (1) urolithiasis; (2) congenital urinary tract malformations; (3) immuno-rheumatologic causes of ureteral obstruction; (4) ureteral localization of infections; (5) other systemic infective causes of ureteral obstruction; (6) neoplastic intrinsic ureteral obstructions; (7) extrinsic ureteral obstructions; and (8) iatrogenic trigonal obstruction or inflammation. Categories are summarized in Table 1.

UROLITHIASIS

Urolithiasis is generally considered a relatively rare disease in children, with some peaks of incidence in Turkey, some South Asian, African and South American countries^[14].

Overall, kidney stone disease is considered to affect boys and girls equally^[15] accounting for 1:1000-1:7600 hospital admissions in the United States of America,

even if some studies pointed out a male prevalence in the first decade and a female prevalence during the second decade of life^[11,15].

Causes of urolithiasis in children

A systematic review of urolithiasis goes beyond the scope of this paper, but some aspects can be of interest in our topic.

It has been evaluated that in some European countries, 75% of stones in children are composed of organic matrix and struvite, mostly sustained by *Proteus* infection or urinary tract anomalies^[14].

Anyway, according to the underlying condition, we could consider systemic/genetic diseases and medical treatment-related conditions, according to Valentini *et al*^[11].

Among systemic diseases, cystic fibrosis and inflammatory bowel diseases are considered risky conditions for stone formation because they result in intestinal calcium chelation, thus freeing up an exceeding amount of unbounded oxalate, which can be absorbed from the intestinal tract, finally becoming available for stone formation^[11].

As well, spinal cord injuries and spina bifida have been traditionally considered potential causes of stone disease because a neurogenic bladder - usually seen in these conditions - is associated with a higher risk of struvite stones, although more recently some metabolic studies showed that calcium phosphate stones are becoming more frequent, with a minor incidence of struvite calculi, probably due to the better bladder care achieved by clean self-catheterization^[11].

Some genetic aspects concern primary hyperoxaluria, classified in type-1 and type-2, which can lead to an early onset of disease with nephrocalcinosis and kidney injury, more clinically relevant in type-1 form.

Other conditions include tubular disorders such as cystinuria, which has been postulated as responsible for 3% of renal stones in one pediatric study^[16]. This autosomal recessive disorder finally causes an increased excretion of the amino-acids cystine, ornithine, lysine and arginine because of a proximal tubular defect.

Other genetic disorders include the X-linked Dent disease, the Lesch-Nyhan syndrome and the extremely rare 2,8-dihydroxyadeninuria^[11].

Clinical presentation

It has been pointed out that stone disease in children may present as flank/abdominal pain or hematuria, similarly to adults^[11], even if urolithiasis in infants may mimic an intestinal colic^[14].

To our knowledge, no studies investigated the real incidence of bilateral ureteral obstruction in urolithiasis among pediatric population.

CONGENITAL URINARY TRACT MALFORMATIONS

Lots of congenital urinary tract malformations can lead

Table 1 Causes of bilateral or potentially bilateral ureteral obstruction in children

Categories of disease	Single entities or underlying causes
Urolithiasis	Idiopathic Neurologic disease Metabolic and genetic disorder Inflammatory bowel disease
Congenital urinary tract malformations	Obstructive megaureter Uretero-pelvic junction obstruction Duplicated collecting system Horseshoe kidney and other anomalies
Immuno-rheumatologic diseases	Necrotizing vasculitis Periarteritis nodosa Kawasaki disease Henoch-Schönlein purpura Eosinophilic ureteritis
Ureteral localization of infections	Fungal infections Viral infections Bacterial infections Tubercular infections
Other systemic infections	Rotavirus
Neoplastic intrinsic ureteral obstructions	Fibroepithelial polyps, ureteritis cystica, malignant neoplasms
Extrinsic ureteral obstructions	Abdomino-pelvic masses Familial adenomatous polyposis Retroperitoneal fibrosis
Iatrogenic trigonal obstruction/inflammation	Device-induced obstruction Bulking agents for vesico-ureteral reflux Obstruction after appendectomy

to kidney injury, including uretero-pelvic junction obstruction, obstructive megaureter, vesico-ureteral reflux and posterior urethral valves.

Anyway, functional impairment may be graded and slowly progressive^[13]. With regard to the purpose of the present review, we remember that megaureter can be characterized by transient or permanent urine flow impairment, above all if secondary to structural or functional obstruction of the distal ureter^[17].

In a retrospective paper about obstructed megaureters in early infancy, 5 infants out of 47 between years 1963-1987 had a solitary kidney and one of them presented with anuria, while 7 out of the 47 patients had bilateral megaureter^[18].

In the literature, just one case of bilaterally duplicated collecting systems with obstructing ureteral stones has been described in an adult patient^[19], along with one case of pediatric bilateral ureteral reflux at the distal part in a bilaterally duplicated collecting system in a 5-year-old girl presenting with repeated urinary tract infections^[20].

By the way, also retrocaval ureter can lead to ureteral obstruction and it can often be associated with other major anomalies (see Lopez Gonzalez *et al.*^[21] for a bibliographic review).

Moreover, ureteropelvic obstruction can be related to horseshoe kidney, extrarenal pelvis, transverse valves of periureteral junction and other congenital anomalies^[22,23], both isolated or in genetic syndromes^[24,25].

As a general rule, congenital urinary tract malformations should always be considered in case of hydronephrosis, both in children and young adults, as they can be asymptomatic for many years, giving signs in adoles-

cence or adulthood.

IMMUNO-RHEUMATOLOGIC CAUSES OF URETERAL OBSTRUCTION

Stenosing ureteritis secondary to rheumatologic diseases is a rare condition, difficult to be estimated exactly because of the lack of papers about.

We found the description about a case of necrotizing vasculitis with ureteral involvement in a 12-year-old girl^[26] firstly admitted to the hospital when she was aged 2 years because of arthritis, fever and growth retardation, successfully treated by aspirin and penicillin and then being healthy until the age of 8, when she had a bronchial asthma episode. A subsequent arthritis manifestation occurred at the age of 11, treated by penicillin and naproxene. At the age of 12 she presented with fever, legs ulcers, abdominal crisis, bronchial asthma, sinus arrhythmia. Radiologic findings showed bilateral ureteral strictures and a skin biopsy revealed necrotizing vasculitis of medium-sized arteries.

The girl was successfully treated by prednisone and azathioprine.

In the literature, we found a couple of descriptions of ureteral involvement during periarteritis nodosa in a 13-year-age girl^[27] and a 6-year-age boy^[28], the latter treated by steroids.

To our knowledge, just one case has been published reporting on left ureteral obstruction in a 7-year-age boy affected by Kawasaki disease, who finally underwent excision of a left upper third ureteral stricture, with left-

dismembered pyeloplasty^[29].

Henoch-Schönlein purpura is a common systemic vasculitic condition of which the majority of cases occur in pediatrics^[30].

Urinary tract involvement in Henoch-Schönlein purpura usually concerns the kidney, with a focal proliferative glomerulonephritis occurring in 20%-90% of cases^[30].

Ureteral obstruction secondary to Henoch-Schönlein purpura is rare, with 14 cases described in the literature. Most patients were treated by medical therapy, while two by surgery.

One of them underwent total bilateral ureteral replacement using ileal segment, but progressed to end-stage renal disease because of reflux along the graft, thus radical excision of the ileal graft and both native kidneys was performed in order to eradicate any infectious process before immuno-suppression therapy^[31].

The other one was a boy aged 7 years, who underwent multiple conservative surgical treatments for two years, including bilateral nephrostomic tubes and ureterocalycostomies along with a left dismembered pyeloplasty, which appeared to be successful at the beginning but were then complicated by infections and worsening of renal function^[30]. Finally, a left nephrectomy was performed and two and a half years after the onset of disease, the boy remained tube-free without hydronephrosis recurrence on the right, with no further hospital readmissions required^[30].

Eosinophilic ureteritis is a rare disease with imaging presentation similar to ureteral tumors^[32], leading to ureteral stricture due to mural involvement, with secondary hydronephrosis^[33].

Even though it may be associated with hypersensitivity to bacteria, parasites, food and drugs, the etiopathogenic mechanism is not completely clear^[34] and peripheral eosinophilia is not a constant finding^[35]. In a paper, filariasis has been proposed as a possible triggering etiology of bilateral upper ureteric strictures in a 54-year-old man, as the patient had a previous history of cellulitis with epididymitis and came from an endemic area^[35].

Up to 1991 just one case of eosinophilic ureteritis in children had been published^[33], describing a 3-year-old boy with bilateral ureteral obstruction.

To our knowledge, no further cases of pediatric eosinophilic ureteritis have been described in the literature, while cases of eosinophilic cystitis have been reported, with some pathological aspects still debated^[33].

Some molecular details of murine ureteritis causing obstructive uropathy with hydronephrosis have been investigated^[34], providing a novel molecular pathogenesis for elucidating causes of aseptic inflammation in human upper urinary tract.

URETERAL LOCALIZATION OF INFECTIONS

Fungal infections

Systemic candidiasis with possible renal localization is uncommon in neonates and infants^[36], although it is a

well-documented entity in several special conditions, such as intensive care in premature newborns^[37], prolonged antibiotic therapy, intravenous lines and immunocompromised patients^[36].

The management of renal obstructive candidiasis is challenging and not well summarized over the past decades^[38]. In a review^[39], the clinical course and management of 35 neonates and infants were considered, with prematurity, broad spectrum antibiotics, prolonged hospital stay and the use of intravascular catheters resulted as predisposing factors. Among the other ones, candidemia and withholding antifungal therapy were poor prognostic factors.

After year 2011, some more cases of candidiasis in newborns have been described in the literature^[40-43], with no standardized treatment at the moment^[44]. Of course, transplant recipients must be considered at high risk for opportunistic pathogens^[45,46] and obstructive anuria due to fungal bezoars has been described^[47].

Therapeutic options range between medical drugs such as amphotericine-B or fluconazole and surgical treatment, consisting of nephrostomy or retrograde stenting along with irrigation by streptokinase as required, until open surgery if needed^[43].

Viral infections

Viral infections can represent severe complications in immunocompromised patients. Among them, BK-virus has been related to hemorrhagic cystitis in bone marrow transplant recipients^[48-50] or to pyelonephritis and ureteral stenosis in renal transplant recipients^[51].

Also adenovirus infections are postulated as causes of urologic complications in bone marrow transplantation, mainly consisting of hemorrhagic cystitis^[52], moreover obstructive pyelonephritis treated by double-J ureteral stenting has also been described^[53].

Management of viral infections, including Epstein-Barr, cytomegalovirus etc, is a challenging problem in both hematopoietic and solid organs transplantation^[54-56].

As to the purpose of this paper, we cite a case of late onset hemorrhagic cystitis and ureteritis induced by cytomegalovirus after kidney transplantation^[57].

Bacterial infections

Although syphilis, toxoplasmosis and candidiasis are recognized as causes of infections leading to kidney injury in newborns^[8], in the literature we found just one case describing a *Pseudomonas aeruginosa* infection with bilateral ureteral involvement^[58]. It concerned a 14-mo-old male diagnosed with an acute lymphocytic leukemia, who showed bilateral ureteral obstruction caused by purulent debris from *Pseudomonas*, with a subsequent anuria. The Authors reported it was not possible to insert a ureteric catheter on the left side, while a right retrograde pyelogram revealed a medial deviation of the right ureter with no chance of further upward progression. An irrigation was performed and the patient became polyuric after the procedure, with a renal function recovery two days after

the cystoscopy, along with ciprofloxacin administration^[58].

Tubercular infection

Tubercular infection is endemic in some geographic areas and genitourinary tract involvement is quite common^[59].

In a paper based on a retrospective study over 13 years in a single Indian centre, Singh *et al.*^[59] identified ureteral involvement in 27.35% out of 117 patients with genitourinary tubercular disease.

In a Russian paper^[60], the Authors analyzed 158 patients with active nephrotuberculosis, identifying 24 without obstructive uropathy, 70 with upper ureter obstruction and 64 with lower ureter obstruction. Bilateral involvement was recorded in 75% of patients. Unfortunately, just an English abstract was available in our research, so we do not know the amount of pediatric patients involved.

Other isolated cases have been published, including major surgical reconstructive treatment in one of them^[61,62] and one case of primary papillary mucinous adenocarcinoma of the ureter mimicking genitourinary tuberculosis in a 54-year-old man^[63].

In our opinion, tubercular infections could be suspected according to the geographic origin of the patient, although actual worldwide travelling habits should invite physicians to be cautious anytime.

OTHER SYSTEMIC INFECTIVE CAUSES OF URETERAL OBSTRUCTION

Rotavirus infections are the most common cause of severe diarrhea in infants and young children worldwide^[64]. In a clinical paper, Ashida *et al.*^[64] retrospectively described 21 cases of gastroenteritis in Japanese children with acute post-renal failure due to ureteral obstruction from bilateral stones.

The patients were 18 boys and 3 girls, with a median age of 1.3 years, ranging between 0.4 and 3 years, while the median duration between the onset of oliguria and that of *Rotavirus* gastroenteritis was 6.7 d, ranging from 3 to 16 d.

The Authors highlighted that all the children were under 3 years old, many of them had hyperuricemia and the stones mainly consisted of ammonium acid urate. Some causes have been considered as possibly responsible for such stones, including a laxative-like mechanism related to water loss or fluctuations in urinary acidity, which in another paper^[65] has been recognized to play a role in ammonium acid uric stones formation.

In our opinion, more studies are advocated to clear this entity.

Moreover, we found a paper published in 1991^[66] describing about 4 cases of children aged between 14 mo and 13 years, including a 3-year-old girl, who presented with oligo-anuria and either flank pain or fluid retention. Three of them had a profuse vomiting and diarrhea in

the previous days, with the forth one revealing a familial history of renal calculi. All the patients showed an evidence of crystalline sludge in their lower ureters.

Dehydration was postulated as a primary predisposing factor, even if three of them had an underlying crystalluria, two had a raised excretion of uric acid and one of cystine.

NEOPLASTIC INTRINSIC URETERAL OBSTRUCTIONS

Benign neoplasms

Fibroepithelial polyps are the most common ureteral benign neoplasms^[67], although this mesodermal tumor rarely occurs in children^[68].

It usually arises along the proximal ureter and is more common in boys, with presenting signs consisting of hematuria or flank pain due to urinary obstruction. Nevertheless, cases of single polyp with mid-ureter^[69] or distal ureter^[70] localization have been described, with one case prolapsing into the bladder, thus mimicking a bladder tumor^[71].

Overall, in the literature we found some 40 cases of pediatric patients affected by ureteral polyps^[72,73], with bilateral obstruction described in at least 5 cases, the first one in 1990^[67,74-77].

Surgical management of such cases is not standardized, with some polyps treated by ureteroscopic procedures and other ones by segmental resection of the ureter^[76,77]. A concomitant ureteropelvic obstruction underwent pyeloplasty, even if more studies are advocated about multiple metachronous polyps recurring after laparoscopic or robotic pyeloplasty^[72].

A differential diagnosis is required between ureteral polyps and ureteritis cystic^[78], which has been reported as a cause of ureteral obstruction in some cases^[79-81], bilaterally in one of them^[80].

Malignant neoplasms

Among malignant neoplasms, we should rapidly consider a collection of rare cases which truly presented as a single-side ureteral involvement.

A paper investigated the extension of Wilms' tumor into the ureter^[82] and 45 children out of the Wilms' Tumor Study Group database showed ureteral involvement, with hydronephrosis identified in 12 and non-function of the kidney in another 8. Tumor was right-sided in 26 and left-sided in 19.

In the literature, we found a case of 17-year-old girl^[83] and of a 12 year-old boy^[84] with Ewing's sarcoma/neuroectodermal tumor with unilateral ureteral localization, both presenting with nausea, vomiting, hematuria and abdominal pain.

One case has been described of a 4-year-old girl presenting with an embryonal rhabdomyosarcoma, botryoid variant, arising within the left ureter^[85].

Ureteral localization of lymphoma was identified in one adult in a clinico-pathological study of 40 cases of

genitourinary tract lymphomas, with the two pediatric cases involving kidney and testis^[86]. Another paper reported a case of penile lymphoma in a 4-year-old boy^[87].

An isolated case of bilateral ureteral obstruction due to lymphoma has been described in an adult^[88]. To our knowledge, no cases of pediatric lymphomas with ureteral localization have been published.

EXTRINSIC URETERAL OBSTRUCTIONS

Abdomino-pelvic masses

Urinary obstruction secondary to malignant pelvic tumors is a well-known condition in adult patients^[89].

In a paper published in 2004, Meir *et al*^[90] retrospectively investigated about the same condition among the records of two major children's hospitals, identifying 17 patients affected by upper urinary tract obstruction - 9 boys and 8 girls - with a median age of 5.7 years, ranging between 0 and 12. The most represented tumor was rhabdomyosarcoma, followed by lymphoma, and the urinary obstruction was bilateral in 11 cases. Most of them were treated by ureteral retrograde stenting or nephrostomy, with just some cases deferred to major surgery.

In another paper, Alexander *et al*^[91] ascertained the incidence and outcome of hydronephrosis in children affected by abdominal (non-renal) or pelvic tumors. They reviewed 366 patients from a database between 1995 and 2009, finding out 66 cases - 39 female and 27 male - of upper urinary obstruction due to a compression by the tumor or by surgery/radiotherapy, with a median age of 5.1 years. Out of those 66 cases, 35 were bilateral. The most represented tumor was neuroblastoma, followed by immature teratoma and rhabdomyosarcoma. For further details about histotypes involved, see Meir *et al*^[90] and Alexander *et al*^[91].

Mucinous cystadenoma of the ovary is a rare neoplasm in pediatric age^[92], with 20 cases described in the literature. Most of them presented late as an abdominal mass, with urinary outflow obstruction due to bilateral distal ureter compression, eventually leading to renal failure^[92].

Mesenteric and omental cysts are considered as rare intra-abdominal lesions, with an incidence of about 1 per 105000 admissions to general hospitals, ranging in age from in-utero to 18 years^[93]. They can lead to hydronephrosis because of compression, as described about an abdominal cyst causing anuria in a newborn girl^[94], for example.

A single case of mesenteric cyst in a neonate responsible for not only obstructive uropathy but also secondary type-1 hyperaldosteronism has been described in the literature^[95]. It concerned a 9-d-old female neonate who presented with lethargy, refusal to feed and anuria over the previous 2 d. An ultrasound scan revealed a round mass in the inferior abdomen, compressing both ureters and leading to bilateral hydronephrosis. The case was treated by subtotal surgical excision of the cyst.

The autosomal-dominant inherited disorder neurofibromatosis type-1 rarely involves the genito-urinary

tract, but some pediatric cases of obstruction and hydronephrosis or bladder involvement have been described^[96-102], with at least one needing ureterocutaneous-tomy^[103].

Cases of bilateral ureteral obstruction have been described both in adults and children due to traumatic pelvic hematoma and increased retroperitoneal pressure, in the so-called acute pelvic compartment syndrome^[104].

Familial adenomatous polyposis

Intra-abdominal desmoid disease is one fearful condition related to familial adenomatous polyposis (FAP), potentially causing ureteric obstruction. Joyce *et al*^[105] retrospectively investigated the incidence of ureteric obstruction among patients with desmoids disease from the FAP registry within the Sanford R. Weiss Center for Inherited Colorectal Neoplasia^[105] and they sorted out that 30 patients out of the 107 with desmoids disease presented with ureteral obstruction, which was bilateral in 13. The median age of first colonic surgery was 21 years, ranging between 11 and 60. Most patients were treated by endoscopic retrograde ureteral stenting or percutaneous nephrostomy, while 4 cases underwent nephrectomy, 1 ureteric resection and reimplantation and 1 ureterolysis.

A preceding Asian paper reports on two patients affected by the same condition, with a review of 14 previous cases in the literature^[106].

Retroperitoneal fibrosis

Retroperitoneal fibrosis is considered a rare entity in childhood^[107], with 26 cases published^[107-109], one of whom associated to lymphoma^[110].

IATROGENIC TRIGONAL OBSTRUCTION OR INFLAMMATION

Device-induced obstruction

In the literature, we found 2 cases of anuria secondary to balloon catheters in children, described in a paper published in 1977^[111].

The first one was a 17-mo-old girl affected by spastic neurogenic bladder, presenting with a 16-Fr Foley catheter with an 8-mL balloon, placed to manage a vesicocutaneous fistula developed after bilateral ureterovesical reimplantation. The catheter was patent and when it was removed the urine output restored.

The second case concerns a 7-d-old male newborn who underwent a transurethral resection of posterior urethral valves, presenting with an 8-Fr Foley catheter with a 3-mL balloon via a perineal urethrostomy. The catheter was found to be patent and by deflating the balloon diuresis was restored. Of course, those complications are less likely to occur with current pediatric devices.

Endoscopic procedures

Patients undergoing minimally invasive endoscopic peri-

ureteral injection of bulking agents for vesicoureteral reflux are potentially at risk of hydronephrosis^[112,113], but those situations are well-known and such patients are deferred to a urologic follow-up after the procedure^[114].

Bilateral ureteral obstruction after appendectomy

Known surgical complications leading to ureteral damage goes beyond the scope of this paper, while in the literature there are some cases reporting on bilateral ureteral obstruction as a rare complication after appendectomy in pediatrics, not related to direct surgical ureteral damage.

The last report found on PubMed, with a review of the literature, dates back to 2005^[115] when the Authors described a case of anuria in a 11-year-old boy, 5 d after surgery for a perforated appendix. At ultrasound examination some echogenic “plugs” were found in the distal portion of both ureters, with no abscess at an abdomino-pelvic computed tomography.

During a cystoscopy a bladder base inflammation was revealed, so the patient was treated by bilateral ureteric stenting, with a prompt recover of diuresis and renal function.

In the review of the literature, the Authors found out 15 similar cases, curiously all boys aged 6-15 years^[115].

An edematous process has been postulated as possibly triggered by a localized peritoneal reaction to intraoperative bacterial contamination, with boys more susceptible because their appendix is located closer to the bladder, while in girls internal genitals are situated between the appendix and the bladder^[116].

In our opinion, such mechanism can be considered as an attractive pathogenesis explanation, although we do not know if an inadequate fluid replacement therapy could play a role, above all in cases with underlying predisposing factors to urolithiasis. More studies would be necessary, including a focus on metabolic disorders in patients presenting with such condition.

Personally, we observed a case of a 16-year-old boy with similar presentation after appendectomy, who was diagnosed with bilateral ureteric stones successfully drained during ureteric bilateral catheterization. He was suggested to undergo a metabolic panel but the patient was lost at follow-up.

CONCLUSION

Bilateral ureteral obstruction in pediatric population is a rare condition and can be related to either medical or surgical underlying causes, thus it is not possible to identify a common etiology.

With regard to pathogenetic mechanisms, some aspects remain unclear, in particular: (1) more studies are advocated to clarify ureteral obstruction secondary to severe diarrhea after *Rotavirus* infection; (2) ureteritis in immuno-rheumatologic diseases is not a completely clear event, although murine models elucidated some details; (3) multiple metachronous polyps recurring after

laparoscopic or robotic pyeloplasty should be further investigated; and (4) sudden ureteral obstruction secondary to appendectomy could be related to dehydration, although in our opinion further studies would be necessary to highlight critical points and to evaluate metabolic aspects.

As a recommendation for clinical practice, a possible ureteral obstruction should be investigated in patients presenting with any picture described in this paper.

An abdominal ultrasound scan could be a simple, first-line diagnostic tool useful in the evaluation of hydronephrosis in most patients.

Treatment of ureteral obstruction deeply varies according to the underlying condition, with some cases successfully managed by drugs and other ones requiring surgery.

Surgical procedures often consist of ureteroscopy, ureteral stenting or nephrostomic tubes, with some cases deferred to major surgery for ureteral resection and reimplantation. Nephrectomy can be an option in patients presenting with advanced infections, particularly if recurrent, inveterate or in those needing an immunosuppression therapy for their underlying condition.

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